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Contrast To Noise Ratio Quality Against Current (mAs) And Voltage (kV) Variations

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Abstrak. Contrast to noise ratio (CNR) is a measure of contrast between tissue and background. CNR is able to visualize an object on a background that depends on the object and its contrast, if CNR is increased it will be easier to visualize using the background. This study was conducted to see the difference in variations in current strength and voltage of the X-ray tube on the contrast-to-noise ratio (CNR). Variations in Voltage (kV) and Current Strength (mAs) used are: 50 kV and 60 kV and 4 mAs, 6.4 mAs, 8 mAs, 10 mAs with variations in the thickness of the Thorax phantom, namely: 10 cm and 15 cm using the phantom as an object and an X-ray machine for imaging. The image results will be analyzed using ROI and will be processed in Microsoft Excel to produce a Contrast to noise ratio (CNR) value. The data processing carried out produced an optimal image at a variation of Voltage 60 kV with a Current Strength of 8 mAs and a thickness of 15 cm compared to other variations.

Keywords: Contrast to Noise Ratio, radiodiagnostics, voltage, current strength.

I. Introduction

Radiodiagnostics is a type of examination that uses ionizing radiation to display the inside of the human body to help diagnose which will be done by a radiologist. While radiotherapy is one of the techniques that uses radioactive to perform therapy. For examinations in the field of radiotherapy and radiodignostics are very helpful in examinations to diagnose diseases in patients.

X-rays are a type of electromagnetic wave with a short wavelength. The short wavelength makes x-rays have strong penetrating properties. In addition, x-rays also have the ability to ionize atoms and materials that they pass through. X-ray have a wavelength ranging from 0.01 nm to 10 nm. The frequency itself is in the range of 30 petaHz to 30 exaHz. Thus, x-ray have extraordinary energy, namely 120 eV to 120 KeV.

The process of taking pictures inside the human body using radiology equipment or the imaging process occurs when a high-frequency X-ray beam penetrates the patient's body and is received by the detector film. The file will display a body image in this era of digital development, images can be easily produced by Computed Radiography and Digital Radiography to help diagnose diseases suffered by patients.

The tube used is a vacuum tube containing two electrodes, namely the anode and cathode. The X-ray tube is connected to a filament transformer. This filament transformer will provide a supply that causes heating of the X-ray tube filament, so that electrons will free themselves from their atomic

bonds, resulting in free electrons and the formation of electron clouds. The anode and cathode are connected to a high voltage transformer (10-150) kV.

From this process, a high voltage is obtained which will be supplied to the X-ray tube electrode. Free electrons around the cathode will be drawn towards the anode, resulting in a loop (closed circuit) then there will be an electron current that is opposite to the electric current called the tube current. At the same time, the electrons drawn to the anode will hit the anode and be held. If the electron collision is right in the nucleus of the atom, it is called a Bremsstrahlung X-ray event and if it hits an electron in the K shell (*called K characteristic*).

This electron transfer will produce an electromagnetic wave with different wavelengths and energies. Electromagnetic waves with a wavelength of (0.1-1) Å are then called X-rays or Rontgen rays. Diagnostic radiology is a branch of radiology that utilizes ionizing rays to aid diagnosis in the form of documented images. The most common examination among radiology examinations, the Thorax examination, has a kV range of 50 kV to 85 kV and has a mAs range of 8 mAs to 12 mAs.

In this study, several variations of mAs and kV will be used to see the optimal image of each variation and the variations of mAs that will be used are: 4, 6.4, 8, 10 and variations in kV are: 50 and 60 with a thickness of 10 cm and 15 cm. Computed Radiography (CR) is obtaining image data by displaying image parameters manipulated by a computer to obtain optimal results. Digital Radiography (DR) in the X-ray imaging process has a digital sensor that is used to replace conventional photographic film with a computer system connected to a laser printer and does not use a cassette system or other image receptors.

To produce optimal images, mAs and kV play a very important role. In this study, several variations of mAs and kV will be used to produce optimal images. Based on this, the author gave this study the title for the final assignment, namely: "*Analysis of the effect of strong current (mAs) and voltage (kV) exposure factors on the Contrast to Noise Ratio value using Image-J software*". The purpose of this study is to determine the quality of the image produced by using *Contrast to Noise Ratio* (CNR) in varying the Current Strength, Voltage and Thickness of the phantom by analyzing based on the results of the ROI calculation obtained using image-J software.

II. Method

The research was conducted at Dr. Adjidarmo Rangkas Bitung Regional Hospital with a time span of February-June 2023. The research conducted was a quantitative method. This study used the Cat Fantom object issued by the University of Indonesia, namely the APELEM X-Ray Aircraft, Image Software which is a Java platform image software in this software, the contrast of the image

can be changed as well as the filters and pixels. This software was designed by Wayne Rasband and the National Institute of Health (NIM) team, Microsoft Excel and Fantom.

The procedure of this research is by arranging a cat phantom to represent the variation of Thorax thickness and exposing the phantom (on acrylic) using an X-ray machine with a specified variation of exposure factors. The use of a thickness of 10 and 15 cm because of the recapitulation data of Indonesian Anthropometry data which shows that the chest thickness of Indonesians aged 5-95 years is between 9-28 cm, the data analysis used is in the form of experimental X-rays.

This can happen because of the occurrence of X-ray experimental events, the heating of the filament that occurs in the X-ray tube will produce electrons that hit the anode will be more and more so that the photon energy will be greater. Variations in voltage values will affect the quality and quantity of X-rays. The higher the voltage value, the higher the X-ray photon energy and the shorter the wavelength produced, so that it will reduce the attenuation of the X-rays. This X-ray attenuation will affect the HU of the tissue and will reduce the noise value. Low noise values will produce good image quality. The data obtained is based on the ROI calculation value.

III. Result and Discussion

Table 1. Variations of mAs (4, 6,4, 8, 10), kV (50, 60) and phantom thickness (10 cm, 15cm)

Tegangan (kV)	Tebal Fantom (cm)	Kuat Arus (mAs)	CNR
50	10	4	4,105
		6,4	5,065
		8	5,489
		10	5,241
	15	4	2,232
		6,4	2,517
		8	2,968
		10	3,417
60	10	4	3,107
		6,4	3,754
		8	4,291
		10	4,345
	15	4	5,333
		6,4	6,161
		8	6,560
		10	6,463

The table above is the result of CNR with 3 repetitions using several variations of Voltage, Phantom Thickness, and Current Strength.

From the repetition above, it has produced CNR values from several variations with the level of accuracy found in the variation of 60 kV Voltage, 8 mAs Current Strength at a thickness of 15 cm.

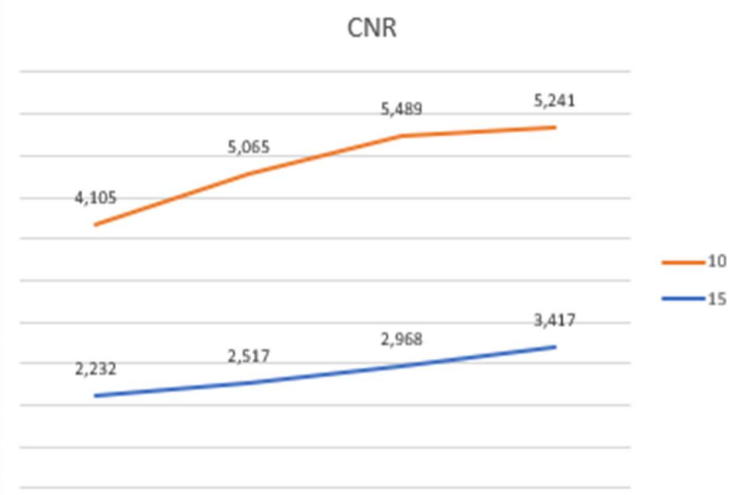

Figure 1. Comparison of CNR values with three repetitions at 50 kV with thicknesses of 10 cm and 15 cm.

Figure 1 shows the CNR results from several variations of current strength of 50 with a thickness of 10 cm and 15 cm and the highest CNR results in Figure 1 are found in the variation of 50 kV Voltage with a Current Strength of 8 mAs and a Thickness of 10 cm.

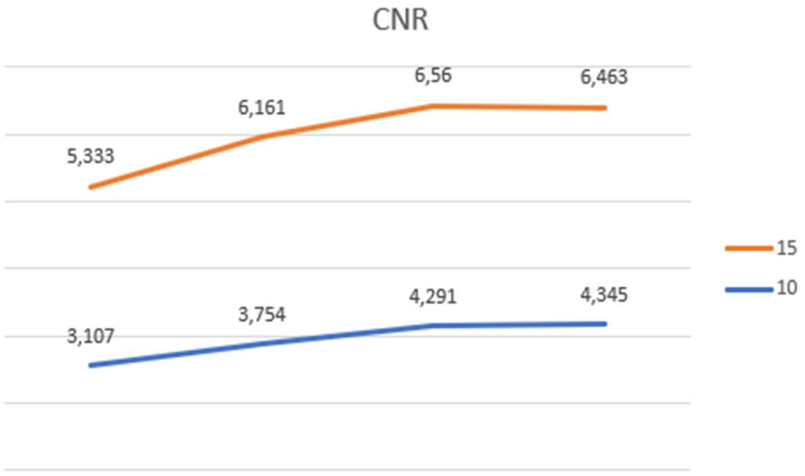

Figure 2. Comparison of CNR values with three repetitions at 60 kV with thicknesses of 10 cm and 15 cm.

Meanwhile, in Figure 2, the highest CNR value is found in the variation of 60 kV voltage with a current of 8 mAs and a thickness of 15 cm.

IV. Conclusion

The conclusions that can be drawn from this research are:

1. Variations in voltage and current greatly affect the quality of an image, where optimal image quality will help a more effective examination for the patient.

2. The relationship between CNR and Voltage and current strength is the determination of the right current and voltage strength will get the optimal CNR value. By repeating several variations to get the optimal value of CNR, namely in the variationVoltage 60 kV with current strength 8 mAs and thickness 15 cm.

References

[1] Retno Endah Savitr; Susilo; Sunarno; (2014) Optimal exposure factor in radio system optimization of exposure factor in digital radiography graphic system using CNR (Contrast to Noise Ratio) analysis.

[2] Rusyadi Luthfi. (2021). Noise analysis on Thorax Pulmonum radiography on the application of 10 kV rule exposure phantom modification.

[3] Surdiyah Asriningrum; Khaerul Ansory; Putra Tri Hasan. (2021). Exposure Factors on Radiographic Image Quality and Patient Dose Using Signal to Noise Ratio (SNR) Assessment Parameters in Posteroanterior Thorax Examination Using Computed Radiography.

[4] Sari Ayu. (2018). The Effect of Exposure Factors with Object Thickness on Thorax X-ray Examination on Radiographic Images.

[5] Luh Gede Puja Satwika, NN (2021). Effect of X-Ray Tube Voltage Variation on Signal to Noise Ratio (SNR) with Application of Anode Heel Effect using Stepwedge. Physics Bulletin.

[6] Lutfatul Fitriana; Hernastiti Sedya Utami (2021). Differences in image noise and dosage values using Automatic Exposure Control (AEC) in CT Scan examinations.

[7] Slamet Riyanto; Wahyu Setia Budi; Choirul Anom (2019). The effect of tube current on noise and image contrast on CT scanners.

[8] Louk, Andreas. (2014). Quality Measurement of Digital X-Ray Radiography Imaging System: Department of Physics, Gadjah Mada University.

[9] Good. (2023). X-rays: Discoverer, Definition, Process of Occurrence, and Benefits: Smart Formula.

[10] Indonesian Anthropometry. (2013). Indonesian Anthropometric Data Recap: Indonesian

Ergonomics Association.