



Optimization of Image Quality Parameters of Cranium Examination to Prevent Radiograph Repetition

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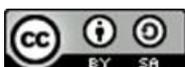
ABSTRACT

Cranium radiography technique is a technique of depicting the cranium using X-rays to obtain radiographs to help establish a diagnosis. In cranium examination, high sharpness and detail are required so that the information obtained on the radiograph is clearly visible. On the other hand, exposure factors, namely tube voltage, tube current, time, and the Focus Film Distance (FFD) factor as well as the width of the radiation field are very important so that the desired object is visualized correctly and well and to avoid repeat radiographs. The purpose of this study is to find a reference for optimizing the mAs exposure factor in Cranium Examination to prevent repeat radiographs. This research method is quantitative experiment. The research sample in the form of a cranium phantom was exposed three times with variations of mAs 16, 20, and 25 at a constant voltage of 60 kV to obtain optimal image results. Based on histogram analysis, mAs 16 produces a more even distribution of intensity values and more optimal contrast compared to mAs 20 and 25. Therefore, mAs 16 is the most efficient variation for AP projection cranium examination because it is able to produce good diagnostic image quality with a low radiation dose.

Keywords: *Cranium; Intensity; Contrast; mAs; Optimization*

INTRODUCTION

Radiography was the first medical imaging technology to utilize X-ray radiation. Radiographic images are useful for a variety of medical purposes, including the diagnosis of fractures, lung cancer, cardiovascular disorders, and



more. X-ray radiation is currently widely used, especially in healthcare, to confirm the diagnosis of a disease. (Akhadi, 2020)

X-rays are electromagnetic waves with very short wavelengths. The X-rays used in radiography range in wavelength from 0.1 m to 1.0 Å. X-rays are produced by a rapidly developing instrument called an X-ray machine. (Balingger, 2019).

One type of examination performed is a cranial examination. Cranial radiography is a technique for depicting the cranium using X-rays to obtain radiographs to help establish a diagnosis. Cranial examinations involve one or more projections. The projections used include the Anterior Posterior (AP), AP Axial (Towne Method), Posterior Anterior Axial (Haas Method), Posterior Anterior (PA), Posterior Anterior (Caldwell), Lateral, and Submentovertex (SMV) projections. (Sudarsih et al., 2019).

The cranium is located superior to the vertebral column. It consists of 22 separate bones divided into two distinct groups: 8 cranial bones and 14 facial bones. The skull is further divided into the calvaria and the base of the skull. The skull forms a protective covering for the brain. The facial bones provide structure, shape, and support for the face. They also form a protective covering for the upper end of the respiratory and digestive tracts. The cranial bones consist of the frontal, parietal, occipital, and temporal bones. The facial bones consist of the nasal bones, lacrimal bones, maxilla, mandible, and orbits. (Balingger, 2019).

In examining the skull, high levels of sharpness and detail are required so that the information obtained on the radiograph is clearly visible. (Mufida et al., 2020). Results rad A good iograph requires providing the appropriate exposure factor. The exposure factor is a factor that influences and determines the quality and quantity of X-ray radiation exposure required in making a radiograph. Providing an exposure factor that is too high can result in a black radiograph (dark) (Yudha et al., 2025). Meanwhile, an exposure factor that is too low will result in a white (bright) radiograph. If the voltage is increased, the photo density will be higher, the contrast will be lower, and the scattered light will increase. (Yudha et al., 2023). The tube current determines the number of electrons that pass through the target, producing X-rays with sufficient intensity and energy to penetrate specific organs. Meanwhile, the time determines the duration of the irradiation, thus determining the quantity of X-rays produced. (Dewilza & Yudha, 2023).

One of the exposure factors that affect the quality of a radiographic image is the tube current and time, which is the product of the electric current in the X-ray tube (mA) and the exposure time (s), abbreviated as mAs. The mAs value determines the total number of X-rays produced during a radiological examination, thus greatly influencing the level of darkness (density) of the radiographic image. produced (Carroll, 2019). The higher the mAs, the more X-ray photons are produced, resulting in a darker image and an increased radiation dose to the patient. Therefore, the mAs must be selected to achieve optimal image quality with the lowest possible radiation dose. (Amroji et al., 2019).

Considering the importance of image quality for establishing a diagnosis, in this study, researchers will conduct experiments related to optimizing image quality in cranium examination to prevent repeat radiograph. Repeat Radiograph or film repetition is the repetition of the creation of an image on a radiograph caused by several factors, namely patient movement, exposure factors, equipment (machine errors), and repetition due to artifacts.(Nansih, 2022)

METHODOLOGY

This research method is quantitative experiment. The research sample in the form of a cranium phantom was exposed three times with variations of mAs 16, 20, and 25 at a constant voltage of 60 kV to obtain the desired image results.optimal(Prayoga et al., 2022).The population in this study was all radiographic images of the cranium using a cranium phantom from the Radiology Laboratory of Baiturrahmah University, Padang. The sampling technique used in this study was total sampling, a sampling technique where the number of samples is equal to the population.(Sugiyono, 2019). All the data obtained were calculated for contrast using the imageJ application, then a comparison of the image results was carried out and conclusions were drawn regarding the optimal cranium examination image data.(Priyono et al., 2020).

RESULTS AND DISCUSSION

RESULTS

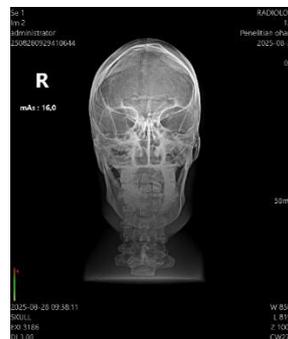


Figure 1. Radiograph with mAs 16

In the image with a mAs value of 16, the anatomical structure of the cranium appears most clearly and is balanced overall. The cortical and trabecular bone shadows can be distinguished well, especially in the area of the frontal sinus, orbit, nasal septum, and maxillary bone, which appear to have a clear contrast boundary. The base of the skull and the upper cervical vertebral column can also be identified in good detail without any shadows that are too dense. The image density appears ideal – neither too light nor too dark – so that anatomical structures can be clearly visualized without losing diagnostic information. Contrast between tissues appears balanced, resulting in good separation between bone and surrounding soft tissue.

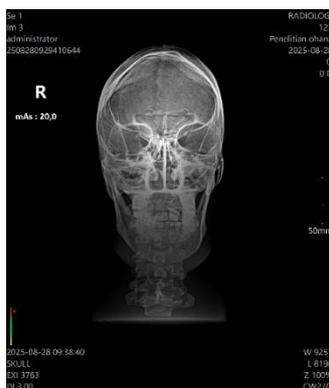


Figure 2. Radiograph with mAs 20

In the image with mAs 20 the anatomical structure of the Cranium still appears quite clear but begins to show an increase in density which causes some fine anatomical details to be slightly reduced in sharpness. The paranasal sinuses, orbital floor, and mandible are still recognizable, but some areas such as the nasal septum and the lateral wall of the maxillary sinus begin to appear darker due to the increased X-ray exposure. In general, the image contrast is slightly reduced - seen from the density difference which is not as clear as in mAs 16. Although noise is reduced due to the increased exposure, the image appears slightly "dense" so that it reduces the ability to assess fine structures within the bone. However, the results are still diagnostically good, only the anatomical contrast and brightness balance are not as optimal as in the image with mAs 16.

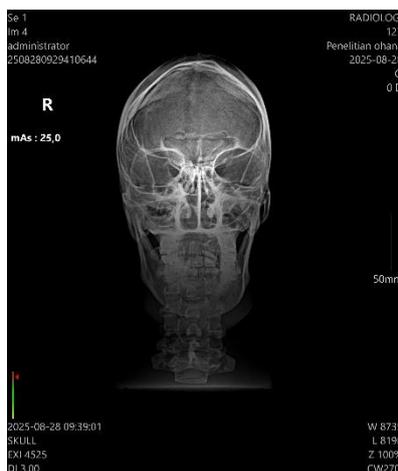


Figure 3. Radiograph with mAs 25

Images with mAs 25 show a significant increase in density, causing some anatomical structures to appear too dark and experience a decrease in detail. The midface and base of the cranium appear to be slightly overexposed, with the trabecular bone texture becoming less visible and the cortical area appearing

homogeneous. The maxillary sinus, orbit, and nasal septum are still recognizable, but the boundaries between these structures become less clear due to the decrease in contrast. Overexposure also makes it more difficult to distinguish between bone and soft tissue [15]. Although noise is barely visible, this is accompanied by a loss of fine detail that is diagnostically important. Overall, images with mAs 25 have poor image quality for detailed anatomical evaluation because increased exposure causes a decrease in contrast and loss of fine anatomical structures in the cranium.

DISCUSSION

The histogram in Image J can be used as information about the brightness and contrast levels of an image. (Labania et al., 2021). This can be determined by looking at the width of the histogram. If the histogram is too narrow, the image is either too bright (overexposed) or too dark (underexposed). (Yudha et al., 2025). Meanwhile, if the histogram width is even, it indicates that the image has good quality because the gray level is full and even at each pixel intensity value. Pixel intensity can be seen from the peak of the histogram. (Sagita Yudha M.Tr.Kes. et al., 2025).

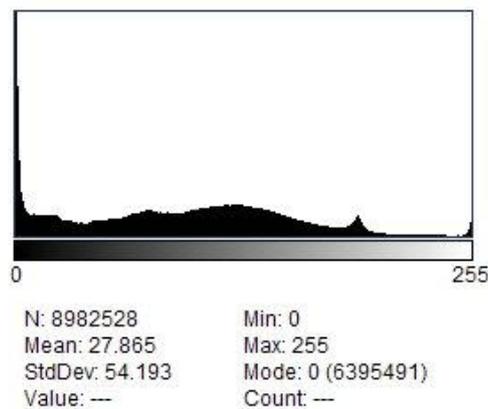


Figure 4. Histogram with mAs 16

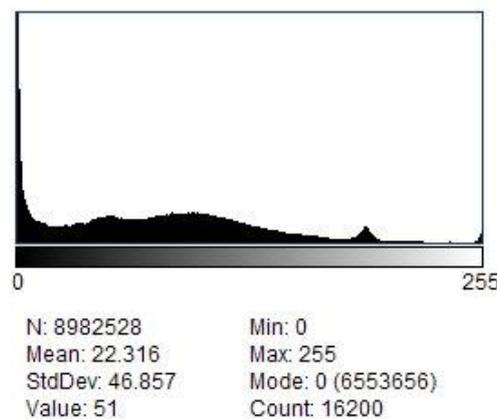


Figure 5 Histogram with mAs 20

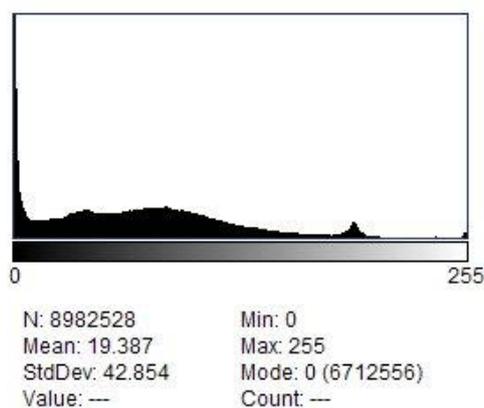


Figure 6 Histogram with mAs 25

The Y-axis on the histogram graph shows the image pixel values while the X-axis shows the image grayscale value. By looking at the grayscale of an image, its brightness or contrast can be determined. If the histogram is clustered at a high gray level (tending to approach a value of 255), then the image is too bright, whereas if the histogram is clustered at a low gray level (tending to approach 0), then the image can be said to be too dark. (Yudha et al., 2023) (Aulia, 2021).

In the mAs 16 histogram, there is a very high peak on the left side (intensity value 0) which indicates many dark areas such as background or air space, then followed by a sloping pixel distribution in the low to medium intensity area and there is a slight increase on the right side approaching the value 255 which indicates a very bright area, so that the image looks quite contrasty and still has good total variation. (Faradina Pratiwi et al., 2023).

At mAs 20, the histogram shape still shows a large peak at intensity 0, but the center is lower and narrower, indicating that the distribution of pixel values is concentrated in dark areas with few bright values, this indicates that the image is starting to darken and the contrast is decreasing compared to mAs 16. (Oktavia Puspita Sari., 2023).

While at mAs 25, the peak at 0 becomes the most dominant and the curve in the middle to right area is getting lower and narrower, indicating that most of the pixels are at dark intensity levels with few bright areas, meaning that this image is the darkest and has the lowest contrast among the three. Overall, the shape of the three histograms shows a shift in intensity distribution towards the left (darker) as the mAs increases, with a decrease in mean and standard deviation indicating a decrease in image brightness and contrast (Irsal & Winarno, 2020).

According to a good image, an image that shows a range of gray values or degrees of grayness is clear without any predominant gray values and a good image histogram distribution is an intensity value or color level that is close to 0-80 without any grayness value or predominant blackness value (Castilho et al., 2023).

Based on histogram analysis resulting from the three mAs variations used, the image with a value of 16 mAs provides the most optimal results because it displays the complete anatomical structure of the skull, firm bone boundaries, balanced contrast, and low noise. While the increase in mAs to 20 and 25 leads to an increase in image density which leads to a loss of fine detail and a decrease in anatomical contrast, thus decreasing the diagnostic quality (Takagi et al., 2019). Therefore, it can be concluded that the variation of mAs in the range results in relatively similar image quality, so the value of 16 mAs can be considered the most optimal variation because it is able to produce adequate diagnostic images with the lowest radiation dose. It can still be used as an alternative without significantly degrading the image quality.

CONCLUSION

Based on the results of histogram analysis, mAs 16 produces a more even distribution of intensity values and more optimal contrast compared to other variations, so that mAs 16 can be considered the most efficient value with good image quality and low radiation dose.

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