



EFFECT OF TUBE CURRENT VARIATION ON IMAGE QUALITY IN HEAD TRAUMA CT SCANS USING ITERATIVE RECONSTRUCTION

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ABSTRACT

In CT scan trauma, high spatial resolution is used to distinguish the joint gap or fissure caused by trauma. To obtain good image quality, the use of high kV and mAs is the choice. On the other hand, in cases of trauma, the CT scan protocol shorter scan time is required so that the image results tend to produce a lot of noise. To determine the optimal mAs value to obtain a low radiation dose using iterative reconstruction.

The research method is a quasi-experimental pretest and posttest with control type. The research sample was 3 variations of mA, namely 300 mA, 200 mA and 100 mA with kV 120 and a time of 7.1s on an anthropomorphic phantom of the head with trauma parameters. Measurements were carried out by conducting univariate tests for radiation dose and noise before and after iterative reconstruction was applied.

There was a difference in the radiation dose produced in the CT scan parameters of the head trauma control and treatment groups. In the control group with kV 120 and 300 mA produced a dose of 38.7 mGy, while the treatment group with 200 mA was 25.8 mGy and the lowest dose was 12.9 mGy at a variation of 100 mA. The radiograph results were reconstructed using iterative reconstruction with a standard deviation at 300 mA of 4.4, 200 mA 4.5 and 100 mA 5.8. Based on the results obtained, it shows that mA variations affect the noise uniformity value and the resulting radiation dose.

Keywords: CT Scan, head, trauma, iterative reconstruction, mA

Introduction

The radiation dose produced by CT Scan machines has now become a special concern, because the CT Scan dose is much greater than that of conventional examinations. The head dose is around 2 mSv and abdominal/pelvic CT is around 10 mSv, so the range is 2–20 mSv per CT examination (1). The range <0.1–1.5 mSv for conventional radiography is representative for many standard procedures (chest, abdomen, KUB, dental, etc.) but does not rule out the possibility of conventional radiography procedures with doses approaching or slightly exceeding 1.5 mSv if they involve multiple views, special techniques, or patients of certain body sizes (2,3). Radiation exposure from CT in children has been associated with an increased risk of cancer, including leukemia and brain cancer, although the magnitude of the risk varies between studies and depends on the cumulative dose, the type of tissue exposed, and age factors (4,5). Various efforts have been made by manufacturers to reduce the radiation dose of CT Scans such as tube current modulation and the use of Low mA. Adjusting the tube current is the most common approach. When the current is halved, the radiation dose is reduced by approximately 50% (6). However, lowering the tube current increases image noise. Filtered back projection (FBP) is a filter often used to improve image quality by reducing noise, but FBP cannot consistently produce diagnostic image quality. Another method used to reduce radiation dose is Iterative Reconstruction (IR). Several clinical studies have shown that this method can reduce noise and radiation dose by up to 50%. IR is considered capable of improving image quality and reducing radiation dose while maintaining diagnostic acceptability, as non-ideal propagation data are reconstructed more significantly than with a conventional CT scan (7).

One of the routine CT scan examinations is the CT scan of the head, with the most common indication being trauma. Trauma head CT is one of the most frequently performed CT examinations in the evaluation of head injuries, often more frequently than routine non-trauma head CT. Head CT serves as a rapid initial investigation for trauma, with short scan times for intracranial hemorrhage, skull fractures, and stroke, and serves as a common initial examination (8–10).

The increased resolution allows for better visualization of the temporal skeleton, supporting ossicles, and small fissures that can be affected by trauma (11,12). Therefore, to achieve good spatial and contrast resolution with low noise, a high exposure factor (kV and mAs) is used. High kV and mAs values result in a higher radiation dose. The appropriate head CT scan is essential for a fast examination while providing maximum diagnostic information. On the other hand, in trauma cases, a faster CT scan protocol is required, which tends to produce more noise. Using iterative reconstruction, the kV and mAs values can be reduced, reducing the resulting radiation dose while maintaining evaluable image quality. Applying high percentages of Adaptive Statistical Iterative Reconstruction (IR) (70% and 100%) and very low tube currents (less than 50 mA) can reduce image spatial resolution, resulting in improved uniformity, noise, CNR, low contrast resolution, and the same spatial resolution as Filter Back Projection (FBP). (13).

Given the radiation hazards of CT scans, the purpose of this study was to determine the appropriate tube current value using iterative reconstruction in CT scans of head trauma cases by varying the mAs, finding the correct mAs value, and using IR. Referring to previous studies, using IR can reduce the dose by up to 50% without compromising image quality.

Methods

The research was conducted sequentially because it was a development of research results from one method to another, so it could not be done randomly. This study began by setting the mAs value, scanning with the head object, reconstructing the image with IR. The object used was an anthropomorphic phantom of the head. The research sample consisted of 3 variations of mA, namely 300 mA, 200 mA and 100 mA with kV 120 and time 7.1s on the anthropomorphic phantom of the head with trauma parameters. Measurements were carried out by conducting univariate tests for radiation dose and noise before and after iterative reconstruction was applied. The use of an anthropomorphic phantom of the head aims as a substitute for the patient's head to avoid the risk of CT Scan radiation doses given during the study. The type of research used was quantitative with a quasi-experimental design of the Pretest-Posttest with control design. This research design aims to obtain anatomical image information with the lowest mAs value or dose compared to the control group in the Head CT Scan examination. From each of these variations, an assessment is then carried out by noise through the standard deviation value of the resulting image.

Results and Discussion

The dose decreased along with the decrease in the mAs value given, this can be seen in table 1 obtained in the control group the mAs used was 300 with a radiation dose of 53.66 mGy, while in the treatment group the highest mAs used was 200 mAs with a dose of 25.8 mGy then the lowest mAs was 100 mAs with a dose of 12.9 mGy.

Table 1. Scanning parameters

Exposure Factor			Slice thickness (mm)	Standard Deviation	CTDI vol (mGy)
kV	mA	s			
120	300	7.1	1	4.4	53,66
120	200	7.1	1	4.5	25,8
120	100	7.1	1	5.8	12,9

In this study, there was a dose reduction in the treatment group with the lowest mAs compared to the control group which is a routine examination protocol. mAs affects the quantity of x-rays produced in proportion to the number of electrons moving from the cathode to the anode per unit time, mAs determines the number of photons (dose) in the patient during scanning because the dose is directly proportional to mAs (6), mA is the X-ray tube current, while s is the exposure time; both mathematically form mAs ($\text{mA} \times \text{s}$), which is traditionally used as a parameter to control the number of photons produced and therefore the noise and total dose in CT images. In general, increasing mAs reduces noise to a plateau within reasonable quality limits, with a direct impact on the cumulative X-ray dose entering the patient (14–16).

Furthermore, IR allows for radiation dose reductions of up to 40–60% without loss of pathology detection capability(17,18). Other studies have shown radiation dose reductions by 35–60% compared to the initial examination protocol (19).

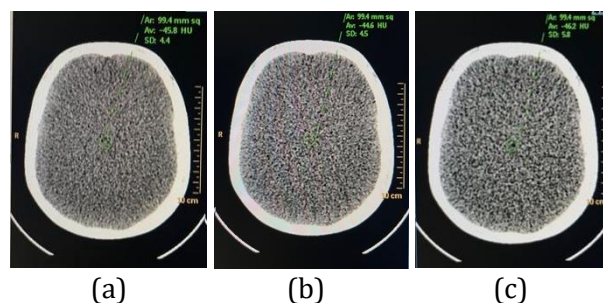


Figure 1 (a) Shows the results of a CT scan image with mA 300 (b) Shows the results of a CT scan image with mA 200 and (c) Shows the results of a CT scan image with mA 100

Figure 1 shows the differences in CT scan images from head trauma cases. Image noise is measured by the standard deviation (SD) in the region of interest (ROI). Lowering the mAs decreases the number of photons entering the detector, increasing photon fluctuations and increasing image noise. Many studies have shown an inverse relationship between the number of photons (related to mAs) and noise and cumulative dose; increasing mAs decreases noise but increases dose (20–22).

Iterative Reconstruction (IR) is an algorithm used for image processing after data acquisition. IR employs a hybrid iterative process of mathematical and statistical modeling to selectively identify and reduce noise in an image (23,24). IR repeatedly changes the Hounsfield pixel values of the image until a final value is found by using matrix algebra to convert each pixel's value (y) to a new estimated pixel value.

In this study, IR was used to reduce dose and improve image quality because the mAs value provided was lower than the routine protocol for CT scans of the head trauma. The type of IR used, Adaptive Statistical Iterative Reconstruction (ASIR), at 60%, is considered sufficient to reduce noise and improve image quality. Previous research has shown that using ASIR below 50% does not significantly improve image quality at very low doses (25). Other research has found that ASIR levels of 20-40% failed to show a significant difference in signal-to-ratio (SNR) improvement compared to FBP. Using ASIR of 60% or higher significantly improved image quality.

In this study, dose reduction occurred in the treatment group with the lowest mAs compared to the control group, which is the

routine protocol. mAs affects the quantity of x-rays produced, proportional to the number of electrons moving from the cathode to the anode per unit time. mAs determines the number of photons (dose) delivered to the patient during the scan, as the dose is directly proportional to mAs (6). mAs is the product of the tube current (mA) and time (s). Both affect noise and radiation dose, so mA and mAs are considered equal (22).

Even the lowest radiation dose always impacts biological systems in the body, both at the molecular and cellular levels. Based on the radiation dose, radiation effects are divided into stochastic and deterministic effects. Stochastic effects occur due to radiation exposure at a dose that causes cellular changes, while deterministic effects do not have a threshold dose that causes cell death. When radiation interacts with the body, the resulting biological effects depend on the amount of radiation energy absorbed and the type of radiation. Children with a cumulative dose of approximately 50 mGy are three times more likely to develop leukemia, while radiation doses of approximately 60 mGy increase the risk of developing brain cancer (26). Children under 17 years of age are at risk for a high cumulative dose in MSCT.

The ALARA (As Low As Reasonably Achievable) concept, which utilizes the lowest possible radiation dose to achieve optimal results, involves optimizing factors that influence radiation dose. Optimization refers to reducing the dose to the lowest possible level while maintaining the image quality required for diagnosis. In this study, researchers optimized the mAs value to achieve acceptable image results. The resulting radiation dose, based on the routine protocol, which is the factory setting, was 53.66 mGy, but measurements and calculations revealed a reduction to 12.6 mGy

Conclusion

There is a difference in the radiation dose produced in the CT Scan parameters of the head trauma control and treatment groups. In the control group with kV 120 and 300 mA produced a dose of 38.7 mGy, while the treatment group with 200 mA was 25.8 mGy and the lowest dose was 12.9 mGy at a variation of 100 mA. The radiograph results were reconstructed using iterative reconstruction with a standard deviation at 300 mA of 4.4, 200 mA 4.5 and 100 mA 5.8. Based on the results obtained, it shows that mA variations affect the noise uniformity value and the resulting radiation dose

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