

## **Slice Thickness Variation Analysis to Spatial Resolution of CT-Scan Device Image at the Radiology Installation of Bali Mandara Hospital**

**Aims:** Slice thickness variation analysis on spatial resolution on CT-scan images by determining CNR and SNR values, by making ROI on object and background images. ROI size of objects and backgrounds can be observed with several criteria based on the provisions of the ACR program, so that optimization of CT-Scan image quality can be achieved.

**Place and Duration of Study:** The Radiology Installation in Bali Mandara Hospital, between 23 March to 20 May 2022.

**Methodology:** Data collection begins with preparing the equipment used, namely CT-Scan, head holder, phantom, and computer. After that, the head holder is placed in the middle of the gantry and then the phantom is placed with the guidance of the laser beam (alignment system). Set the axial beam on the vertical line of section 1 and then set the coronal beam on the horizontal line of section 2. After that, setting the type of examination using the adult head protocol and setting the scan parameters to 80 kV, 100 mAs, and slice thicknesses 1, 2, 3, 4, 6, and 8 mm. After the preparation is done then the next exposure to the phantom. Then the research data in the form of phantom images will be seen as a whole to program on the computer monitor. Measurements were made 5 times for each slice thickness. Next is to analyze the CNR of digital phantom image data on a computer. So that it can be determined object ROI, background ROI, object mean, background mean, and standard deviation of the background.

**Results:** The results showed that the thicker the Slice Thickness, the higher the CNR and SNR values. The highest CNR value occurred in air medium (13.70) and the lowest occurred in Nylon (0.86). Likewise, the highest SNR value occurred in air medium (13.84) and the lowest in Nylon (0.99). The highest CNR and SNR values occurred in air medium and the lowest occurred in Nylon.

**Conclusion:** Slice Thickness variations affect the spatial resolution of CT-Scan images as indicated by the CNR and SNR values however, the CNR and SNR values are still above 1.0 for adult head examination and above 0.7 for children's head examination. So that the quality of CT-Scan images at Bali Mandara Hospital is still very good.

### **ABSTRACT**

*Keywords: CNR, image quality, spatial resolution, ROI, slice thickness, SNR*

#### **1. Introduction**

The Radiology Service Unit is a medical support installation using ionizing radiation sources to diagnose the presence of a disease in the patient's anatomy which is displayed in image form [1]. One of the applications of ionizing radiation is the use of a Computed Tomography (CT) Scan. CT-Scan is an X-ray imaging tool that is combined with a data processing computer so that it can produce cross-sectional images of the patient's body. CT-Scan has developed into a medical imaging method that is indispensable in radio diagnostic examinations. The direction of development of CT-Scan technology is currently more focused on increasing the speed of imaging with multi-slice detectors, increasing image resolution, and reducing the radiation dose received by patients

[2],[3]. The quality of CT-Scan images is influenced by several factors, namely spatial resolution, resolution contrast, noise, and artifacts. One of the important parameters in image quality is the selection of slice thickness so that the selection of the right slice thickness can establish a good diagnosis, therefore research on image quality is very important to do because good image quality can provide accurate information for the medical team so that medical action done right [4].

Slice thickness has a direct effect on the spatial resolution of the resulting image at the time of scanning. Spatial resolution is the ability to display object images with high contrast levels. The thicker the slices, the better the spatial resolution of the image. Another factor that affects image quality is

noise. High noise greatly affects spatial resolution, because high noise can reduce the spatial resolution of images [5].

The measurement of spatial resolution is related to Signal to Noise Ratio (SNR) and Contrast to Noise Ratio (CNR). Technically, the detector must be able to distinguish small differences in X-ray attenuation, so that it can be detected in soft tissue contrast. The factors that affect this spatial resolution are kV, mAs, radiation dose, pixel size, filter reconstruction, and slice thickness. Other factors such as extrinsic factors are related to image acquisition protocols which can be optimized in managing subject contrast in images [6],[7]. For clinical applications, it is necessary to optimize according to the purposes used, for this reason, it is necessary to research the analysis of slice thickness variations on the spatial resolution of CT-scan aircraft images. The images obtained were analyzed using the CNR and SNR parameters.

## 2. METHOD

### 2.1 Place and Duration of Study

The study was conducted from March to May 2022 at the Radiology Installation of Bali Mandara Hospital.

### 2.2 Research Tools

The tools used in this study were CT-Scan, Phantom, CR (Computer Radiography), and imaging plates.

### 2.3 Data Processing

2.3 Data collection in this study began with preparing the equipment used, namely CT-Scan, head holder, phantom, and computer. After that, the head holder is placed in the middle of the gantry and then the phantom is placed with the guidance of the laser beam (alignment system) [8]. Set the axial beam on the vertical line of section 1 and then set the coronal beam on the horizontal line of section 2. After that, setting the type of examination using the adult head protocol and set the scan parameters of 80 kV, 100 mAs, and slice thicknesses 1, 2, 3, 4, 6, and 8 mm. After the preparation is done then the next exposure to the phantom. Then the research data in the form of phantom images will be seen as a whole to program on the computer monitor. Measurements were made 5 times for each slice

thickness.

## 2.4 Data Analysis

The research data is quantitative data that is analyzed comparatively and statistically, namely by looking at and comparing the results of observations from the research conducted. The next step is to analyze the CNR and SNR of digital phantom image data on a computer. So that it can be determined object ROI, background ROI, object mean, background mean, and standard deviation of background. Then calculate the CNR value according to equation 2.1 as follows [6].

$$CNR = \frac{|\bar{x}_{ob} - \bar{x}_{bg}|}{\sigma} \quad (2.1)$$

Where:  $x_{ob}$  = mean ROI of the object,  $x_{bg}$  = mean ROI background and  $\sigma$  = standard deviation of the background ROI. The SNR value can be calculated by the following Equation 2.2,

$$SNR = \frac{\bar{x}_{ab}}{\sigma} \quad (2.2)$$

The CNR value must be greater than 1.0 for the adult head protocol, while for the protocol in children, it must be greater than 0.7 [9].

## 3. RESULTS AND DISCUSSION

The research results were obtained from phantom images by varying the slice thickness of the image quality and measuring the mean and standard deviation values of each ROI with 5 repetitions for each slice thickness. can be shown in Table 1.

Table 1 The mean value of each ROI on slice thicknesses of 1, 2, 3, 4, 6, and 8 mm.

Slice thickness (mm)	Mean ( $\bar{x}$ )					bg	Standard Deviation background
	Ob <sub>Air</sub>	ob <sub>Derim</sub>	ob <sub>Acrylic</sub>	ob <sub>Nylon</sub>	ob <sub>Polypropylene</sub>		
1	1015,72	341,52	110,82	72,54	140,32	9,7	73,40
2	1005,78	339,22	104,74	66,52	135,58	3,62	62,84
3	1014,96	343,84	111,14	69,54	140,64	6,98	50,56
4	1006,72	333,76	106,94	71,18	139,16	3,38	45,52
6	1004,66	336,82	105,68	70,82	140,28	2,20	40,28
8	999,86	328,94	103,58	69,80	137,46	0,90	28,92

Furthermore, the data that has been obtained is analyzed to determine the CNR and SNR values with Equations 2.1 and 2.2 as shown in Tables 2 and 3. following,

Table .2. CNR value for each object in the phantom.

Slice thickness (mm)	CNR				
	Air	Derlin	Acrilic	Nylon	Polypropilene
1	13,70	4,52	1,38	0,86	1,78
2	15,94	5,34	1,60	1,00	2,10
3	19,94	6,67	2,06	1,24	2,64
4	22,04	7,25	2,27	1,48	2,98
6	24,88	8,30	2,57	1,70	3,42
8	34,54	11,34	3,55	2,38	4,72

Table 3. SNR values for each object in the phantom.

Slice thickness (mm)	SNR				
	Air	Derlin	Acrilic	Nylon	Polypropilene
1	13,84	4,65	1,51	0,99	1,91
2	16,01	5,40	1,67	1,06	2,68
3	20,07	6,80	2,20	1,38	2,78
4	22,17	7,33	2,35	1,56	3,10
6	24,94	8,36	2,62	1,76	3,48
8	34,57	11,37	3,58	2,41	4,75

The results of the analysis of the CNR and SNR values in Tables 2 and 3 can be represented in a graph of the thickness variation of Slice thickness to the CNR and SNR values for each phantom motorcycle taxi as shown in Figures 1 and .2 below,

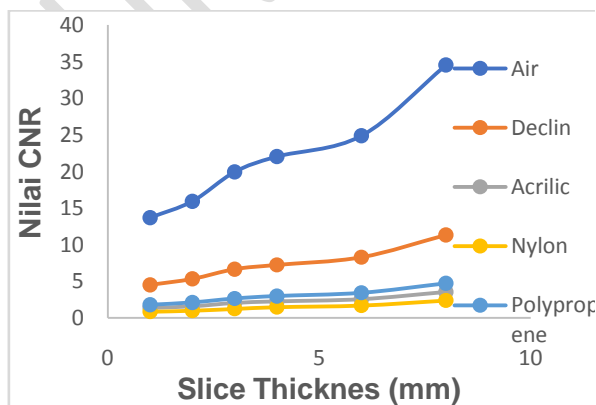


Figure 1 Graph of variation of slice thickness to CNR value.

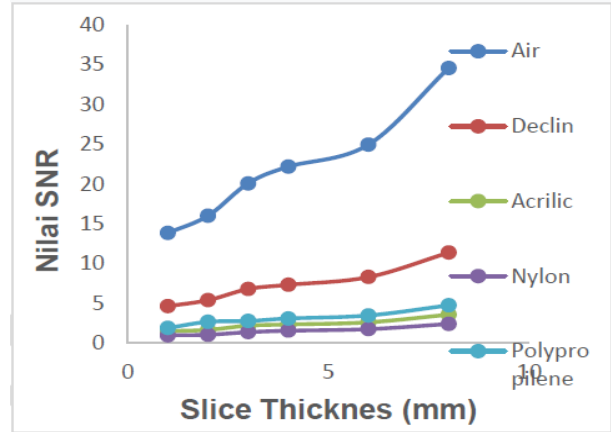


Figure 2 Graph of variation of slice thickness to SNR value.

Based on the research results it can be observed that slice thickness with CNR and SNR has a strong influence [10]. This is caused by the contrast ratio and signal-to-noise influenced by several factors, one of which is the slice thickness, and when using a thin slice thickness it produces minimum CNR and SNR values, this is caused by the amount of noise in the image which causes a decrease in the spatial resolution of the image [11]. On the other hand, the use of a thick slice thickness results in maximum CNR and SNR values, due to the minimal noise in the image which increases the spatial resolution image. The size of the slice thickness used depends on the diagnostic needs of the object being examined. After knowing that slice thickness is a very important factor in the use of CT-Scans, it is necessary to have quality control and quality accuracy for the evaluation of slice thickness on CT scans by BAPETEN Regulation Number 2 of 2018 concerning Conformity Tests for Diagnostic and Interventional Radiology X-Ray Devices [12].

#### 4. CONCLUSION

The results of this study can be concluded that the thicker the Slice Thickness, the CNR and SNR values increase. The highest CNR and SNR values occurred in Air medium and the lowest occurred in Nylon, however, all CNR values were still above 1.0 for adult head examination and above 0.7 for children's head examination. So that the quality of CT-Scan images at Bali Mandara General Hospital is still very good.

## REFERENCES

1. Nanholy, M.B. 2011. Geometry Correction Factors in Dosing Measurements on Phantoms Using CTDI in air and CTDI Methods on phantoms. *Thesis*. Depok: Faculty of Mathematics and Natural Sciences, University of Indonesia.
2. Kartawiguna, D. 2009. Multi Slice Computed Tomography (MSCT). Public Lecture Papers Semarang: Electrical Engineering Competency Improvement Training, IKATEMI Central Java and Basic CT Scan Training for Diploma III Radiodiagnostic Engineering and Radiotherapy Engineering Poltekkes Kemenkes Semarang. March 15, 2009 and July 24, 2010.
3. Morgan, C. L. 1983. *Basic Principles of Computed Tomography*. Baltimore: University Park Press.
4. Aprilyanti, D. D., Milvita, H. Prasetio, and Yuliati. 2013. The Effect of Phantom Diameter and Slice Thickness on CTDI Values in Examination Using a CT-Scan. *Journal of Physics*, Andalas University Padang. 2(2).
5. Choirul A, Makmur W.A., Wahyu S. 2013. Evaluation of Slice Thickness on a Single Slice CT Scan. *Department of Physics, Faculty of Science and Mathematics, Diponegoro University*, Central Java.
6. Bushberg, J.T., J. A. Seibert, E. M. Leidholdt dan J. M. Boone. 2012. *The Essential Physics of Medical Imaging*. Third Edition. Baltimore: Williams and Wilkins.
7. Bryan Tatone, 2014. Characterization of the effect of normal load on the discontinuity morphology in shear specimens using X-ray Micro-CT. *Department of Civil Engineering, University of Toronto*, Canada.
8. Seeram E, 2001. *Computed Tomography Physical Principles, Clinical Applications and Quality Control*, Second Edition, WB Saunders Company, Philadelphia.
9. College of Radiology (ACR). 2017. *American College of Radiology CT Accreditation Program Testing Instructions. Revisi 2017*. New York: American Institute of Physics.
10. Sprawls and Perry. 1995. Physical principles of Medical Imaging. *Department of Radiology*, Emory University, Atlanta.
11. Kofler, J. M., L. Yu., S. Leng., Y. Zhang., Z. Li., R. E. Carter, dan C. H. McCollough. 2016. *Assesment of Low Contrast Resolution Fir The ACR CT Accreditation Program*. HHS Public Acces Author Manuscript. 39(4): 619-623.
12. Sumarni and Terry Mart. 2000. Determination of the Effective Energy of Radiodiagnostic X-Rays. *Center for Research and Development of Radiation Safety and Nuclear Biomedicine*, Department of Physics, University of Indonesia.