

The Effect of Increment Reconstruction Variations in Ct-Scans of Head Trauma on the Contrast to Noise Ratio (CNR) in the Radiology Department of the Prof. Dr. M.A. Hanafiah General Hospital, SM Batusangkar

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Abstract

Computed Tomography (CT) is an essential imaging modality for evaluating head trauma due to its ability to provide detailed cross-sectional images. Image quality, particularly the Contrast to Noise Ratio (CNR), plays an important role in diagnostic accuracy. This study aimed to determine the effect of reconstruction increment variations on CNR values in head trauma CT examinations and to identify the increment that provides the most optimal image quality. This research was a quantitative experimental study conducted at the Radiology Unit of RSUD Prof. Dr. M.A. Hanafiah, SM Batusangkar, in February 2025. The population consisted of all patients who underwent CT brain examinations with clinical head trauma during the study period, totaling 12 patients, of whom five patients were selected as samples using purposive sampling. Secondary image data were reconstructed using two increment variations, 0.7 mm and 1 mm, with identical scanning parameters. CNR values were calculated using Radiant Viewer by measuring regions of interest (ROI), and the data were analyzed using the Shapiro–Wilk normality test followed by the Independent Samples T-Test. The results showed that the mean CNR value for the 0.7 mm increment was 304.52, which was higher than the 1 mm increment with a mean CNR of 288.51. However, statistical analysis demonstrated no significant difference between the two increment variations ($p = 0.155$; $p > 0.05$). In conclusion, both reconstruction increments produce comparable image quality in head trauma CT examinations. Nevertheless, the 0.7 mm increment provides higher CNR values and may be considered more optimal for improving image clarity

Keywords: CT-Scan, head trauma, reconstruction increment, image quality, CNR

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1. Introduction

Computed TomographyCT (Computed Tomography) is a radiology modality that can establish a diagnosis. A CT scan is a diagnostic support method that utilizes x-rays and a computer to create cross-sectional images of the human body. The resulting CT scan images are then image reformatted. Image reformatted is a data processing technique that takes a computer-generated 3D image of the patient and displays it in 2D on a monitor to obtain a volumetric image (Theresiani Dae et al., 2023). CT scans, as a tool to support diagnosis, are expected to provide informative images, especially the desired anatomical information (Rachmani et al., 2018).

One form of CT scan is a head CT scan. A head CT scan is a specialized examination of the head that uses tomography techniques with X-ray beams penetrating the patient's head from various directions using a computer system to produce anatomical images in axial, sagittal, and coronal planes (Liliosa Miu et al., 2023). A head CT scan is the gold standard diagnostic method for head injury cases, considering that this procedure is not only non-invasive (and therefore safe), but also has high reliability (Manarisip et al., 2014).

Trauma is emotional and psychological distress, generally caused by an unpleasant event or experience related to violence. The word trauma can also be used to refer to an event that causes excessive stress. An event is considered traumatic if it causes extreme stress and exceeds the individual's ability to cope (Giller, 1999).

Image quality is a measure of the effectiveness of a diagnostic procedure. Generally, parameters that indicate CT scan image quality include spatial resolution, contrast resolution, noise, and artifacts. Image processing in CT scans aims to achieve better image quality, including reduced noise, higher spatial resolution, and increased contrast resolution (Azhara et al., 2023).

Image quality is assessed objectively, one of which is by using the Contrast to Noise Ratio (CNR). CNR is a measure of how well a signal can be distinguished from the background. The higher the contrast value, the easier it is to distinguish the signal from the background (Ningtias et al., 2022). CNR is defined as the difference between the mean ROI (Region of Interest) of the object and the mean ROI of the background, divided by the standard deviation of the background (Ningtias et al., 2022).

Some CT scan parameters include slice thickness, range, Kv, mAs, field of view, reconstruction algorithm, window width and window level, and increment reconstruction. One way to achieve good image quality is to perform increment reconstruction. Increment reconstruction is the distance between reconstructed images in the volume data. Three types of increment reconstruction are as follows: overlapping increment, which is set smaller than the slice thickness, contiguous increment, which is set equal to the slice thickness, and gap increment, which is set larger than the slice thickness (Theresiani Dae et al., 2023).

Previous research conducted by Jesus et al., (2023) in the journal "Comparison of Head CT-Scan Image Quality in Trauma Cases with Increment Variations" has research results that the increment reconstruction variation value of 0.7 mm has the highest CNR value, namely a mean of 38.56 in the GM-ventricular area, in the GM-WM area of 15.13. While the increment variation value of 0.9 mm produces 19.88 in the GM-ventricular area, in the GM-WM area of 7.1. So it can be concluded that the 0.7mm increment variation is the most optimal increment variation in showing the image quality of Head CT-Scan examinations in Trauma Cases.

Head CT-Scan examination has an increment value in the range of 0.1-10 mm. Meanwhile, according to Jesus et al., (2023) recommends increment reconstruction using 0.7 mm to show optimal image quality while at RSUD. Prof. Dr. MA Hanafiah, SM Batusangkar uses a 1 mm increment variation for Head CT-Scan examination. Researchers are interested in conducting a study with increment reconstruction variations of 0.7 mm and 1 mm on head trauma CT-Scan. This study aims to determine the optimal image quality (CNR) by using increment reconstruction variations on head CT Scan examinations with trauma cases.

2. Method

The type of research conducted in writing this scientific paper is quantitative research with experimental studies.. The location of this research was conducted at the Radiology Unit of RSUD. Prof. Dr. MA Hanafiah, SM Batusangkar and was conducted in February 2025. The population in this study was all CT Scan Brain examinations with clinical trauma during the last month, namely in February 2025, the number of patients was 12 people. In this study, researchers used 5 patients as samples. Sample processing using ROI on radiant viewer is then processed with SPSS with Univariate and Bivariate analysis, then the data is presented in table form. After that, conclusions and suggestions are drawn

3. Results and Discussion

Result

A. Sample Characteristics

Table 1 Sample Characteristics

Sample	Age	Type Sex	Clinical
Sample 1	74 Years	Woman	Bleeding in the right temporal lobe
Sample 2	53 Years	Man	Bleeding in the left frontal lobe
Sample 3	17 years	Woman	Bleeding in the left temporal lobe
Sample 4	32 Years	Woman	Bleeding in the left frontal lobe
Sample 5	15 years	Man	Bleeding in the right frontal lobe

B. Image Results

Sample 1

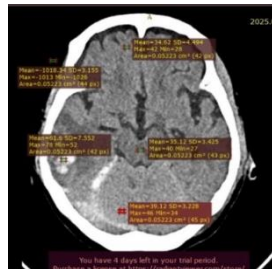


Figure 1 Increment 0.7 mm cut to 152

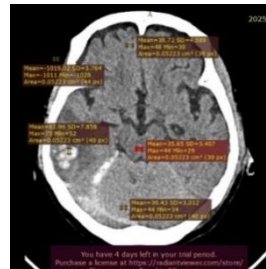


Figure 2 Increment 1 mm cut to 152

Sample 2

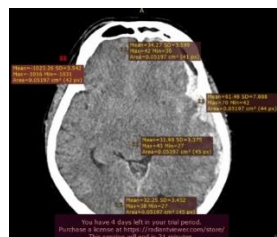


Figure 3 Increment 0.7 mm cut to 13

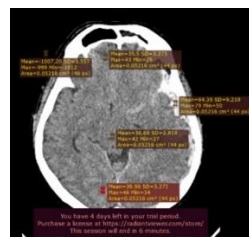


Figure 4 1 mm increment of the 137th cut

Sample 3

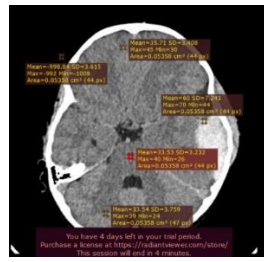


Figure 5 Increment 0.7 mm cut to 126



Figure 6 1 mm increment of the 126th cut

Sample 4

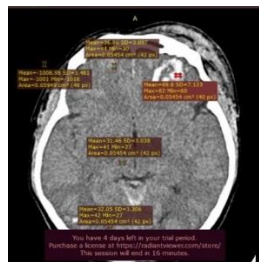


Figure 7 Increment 0.7 mm cut to 80

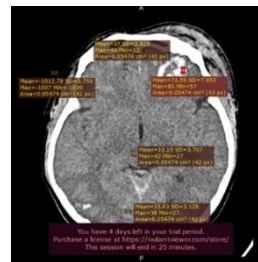


Figure 8 Increment 1 mm cut to 80

Sample 5

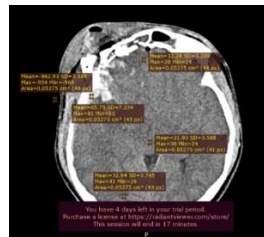


Figure 9 Increment 0.7 mm cut to 133

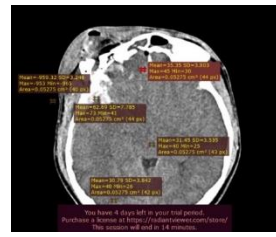


Figure 10 Increment 1 mm cut to 133

Table 2 Mean ROI values for variations of 0.7 mm increment and 1 mm increment for each sample

No	Increment	Image	Mean				
			Bleeding	Lobes Frontal	Occipital Lobe	Punch Background	
1	0.7 mm	1	61.6	34.62	39.12	35.12	-1018.34
2		2	61.48	34.27	32.25	31.98	-1023.26
3		3	60	35.71	33.54	33.53	-998.84
4		4	69.8	36.86	32.05	31.46	-1008.98
5		5	65.75	32.28	32.94	31.93	-962.93
1	1 mm	1	61.69	38.72	39.43	35.65	-1019.02
2		2	64.39	35.5	39.96	36.69	-1007.20
3		3	57.16	38.14	35.64	32.44	-998.87
4		4	73.59	37	33.03	33.15	-1012.79
5		5	62.69	35.35	30.79	31.45	-959.32

Table 3 Mean ROI values for variations of 0.7 mm increment and 1 mm increment for each sample

No	Increment	Image	Standard Deviation				
			Bleeding	Lobes Frontal	Occipital Lobe	Punch	Background
1	0.7 mm	1	7,552	4.4494	3,228	3,425	3.155
2		2	7,888	3,599	3,452	3,375	3,542
3		3	7,241	3,408	3,759	3,232	3,615
4		4	7,123	3,057	3,306	3,038	3,481
5		5	7,274	3,209	3,745	3,588	3,385
1	1 mm	1	7,858	4,589	3,012	3,407	3,764
2		2	9,219	3,275	3,271	2,819	3,557
3		3	8,094	3,537	3,303	3,413	3,781
4		4	7,953	2,829	3,128	3,707	3,759
5		5	7,785	3,803	3,842	3,535	3,246

Table 4 Average results of the mean of 3 objects

Increment	Image	Bleeding	Frontal Lobe	Occipital Lobe	Punch	Mean Average of Objects	Standard Deviation
0.7 mm	1	61.60	34.62	39.12	35.12	42.62	3.155
	2	61.48	34.27	32.25	31.98	40.00	3,542
	3	60.00	35.71	33.54	33.53	40.70	3,615
	4	69.80	36.86	32.05	31.46	42.54	3,481
	5	65.75	32.28	32.94	31.93	40.73	3,385
1 mm	1	61.69	38.72	39.43	35.65	43.87	3,764
	2	64.39	35.50	39.96	36.69	44.13	3,557
	3	57.16	38.14	35.64	32.44	40.85	3,781
	4	73.59	37.00	33.03	33.15	46.19	3,759
	5	62.69	35.35	30.79	31.45	40.07	3,246

C. Analysis of the Influence of Increment on CNR

Table 5 CNR values in ROI comparison

Increment	Image	Mean Average of Objects	Mean Background	Background Standard Deviation	CNR
0.7 mm	1	42.62	-1018.34	3.155	336.28
	2	40.00	-1023.26	3,542	300.19
	3	40.70	-998.84	3,615	287.56
	4	42.54	-1008.98	3,481	302.07
	5	40.73	-962.93	3,385	296.50
1 mm	1	43.87	-1019.02	3,764	282.38
	2	44.13	-1007.20	3,557	295.57
	3	40.85	-998.87	3,781	274.99
	4	46.19	-1012.79	3,759	281.72
	5	40.07	-959.32	3,246	307.88

D. Bivariate Analysis

Table 6 Normality Test

Test of Normality					
Dependent Variable	Independent Variable	Shapiro-Wilk			
		Statistics	df	Sig.	
CNR	0.7	,821	5	,119	
	1	,919	5	,521	

Table 7 Results of Independent T Test

Dependent Variable	Levene's Test for Equality of Variances		Sig. (2-tailed)
	F	Sig.	
CNR Equal variances assumed	,128	,730	,155

Table 8 Results of the Independent T-Test Mean

Statistics Group		
Independent Variable	Dependent Variable	Mean
CNR	0.7	304.5200
	1	288.5080

Discussion

1). The Effect of Increment Variation on CNR Image Quality

Based on statistical calculations, an Independent Samples TTest test was performed on the variation of increments on CNR. The results of the analysis showed a Sig. (2-tailed) value of 0.155 ($p > 0.05$). This means that there is no significant difference between a 0.7 mm increment and a 1 mm increment on the quality of the CNR image. Thus, H_0 is accepted and H_a is rejected. Although a 0.7 mm increment produces a higher CNR value, the difference is not statistically significant. This is likely due to the relatively small increment difference (0.3 mm) so it does not significantly affect the CNR value. The results of this study differ from the study of Jesus et al. (2023) that a 0.7 mm increment has an effect on increasing CNR on head trauma CT scans. However, this study is in line with the opinion of Brink et al. (1994) stated that using smaller increments can indeed improve anatomical detail, but does not always make a significant difference to the CNR value. Thus, it can be concluded that both 0.7 mm and 1 mm increments are capable of producing relatively equivalent image quality.

2). Increment Reconstruction Value to Produce Optimal CNR Image Quality

CNR is a measure of how well a signal can be distinguished from the background. The greater the contrast value, the more easily the signal is distinguished from the background (Ningtias et al., 2022). Smaller reconstruction increments or intervals result in overlapping slices. This condition increases the number of slices passing through small structures, making anatomical details more visible. Thus, contrast differences between tissues are more easily distinguished, thus increasing the CNR value. Research by Searle, B., & Starkey, D. (2020) shows that using a smaller reconstruction interval can improve spatial accuracy and anatomical visualization in three-dimensional models, compared to a larger interval. The same principle applies, with a 0.7 mm increment being more optimal than a 1 mm increment because it provides denser slices and better anatomical detail.

Based on the results of the Independent T-Test, an increment of 0.7 mm significantly provides more optimal results for the CNR value with a mean rank of 304.5200. This value is higher than the 1 mm increment which only produces a mean of 288.5080. The high contrast to noise ratio (CNR) value indicates optimal image quality, so it can be concluded that an increment of 0.7 mm is able to produce a more optimal CNR in CT-Scan examinations of head trauma cases with the highest CNR value of 304.5200.

4. Conclusions and Suggestions

Based on the results of the Independent T-Test statistical test, it shows that the increment variation on CNR does not have a significant effect with a significance level of 0.155 ($p > 0.05$). Thus, H_0 is accepted and H_a is rejected. Based on this research, the increment variation that is able to produce a more optimal CNR value in CT-Scan of head trauma cases is an increment of 0.7 mm with a CNR value of 304.5200.

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