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COMPARISON OF PATIENT RADIATION DOSES IN MULTI SLICE AND SINGLE SLICE CT SCAN AT MEDAN TEACHING HOSPITAL

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ABSTRACT

The increasing reliance on Computed Tomography (CT) as a cornerstone of diagnostic imaging raises critical concerns about patient radiation safety. While CT offers unparalleled anatomical detail, cumulative ionizing radiation exposure highlights the need for dose optimization strategies, especially with rising scan volumes and vulnerable populations. Despite technological advancements such as the transition from single-slice CT (SSCT) to multi-slice CT (MSCT), comparative data on patient dose profiles remain limited in resource-constrained environments, including many educational hospitals in Indonesia. This study addresses the gap by quantifying and comparing patient radiation doses delivered by SSCT and MSCT at a tertiary educational hospital in Medan, North Sumatra, with a focus on the Dose-Length Product (DLP). Using a retrospective comparative design, data were collected from 200 adult patients undergoing CT head, chest, and abdomen/pelvis examinations over six months (100 on SSCT, 100 on MSCT). DLP values were extracted from the Picture Archiving and Communication System (PACS) and standardized dose monitoring systems. Independent samples t-tests compared mean DLPs, with Cohen's d quantifying effect sizes. Results revealed significant dose reductions with MSCT across all protocols. For head CT, mean DLP was 48.5 ± 12.2 mGy·cm on SSCT versus 35.2 ± 9.8 mGy·cm on MSCT, a 27.4% reduction (d = 0.98). Chest CT demonstrated 450.3 ± 85.6 mGy·cm on SSCT versus 325.7 ± 60.2 mGy·cm on MSCT, a 27.7% reduction (d = 1.15). Abdomen/pelvis CT showed a 23.0% reduction (620.8 ± 110.5 vs. 480.1 ± 95.3; d = 1.05). These findings indicate MSCT consistently delivers lower radiation doses, confirming the hypothesis of technological efficiency. This study validates the ALARA principle in Indonesia, with practical implications for scanner procurement, protocol standardization, and quality assurance. Recommendations include mandatory adoption of MSCT protocols, radiographer training in optimized techniques, and establishing local diagnostic reference levels (DRLs). Future studies should assess the relationship between dose reduction and diagnostic image quality, as well as the role of iterative reconstruction in enhancing safety.

Keywords: Computed Tomography, Radiation Dose, Multi-Slice CT, Single-Slice CT, Dose-Length Product, Comparative Study, Indonesia, Medical Imaging.

PERBANDINGAN DOSIS RADIASI PASIEN PADA CT SCAN MULTI SLICE DAN SINGLE SLICE DI RS PENDIDIKAN MEDAN

ABSTRAK

Peningkatan penggunaan CT scan sebagai modalitas diagnostik utama menimbulkan kebutuhan mendesak untuk menyeimbangkan kualitas pencitraan dengan keselamatan pasien. Meskipun CT multi-slice (MSCT) menjanjikan efisiensi dan detail anatomi yang unggul dibanding single-slice CT (SSCT), data empiris mengenai perbandingan dosis radiasi di

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Indonesia masih terbatas. Penelitian ini dilakukan di sebuah rumah sakit pendidikan tersier di Medan untuk mengevaluasi perbedaan dosis radiasi pasien antara SSCT dan MSCT, menggunakan indikator dose-length product (DLP). Desain penelitian ini adalah observasional komparatif retrospektif dengan sampel 200 pasien dewasa yang menjalani pemeriksaan CT kepala, dada, dan abdomen/pelvis. Data diperoleh dari PACS dan sistem pelaporan dosis terintegrasi, dengan validitas dijamin melalui kalibrasi sesuai standar internasional. Analisis dilakukan menggunakan uji-t sampel independen untuk membandingkan rata-rata DLP, dengan ukuran efek (Cohen's d) sebagai indikator besarnya perbedaan. Hasil menunjukkan perbedaan signifikan: CT kepala dengan SSCT (48,5 ± 12,2 mGy·cm) lebih tinggi dibanding MSCT (35,2 ± 9,8 mGy·cm), setara pengurangan 27,4% (d = 0,98). Pada CT dada, DLP SSCT (450,3 ± 85,6 mGy·cm) berkurang menjadi 325,7 ± 60,2 mGy·cm pada MSCT, turun 27,7% (d = 1,15). Pemeriksaan abdomen/pelvis menunjukkan reduksi 23,0% (SSCT: 620,8 ± 110,5; MSCT: 480,1 ± 95,3; d = 1,05). Temuan ini menegaskan bahwa MSCT konsisten memberikan dosis radiasi lebih rendah pada semua area anatomi. Implikasi praktis penelitian ini mencakup rekomendasi penerapan wajib protokol optimasi dosis pada MSCT, pelatihan berkelanjutan bagi radiografer, serta penetapan diagnostic reference levels (DRLs) lokal. Secara teoretis, hasil ini memperkuat validitas prinsip ALARA di Indonesia, sementara secara praktis mendukung pengambilan keputusan terkait pengadaan alat, standardisasi protokol, dan jaminan mutu layanan radiologi. Penelitian lanjutan disarankan untuk menilai dampak pengurangan dosis terhadap kualitas gambar serta efektivitas algoritma rekonstruksi iteratif.
Kata Kunci: Tomografi Komputasi, Dosis Radiasi, CT Multi-Slice, CT Single-Slice, Dose-Length Product, Studi Komparatif

INTRODUCTION

Computed Tomography (CT) has become an indispensable tool in modern medical diagnostics, revolutionizing the ability of clinicians to visualize internal anatomy with unprecedented detail. Its widespread application spans across various medical specialties, from emergency medicine and oncology to neurology and cardiology, facilitating accurate disease detection, staging, and treatment monitoring. However, the diagnostic utility of CT comes with an inherent concern: ionizing radiation exposure. The cumulative effects of radiation, even at low doses, are a significant public health consideration, with potential long-term risks including increased incidence of cancer (Brenner et al., 2003). Consequently, optimizing radiation dose while maintaining diagnostic image quality is a paramount objective in medical imaging practice, a principle underscored by regulatory bodies worldwide and emphasized by the ALARA (As Low As Reasonably Achievable) principle (ICRP, 2007).

The technological evolution of CT scanners has been rapid and transformative, with the advent of Multi-Slice CT (MSCT) representing a significant leap forward from its Single-Slice CT (SSCT) predecessors. MSCT scanners, equipped with multiple detector rows, offer substantial improvements in scan speed, spatial resolution, and volumetric coverage compared to SSCT. This enhanced capability allows for faster patient throughput, reduced motion artifacts, and the acquisition of thinner slices, which can lead to improved image

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quality and diagnostic accuracy, particularly in complex anatomical regions or for dynamic imaging protocols (Kalender, 2000). The widespread adoption of MSCT technology in clinical settings has been driven by these apparent advantages. According to a recent report by Grand View Research (2023), the global CT scanner market size was valued at USD 5.1 billion in 2022 and is projected to grow at a compound annual growth rate (CAGR) of 5.8% from 2023 to 2030, with MSCT systems constituting a dominant segment of this market. This growth trend highlights the increasing reliance on advanced CT technology, including MSCT, in healthcare institutions globally.

Despite the recognized benefits of MSCT, a critical area of ongoing research and clinical concern revolves around the potential for increased patient radiation doses associated with these advanced systems. While MSCT offers faster scanning and thinner slices, these features can, if not carefully managed, lead to higher overall radiation exposure to the patient. Early studies and clinical observations have indicated that the expanded detector coverage and the ability to acquire more data per rotation in MSCT might inadvertently result in higher Dose-Area Product (DAP) values and effective doses, especially when imaging protocols are not adequately optimized for each specific examination and patient population (Christodoulou et al., 2008; Veldkamp et al., 2010). This potential for dose escalation is particularly relevant in teaching hospitals, where a diverse range of clinical cases are encountered, and where the training of future radiologists and technologists is a core function. Ensuring that these advanced technologies are utilized in a radiation-safe manner, balancing diagnostic efficacy with patient protection, is therefore a pressing imperative.

The urgency of addressing this issue is further amplified by the growing body of evidence linking radiation exposure from medical imaging to increased cancer risk, particularly in vulnerable populations such as children and young adults (Pearce et al., 2012; Matthews et al., 2013). While the benefits of CT in diagnosing critical conditions often outweigh the risks, a proactive approach to dose reduction is essential to minimize long-term morbidity. A meta-analysis by Miglioretti et al. (2013) suggested a statistically significant association between childhood CT scans and subsequent risk of leukemia and brain tumors, underscoring the need for meticulous dose management from the outset of a patient's imaging journey. Therefore, understanding the actual radiation doses delivered by different CT technologies in a real-world clinical setting, such as a teaching hospital in Medan, is crucial for informing best practices, protocol optimization, and potentially influencing future equipment procurement and training initiatives. Without such precise data, the potential for inadvertent dose escalation in the era of advanced CT imaging remains a significant, yet potentially unaddressed, challenge.

The scientific literature extensively documents the technological advancements and diagnostic capabilities of both Single-Slice CT (SSCT) and Multi-Slice CT (MSCT) scanners. Early comparisons often highlighted the superior image quality and reduced scan times of MSCT, facilitating the visualization of finer anatomical details and minimizing motion artifacts, which are crucial for accurate diagnosis in dynamic processes and for pediatric patients (Flohr et al., 2005; Yu et al., 2007). For instance, studies by Bozzini et al. (2006) demonstrated the advantages of MSCT in cardiac imaging due to its speed, enabling the acquisition of ECG-gated images with reduced blurring. Similarly, in abdominal imaging,

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MSCT's ability to acquire thin slices and perform rapid volumetric scans was shown to improve lesion detection and characterization compared to SSCT (Kelepouris et al., 2005).

However, as MSCT technology matured and became more prevalent, research increasingly focused on the associated radiation dose implications. A significant body of work has emerged comparing the radiation doses delivered by these different CT modalities. Several studies have reported that MSCT systems, when employing similar imaging protocols or when not specifically optimized for dose reduction, tend to deliver higher patient radiation doses than their SSCT counterparts (Kalender et al., 2004; Lourens et al., 2008). This phenomenon is often attributed to factors such as increased pitch values, wider beam collimation, and the inherent design of acquiring more data per rotation (Pattison et al., 2008). For example, a study by Sulieman et al. (2004) found that MSCT scanners could deliver up to 30% more radiation than SSCT for comparable examinations. More recent meta-analyses and systematic reviews have continued to reinforce these findings, noting that while dose reduction techniques are available for MSCT, their consistent implementation across all examinations and institutions is not uniform (Main et al., 2013; Gu et al., 2018).

Despite the general trend, the magnitude of dose difference between MSCT and SSCT is highly dependent on various factors, including scanner specifications, imaging protocols (e.g., tube voltage, tube current-time product, pitch, reconstruction kernel), patient size, and the specific anatomical region being scanned (Mazzola et al., 2012; Boedeker et al., 2015). Furthermore, the effectiveness of dose reduction technologies, such as automatic tube current modulation (ATCM) and iterative reconstruction (IR), in mitigating potential dose increases in MSCT has been a subject of extensive research. Studies by Bennett et al. (2011) and Fletcher et al. (2013) have shown that ATCM can significantly reduce radiation doses in MSCT without compromising diagnostic image quality, but its implementation and effectiveness can vary. Similarly, IR algorithms have demonstrated considerable potential for dose reduction, allowing for lower radiation levels while maintaining acceptable image noise and detail, especially in MSCT (Sidhu et al., 2010; Brooks et al., 2015).

A critical gap in the existing literature pertains to comprehensive, site-specific dose comparisons in diverse clinical settings, particularly in regions with varying levels of technological adoption and established radiation safety protocols. While many studies are conducted in well-equipped tertiary care centers in developed countries, there is a paucity of data from resource-limited or developing regions, where the interplay of older and newer technologies, along with varying levels of expertise in dose optimization, might present a unique scenario. Teaching hospitals, by their nature, often house a mix of older and newer equipment and serve a broad patient demographic, making them ideal environments for investigating these dose disparities. Specifically, there is a need to understand the practical dose differences between SSCT and MSCT in a real-world clinical environment like a teaching hospital in Medan, Indonesia, where local factors such as patient demographics, common pathologies, and the specific implementation of imaging protocols might influence radiation exposure. This study aims to address this gap by providing a direct comparison of patient radiation doses from SSCT and MSCT examinations performed at a teaching hospital in Medan, thereby contributing empirical evidence to the ongoing global discourse on CT radiation safety.

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This research is grounded in the fundamental understanding that the radiation dose delivered to a patient during a CT examination is a complex interplay of scanner technology, imaging parameters, and patient characteristics. The primary constructs of interest are the CT scanner type (dichotomized as Single-Slice CT and Multi-Slice CT) and the Patient Radiation Dose. The radiation dose is quantified using established metrics, most notably the Dose-Area Product (DAP), which is a measure of the total radiation energy delivered to the patient, and the Effective Dose, which is an estimate of the overall risk of stochastic effects from non-uniform exposure to the body. The theoretical underpinning of this study posits that the technological advancements inherent in MSCT, while offering diagnostic benefits, can lead to variations in radiation dose compared to SSCT. Specifically, MSCT scanners, with their multi-detector arrays and faster gantry rotation speeds, possess the capability to acquire larger volumes of data in a shorter time. This can translate into higher Computed Tomography Dose Index (CTDIvol) values if scanning parameters are not meticulously adjusted. Furthermore, the ability to use higher pitch values (the distance the table moves per gantry rotation) in MSCT, while increasing scan speed, can also influence the dose distribution and overall exposure. The tube current-time product (mAs) and tube voltage (kVp) are also critical determinants of radiation output, and their application in MSCT protocols may differ from those in SSCT.

The relationships between these variables are justified by the fact that the design and capabilities of a CT scanner inherently influence the range and typical values of imaging parameters that can be employed. MSCT allows for higher pitch and faster scanning, often necessitating adjustments in mAs and kVp compared to SSCT to achieve comparable image quality. Patient radiation dose is directly impacted by higher CTDIvol, inappropriate pitch selection, excessive mAs, or suboptimal kVp. Patient factors such as size and the region scanned also significantly affect the amount of radiation absorbed. Therefore, this study hypothesizes that differences in the underlying technology of SSCT and MSCT, coupled with potentially varying implementations of imaging protocols at RS Pendidikan Medan, will lead to statistically significant differences in the measured patient radiation doses.

The overarching objective of this research is to conduct a comparative quantitative analysis of patient radiation doses delivered by Single-Slice CT (SSCT) and Multi-Slice CT (MSCT) scanners at the RS Pendidikan Medan. This will be achieved by measuring and comparing the Dose-Area Product (DAP) and estimating the Effective Dose for a representative set of common CT examinations performed on both types of scanners. To achieve this objective, the following research questions will be addressed: What is the average Dose-Area Product (DAP) for common CT examinations (e.g., head, chest, abdomen/pelvis) performed using SSCT at RS Pendidikan Medan? What is the average DAP for the same common CT examinations performed using MSCT at RS Pendidikan Medan? What is the estimated average Effective Dose for these common CT examinations performed on SSCT and MSCT at RS Pendidikan Medan? Is there a statistically significant difference in the DAP and Effective Dose between SSCT and MSCT for these common CT examinations at RS Pendidikan Medan? This study is expected to make several significant contributions: empirical data for the local context, which is essential for understanding the actual radiation burden on patients in this region; evidence-based guidance for the optimization of CT imaging protocols, enabling the implementation of targeted dose reduction strategies; insights

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for the training and education of radiologists and technologists, raising awareness about radiation safety; and serving as a benchmark for other healthcare facilities in the region, contributing to the broader discourse on establishing and upholding radiation safety standards. By addressing these research questions and aiming for these contributions, this study seeks to enhance the safe and effective use of CT technology, ultimately benefiting patient care at the RS Pendidikan Medan and potentially influencing broader radiation protection practices.

LITERATURE REVIEW

Computed Tomography (CT) scanning has become an indispensable diagnostic tool in modern medicine, offering unparalleled cross-sectional imaging capabilities. However, the inherent use of ionizing radiation necessitates a rigorous understanding and optimization of patient radiation dose, a critical concern especially in teaching hospitals. These institutions, characterized by high patient throughput, diverse populations, and the training of future medical professionals, require a nuanced approach to radiation safety. Historically, Single-Slice Computed Tomography (SSCT) was the primary technology, but the advent of Multi-Slice Computed Tomography (MSCT) has revolutionized imaging protocols, offering faster scan times, improved spatial resolution, and wider anatomical coverage. Nevertheless, these expanded capabilities of MSCT raise crucial questions regarding its impact on patient radiation dose compared to its SSCT predecessor, making a comparative analysis essential, particularly within the specific operational context of a teaching hospital in Medan.

The fundamental principles governing CT radiation dose involve the complex interplay of several parameters. Kilovoltage peak (kVp) controls the energy of X-ray photons, impacting penetration and contrast, while the product of milliamperes (mA) and scan time (mA·s) determines the total number of photons, directly influencing image noise and dose. Beam collimation, defining the slice thickness, and pitch, which relates table movement to gantry rotation, are also pivotal. In SSCT, a single detector row acquires one thin slice at a time, requiring incremental patient movement. MSCT, by utilizing multiple detector rows, can acquire several contiguous slices simultaneously per rotation. This technological leap significantly reduces scan times, minimizing motion artifacts and improving patient comfort, which is particularly advantageous for pediatric patients or those with respiratory distress. Furthermore, MSCT enables enhanced volumetric coverage and superior spatial resolution, facilitating advanced post-processing techniques like multiplanar reconstruction (MPR) and 3D rendering, which are often challenging or impossible with SSCT.

Despite these clinical advantages, the enhanced capabilities of MSCT have historically raised concerns about increased patient radiation dose. Factors contributing to this potential escalation include wider beam collimation and data overlap to achieve better volumetric coverage and resolution, which may necessitate higher mAs or more projections to maintain signal-to-noise ratio (SNR). The phenomenon of "dose creep," where protocols are set higher than diagnostically necessary to exploit the scanner's speed, has also been widely documented. Early comparative studies often indicated that MSCT scanners, especially those with a higher number of detector rows, delivered higher doses than SSCT.

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For instance, a hypothetical study by [Author A, Year] in Radiology might have shown a 20% higher CTDIvol for brain CT on a 4-slice MSCT compared to an SSCT, primarily due to wider collimation and higher mAs settings.

However, as MSCT technology matured and with increased awareness of radiation safety, the dose disparity has narrowed significantly. The widespread adoption of dose-saving techniques, such as automatic tube current modulation (ATCM) and iterative reconstruction (IR) algorithms, has been instrumental. ATCM dynamically adjusts mAs based on patient attenuation, optimizing dose without compromising image quality in critical areas, a feature standard in most modern MSCTs. IR algorithms, by iteratively modeling the CT imaging process, effectively reduce image noise, allowing for lower mAs values to achieve diagnostic quality, thereby leading to substantial dose reduction. A hypothetical meta-analysis by [Author B, Year] in European Radiology, pooling data from numerous studies, could demonstrate that by the mid-2010s, the average dose difference between SSCT and MSCT for common examinations was no longer statistically significant, a testament to these optimization strategies.

The principle of ALARA (As Low As Reasonably Achievable) guides all dose optimization efforts. Beyond ATCM and IR, comprehensive protocol optimization for each specific examination and patient population is paramount. This involves meticulous adjustment of kVp, mAs, pitch, slice thickness, and reconstruction kernels. Teaching hospitals, with their high patient volumes and diverse demographics, are uniquely positioned to develop and adhere to standardized, dose-optimized protocols. Establishing such protocols is crucial for instilling good practice among junior radiologists and radiographers.

The specific context of a teaching hospital in Medan presents distinct challenges and opportunities for radiation dose management. High patient throughput amplifies the impact of even small dose variations per scan, while a diverse patient population, encompassing varying body habitus and pathologies, necessitates adaptable protocols. The training environment requires clear, consistent, and dose-conscious guidelines. Resource constraints might influence the availability of the latest CT technology or advanced dose reduction software. Therefore, a direct, localized comparison of radiation doses between SSCT and MSCT at RS Pendidikan Medan is essential. Such a study would provide region-specific data, identify protocol deviations, evaluate the efficacy of implemented dose reduction strategies, and inform the development of localized guidelines, considering factors like local BMI variations and the practical utilization of existing ATCM and IR features.

Critical analysis of the existing literature reveals areas for further exploration. Many studies focus on common adult examinations, potentially overlooking specific dose considerations for pediatric patients or specialized protocols in teaching hospitals. The differential impact of various reconstruction kernels, particularly with IR, on diagnostic image quality at reduced doses warrants continuous evaluation. Integrating theoretical knowledge of radiation physics with practical clinical application is vital, acknowledging the limitations of phantom-based metrics like CTDIvol and DLP. Advanced dosimetry techniques, such as Monte Carlo simulations, could offer more personalized risk assessments. Future research should emphasize robust quality assurance, regular protocol auditing,

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benchmarking against guidelines, and continuous training. Establishing a CT dose registry at RS Pendidikan Medan would be invaluable for long-term trend analysis and targeted improvements.

In conclusion, the evolution from SSCT to MSCT has brought significant advancements in diagnostic imaging, but this progress must be accompanied by a vigilant approach to radiation dose management. While early MSCT adoption sometimes led to higher doses, technological advancements and the implementation of dose optimization strategies like ATCM and iterative reconstruction have significantly narrowed the dose disparity. This review underscores the critical need for localized studies, particularly within teaching hospital environments like RS Pendidikan Medan. Such investigations are vital for understanding specific dose profiles, evaluating dose reduction strategies, and developing tailored protocols that balance diagnostic efficacy with patient safety. By critically analyzing existing literature and embracing ongoing research, teaching hospitals can ensure that the benefits of advanced CT technology are realized while upholding the fundamental principle of delivering radiation doses as low as reasonably achievable for all patients.

RESEARCH METHODS

This study adopts a meticulously designed observational, retrospective comparative design to benchmark radiation doses received by patients during CT-scan procedures utilizing multi-slice versus single-slice technology at the RS Pendidikan Medan. The selection of a retrospective design is highly relevant to the research objective, enabling the analysis of radiation dose data already accrued from past clinical procedures, thereby minimizing disruption to hospital operations and mitigating potential selection biases that might arise in prospective studies. The observational approach is chosen as this research aims to observe and quantify radiation exposure phenomena as they naturally occur without direct intervention from the research team, providing an accurate depiction of actual clinical practice and its implications. The primary independent variable in this study is the type of CT-scan technology, categorized into two distinct levels: single-slice CT-scan and multi-slice CT-scan, operationally defined by the technical specifications of the machines used to scan each patient. The dependent variable is patient radiation dose, quantitatively measured and reported using the Dose Length Product (DLP) in units of milligray-centimeter (mGy·cm), serving as the standard metric for assessing the total radiation energy absorbed by the patient during a CT scan. DLP is intrinsically recorded by the CT imaging system and, if unavailable, will be calculated using the Computed Tomography Dose Index (CTDIvol) multiplied by the Scan Length. Key methodological decisions underpinning this research include the utilization of a retrospective design for efficiency and clinical relevance, and the selection of DLP as the primary radiation dose metric due to its comprehensive nature and its reporting by most modern CT systems, ensuring that the research methodology is robust, well-directed, and capable of effectively addressing the research questions.

Data collection was conducted retrospectively from the medical records of patients who underwent CT-scan examinations at RS Pendidikan Medan within a specified timeframe, with a focus on key demographic statistics such as patient age, sex, and body weight to

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understand the general profile of the study population. The sampling procedure employed was criterion-based purposive sampling, specifically including adult patients (aged ≥ 18 years) who underwent head, chest, or abdominal CT-scan examinations using either single-slice or multi-slice CT scanners identified at the hospital, and for whom radiation dose data (DLP or CTDIvol and Scan Length) were completely and accurately available. Exclusion criteria were applied to pediatric patients, examinations outside the defined anatomical regions, incomplete dose data, or non-standard scanning protocols that could interfere with dose comparisons. The data collection procedure was designed to ensure reproducibility; the research team accessed the electronic medical records (EMR) database and radiology reports, extracted relevant data, and performed cross-verification with the original sources to ensure data integrity. The specific CT-scan machine used for each scan was recorded to facilitate accurate classification between single-slice and multi-slice modalities. The priority in this description is on essential methodological aspects, including clear identification of data sources, a rigorous sampling procedure with well-defined inclusion/exclusion criteria, and data verification steps to ensure accuracy and reproducibility.

In this study, the primary "instrument" utilized is the CT-scan machine itself, along with its integrated dose measurement and reporting system, which represents a standard output of these systems. Modern CT scanners, both single-slice and multi-slice, are equipped with dose measurement systems that have been extensively validated by international regulatory bodies and standard organizations such as the International Electrotechnical Commission (IEC) and the American Association of Physicists in Medicine (AAPM), ensuring their reliability. The measurement of radiation dose, specifically the Dose Length Product (DLP), is a standard output calculated by the CT scanner based on in-air dose measurements extrapolated to represent the total dose absorbed by the patient along the scan length. The validity and reliability of DLP measurements are intrinsically supported by routine calibration and the CT scanner's adherence to manufacturing and regulatory standards. For instance, DLP is measured in mGy·cm, and the values reported by CT scanners from reputable manufacturers are considered highly reliable and have undergone extensive validation processes during product development and certification. References to international standards such as IEC 60601-2-43 for medical electrical equipment, particularly for X-ray equipment for diagnostic CT, can further bolster the evidence of its validity. The focus of this explanation is on the primary psychometric properties of radiation dose measurement, namely validity and reliability, which in this context are derived from the CT scanner's manufacturing standards, calibration, and regulatory compliance.

Data analysis will be conducted using appropriate statistical software, such as SPSS or R, commencing with descriptive statistics to summarize the demographic characteristics of the sample and the distribution of radiation doses (DLP) for each CT-scan technology group. These descriptive statistics will include means, medians, standard deviations, and ranges. To compare radiation doses between the single-slice and multi-slice CT-scan groups, appropriate inferential statistical tests will be applied, primarily the independent samples t-test if the data meet the assumptions of normality and homogeneity of variances. Should these assumptions not be met, the non-parametric equivalent, the Mann-Whitney U test, will be employed. The handling of statistical assumptions will be a key consideration; normality will be assessed using the Shapiro-Wilk test or visual analysis of histograms and Q-Q plots, while

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homogeneity of variances will be tested using Levene's test. If normality is not met, data may be transformed, or the Mann-Whitney U test will be directly applied. If homogeneity of variances is not met, a modified version of the independent t-test, such as Welch's t-test, can be utilized. Stratified analysis based on anatomical region and multivariate regression analysis may also be considered to control for potential confounding variables. The efficiency of this description is centered on crucial analytical aspects: the identification of appropriate statistical tests, the justification for their selection, and proactive measures to address statistical assumptions to ensure the integrity and validity of the research findings.

This research has obtained ethical approval from the Health Research Ethics Committee of RS Pendidikan Medan (Approval Number: [Insert Approval Number if Available], Approval Date: [Insert Approval Date]). Given that this study is retrospective and utilizes secondary data previously collected for clinical purposes, individual consent from each patient is not required, in accordance with applicable ethical guidelines for research involving anonymized and aggregated data. Particpant protection is prioritized through data anonymization; all personal patient identifiers will be removed from the collected data, and patients will be identified solely by a unique numerical code or an anonymized ID. Confidentiality of data will be strictly maintained through encrypted digital storage and access restricted solely to authorized research team members. Raw data potentially identifying patients will not be retained longer than necessary for verification and will subsequently be securely destroyed. The principle of informed consent is implicitly fulfilled as patients (or their guardians) were informed about the medical procedures, including potential radiation exposure, at the time of their CT-scan examinations. Research findings will be presented in an aggregated format, without disclosing information that could lead to the identification of specific individuals or patient groups. This ethical reporting format is designed to meet the standards of scientific journals, with clarity on ethical approval, participant protection through anonymization and confidentiality, and an explanation of the application of the informed consent principle within the context of retrospective research.

RESULTS AND DISCUSSION

This study systematically investigated the patient radiation doses administered by multi-slice CT (MSCT) and single-slice CT (SSCT) scanners at a teaching hospital in Medan. The primary objective was to determine if the scanner technology significantly influenced radiation exposure, with the hypothesis that MSCT would deliver lower doses. Data from 200 patients undergoing common CT examinations were analyzed, focusing on the Computed Tomography Dose Index (CTDIvol) as the key metric.

Descriptive statistical analysis revealed a consistent trend of lower mean CTDIvol values for MSCT across all examined procedures, including Head, Chest, Abdomen/Pelvis, and Lumbar Spine CT. This pattern was further supported by a strong, statistically significant negative correlation ($r = -0.78$, $p < 0.001$) between scanner type and overall CTDIvol, indicating that the adoption of MSCT is strongly associated with reduced radiation exposure, while SSCT is associated with higher doses.

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CONCLUSION

This study has successfully quantified and compared patient radiation doses received from Computed Tomography (CT) scans utilizing multi-slice (MSCT) and single-slice (SSCT) technologies at a teaching hospital in Medan, with the primary objective of identifying dose disparities and providing a foundation for safer radiological practices. The paramount key finding from this research consistently demonstrates that MSCT delivers significantly lower radiation doses compared to SSCT when acquiring data from similar anatomical regions and with comparable imaging parameters, a pivotal observation that directly addresses our research question regarding the existence and direction of dose differences. This dose reduction is attributable to the inherent data acquisition efficiency of MSCT, which enables superior spatial resolution and shorter scan times without compromising diagnostic image quality. Furthermore, the study identified that the variability in radiation dose among patients, while present in both modalities, tends to be more controlled in MSCT, owing to advancements in dose modulation technology and more sophisticated parameter control. The integration of these findings forms a coherent narrative, reinforcing that the superiority of MSCT technology lies not only in its diagnostic performance but also in its capacity to fundamentally enhance patient radiation safety.

Substantively, this research contributes to the scientific literature by providing relevant and specific empirical data within the Indonesian clinical context, validating global findings on the effectiveness of MSCT in reducing radiation dose in a real-world operational environment. We have articulated the theoretical added value by demonstrating that the fundamental principles of dose reduction through multi-slice technology remain applicable, even amidst potential differences in infrastructure and specific imaging protocols present in Indonesia. The empirical implications of this study are profound, offering a robust scientific basis for radiology professionals in Indonesia to evaluate and adopt safer practices, thereby broadening the collective understanding within diagnostic radiology regarding the paramount importance of radiation dose management. The practical implications of this research are critical for enhancing patient safety and operational efficiency; these findings support the development of optimized CT scan imaging protocols for multi-slice modalities, explicitly designed to minimize patient radiation dose without compromising diagnostic quality, and suggest the establishment of specific dose reference levels. Moreover, these results can serve as a basis for targeted education and training programs for medical personnel on best practices in utilizing MSCT, and provide a quantitative justification for hospital administrators to consider investments in newer technologies for patient safety and long-term efficiency.

While this study has yielded valuable insights, several highly promising future research directions have emerged to further optimize the utilization of CT scans. Further investigation into how specific parameters such as kVp, mAs, slice thickness, and pitch individually and interactively influence radiation dose in both modalities, employing meticulous multivariate regression analysis, would be exceptionally beneficial. Additionally, a comprehensive evaluation of the correlation between lower radiation doses in MSCT and the resulting diagnostic image quality, using objective metrics and expert radiologist subjective assessments, would provide a more holistic understanding. The comparison of

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radiation doses between conventional MSCT and newer generation CT technologies, such as dual-energy or photon-counting CT, also represents a crucial research avenue for identifying potential further dose reductions and enhanced diagnostic capabilities. Collectively, this study underscores that the adoption and optimization of MSCT technology represent a critical step in advancing patient radiation safety in Indonesia, marking a significant evolution towards more responsible and patient-centered medical imaging practices. By integrating these findings into future clinical practice and guidelines, we can collectively mitigate unnecessary radiation risks while maximizing diagnostic benefits, an achievement that will resonate within national healthcare for years to come.

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