Archipel: Journal of Indonesian Interdisciplinary Studies
E-ISSN : 3124-6621
F-Vol.1 No. 10 May 2026
https://ojsap.com/index.php/archipel/index
DOI : https://doi.org/10.65739/archipel.v1i10.65

Analysis of the Effect of Varying Slice Thickness on Image Quality in CT Scans of the Brain With Clinical Infarction at Siti Rahmah Islamic Hospital in Padang

Wahdini Hanifah[1], Nerifa Dewilza[2], Sagita Yudha[3], Livia Ade Nansih[4], Santa Mareta[5], Rina Astuti[6]
[1,2,3,4,5,6]DIII Radiology Study Program, Vocational Faculty, Baiturrahmah University, Padang, Indonesia

Email*: wahdinihanifah@fv.unbrah.ac.id

Submit : May 09, 2026
Revised : 31 May 2026,
Accepted: June 18, 2026
Published : June 29, 2026

ABSTRACT

An Analysis Of The Effect Of Slice Thickness Variation On Image Quality In Ct-Scan Examination Of The Brain With Clinical Infarction At Siti Rahmah Islamic Hospital In Padang. Infarction stroke occurs when blood flow in the brain is disrupted, causing damage to brain tissue. The appropriate slice thickness increases picture quality and allows for more accurate detection of infarction stroke, reducing the possibility of error. The purpose of this study is to investigate the influence of slice thickness variation on image quality in a brain CT-scan examination with clinical infarction performed at RSI Siti Rahmah Padang. This study was carried out at the RSI Siti Rahmah Padang radiology installation in May-June 2024 utilizing an experimental quantitative research design and a purposive sample technique. Five CT-Scan infarction pictures were taken with a slice thickness of 5 mm and reconstructed to 2 mm and 3 mm. The reconstruction result is then in the ROI on the radiant dicom, then the CNR and SNR calculations are carried out and analysed using SPSS with the Manova test. The result of the slice thickness variation value towards CNR and SNR that has been processed using the Manova test obtained R square CNR 0.839 and SNR 0.797 with a significance level of p of 0.000<0.05, then it was concluded that the slice thickness variation had an effect on the CNR and SNR values. The highest mean value that is optimally meaningful is obtained at a slice thickness of 5 mm, so it can be concluded that the size of the slice thickness is directly proportional to the increase in CNR and SNR values.

Keywords: *CT-Scan, Slice Thickness, Image Quality, Cerebral Infarction, CNR, SNR*

INTRODUCTION

Cerebral infarction, commonly referred to as ischemic stroke, is a critical neurological emergency characterized by the sudden interruption of blood supply to brain tissue, resulting in irreversible neuronal death if not promptly addressed. According to the World Health Organization (WHO), stroke is the second leading cause of death globally and represents a major cause of long-term disability, imposing substantial socioeconomic burdens on healthcare systems and families. In Indonesia, stroke constitutes a serious public health concern with consistently high morbidity and mortality rates across hospitals, including secondary and tertiary care facilities.

Computed Tomography Scan (CT-Scan) has become the cornerstone of initial neurological imaging, particularly in emergency settings, owing to its widespread availability, rapid acquisition time, and cost-effectiveness compared to Magnetic Resonance Imaging (MRI). CT-Scan employs X-ray beams and computer-processed algorithms to generate cross-sectional images of internal organs, enabling clinicians to identify pathological changes such as hypodense areas indicative of cerebral infarction, hemorrhagic transformation, or mass effects. In the clinical context of stroke, early and accurate detection on CT images is directly linked to timely therapeutic decisions, including thrombolytic therapy eligibility and surgical intervention, which are critically time-dependent.

Among the various technical parameters that determine the quality and diagnostic utility of CT images, slice thickness is one of the most fundamental and impactful. Slice thickness refers to the width of the tissue volume sampled in each cross-sectional image, typically measured in millimeters. In brain CT protocols, the range of slice thickness commonly used spans from 2 mm to 10 mm (Seeram, 2016). Thinner slices offer enhanced spatial resolution and better detection of small lesions by reducing partial volume averaging effects, wherein signal from multiple tissue types within a single voxel is blended. Conversely, thicker slices reduce image noise, improve Signal-to-Noise Ratio (SNR), and increase Contrast-to-Noise Ratio (CNR), which are essential parameters for differentiating between infarction tissue and surrounding normal brain parenchyma.

Signal-to-Noise Ratio (SNR) is a quantitative measure that reflects the strength of the diagnostic signal relative to background noise. A higher SNR indicates a cleaner image with less interference, enabling radiologists to detect subtle density differences between normal and infarcted tissue. Contrast-to-Noise Ratio (CNR), on the other hand, measures the differential signal intensity between target tissue (e.g., infarction) and adjacent background tissue, normalized by image noise. Together, SNR and CNR serve as the primary objective metrics for evaluating CT image quality in clinical and research settings.

Current practice and evidence-based recommendations for slice thickness in brain CT vary. Baert (2018) recommends a slice thickness of 3 mm for optimal visualization of cerebral infarction, while Hutami et al. (2021) advocate for 2 mm to maximize spatial resolution and infarction delineation. In contrast, Siti Rahmah Islamic Hospital in Padang routinely employs a 5 mm slice thickness protocol for standard brain CT examinations, which is consistent with widespread practices at many Indonesian hospitals. This discrepancy between recommended thicknesses (2–3 mm) and clinical practice (5 mm) raises important questions about the trade-off between spatial resolution and image noise in the diagnosis of cerebral infarction.

Recent studies have increasingly explored the relationships between CT acquisition parameters and image quality metrics. Abdulkareem et al. (2023) demonstrated that slice thickness significantly influences both noise levels and diagnostic content in multi-slice CT, with thicker slices reducing noise but potentially sacrificing small lesion detectability. Anggarani et al. (2023) found that slice thickness variation substantially impacts spatial resolution and CNR in CT phantom studies at Bali Mandara Hospital. Solong et al. (2023) confirmed the effect of slice thickness variation on image quality in brain CT for hemorrhagic stroke at Pelamonia Hospital, Makassar, finding that 5 mm slice thickness produced superior CNR and SNR values for stroke cases. These studies collectively underscore the clinical relevance of optimizing slice thickness based on the specific diagnostic target.

Emerging reconstruction technologies such as iterative reconstruction (IR) and deep learning image reconstruction (DLIR) have been shown to mitigate noise penalties associated with thin-slice acquisitions, enabling the diagnostic benefits of reduced slice thickness without proportional image quality degradation. Sun et al. (2025) demonstrated that thin-slice (1 mm) brain CT with deep learning-based reconstruction achieved significantly improved CNR and SNR compared to conventional filtered back projection (FBP), even outperforming standard 5 mm FBP protocols. Similarly, Inoue et al. (2024) reported that hybrid iterative reconstruction and deep learning methods effectively reduced noise in brain CT across multiple parameters, supporting thinner slice use in clinical practice.

Despite the growing body of literature on slice thickness and CT image quality, there remains a notable gap in studies specifically examining the effect of slice thickness variation on CNR and SNR in brain CT examinations for clinical cerebral infarction in the Indonesian clinical context. Most existing studies have focused on phantom-based assessments, hemorrhagic stroke cases, or used advanced reconstruction algorithms not universally available in regional hospitals. Furthermore, the specific comparison of 2 mm, 3 mm, and 5 mm slice thicknesses—encompassing the recommended research thicknesses and the actual clinical protocol used at Siti Rahmah Islamic Hospital—has not been rigorously evaluated in a patient-based infarction cohort from this setting.

The novelty of this study lies in its direct, patient-based quantitative evaluation of three clinically relevant slice thicknesses (2 mm, 3 mm, and 5 mm) in brain CT examinations specifically for cerebral infarction cases at a single Indonesian Islamic hospital. Unlike previous studies employing phantom models or focusing on different pathologies, this research uses actual patient DICOM data reconstructed from 5 mm acquisitions and evaluates CNR and SNR across anatomically consistent Regions of Interest (ROI) in the frontal lobe, pons, and infarcted tissue. By bridging the gap between theoretical recommendations and regional clinical practice, this study provides hospital-specific evidence to guide protocol optimization for cerebral infarction CT imaging in Indonesian healthcare settings.

Additionally, the multivariate statistical approach (MANOVA) applied in this study allows simultaneous analysis of both CNR and SNR as dependent variables, providing a more comprehensive and statistically robust assessment of slice thickness effects than univariate methods. The findings are expected to contribute directly to evidence-based refinement of brain CT protocols at Siti Rahmah Islamic Hospital and similar facilities across the region, ultimately improving diagnostic accuracy, patient outcomes, and institutional imaging efficiency.

METHODS

This study employed a quantitative quasi-experimental design by conducting a direct analysis of reconstructed CT image data obtained from patients diagnosed with cerebral infarction. The research was conducted at the Radiology Installation of Siti Rahmah Islamic Hospital (Rumah Sakit Islam Siti Rahmah/RSI Siti Rahmah), Padang, West Sumatra, Indonesia, between May and June 2024. The study population consisted of all patients who underwent brain CT examinations with a clinical diagnosis of cerebral infarction during the study period. Purposive sampling was used to select eligible cases based on predefined inclusion and exclusion criteria. Patients were included if they had a clinical diagnosis of cerebral infarction confirmed by a neurologist, complete DICOM image datasets, and CT scans acquired using the standard 5 mm slice thickness protocol. Cases were excluded if image quality was affected by motion artifacts, the imaging dataset was incomplete, or concomitant intracranial hemorrhage was present. After the selection process, a total of five patient CT datasets met all eligibility criteria and were included in the final analysis.

All CT examinations were performed using the 16-slice CT scanner available at the Radiology Installation of RSI Siti Rahmah Padang. Image acquisition followed the hospital's standard brain CT protocol with a tube voltage of 120 kVp, automatic tube current modulation, a standard head reconstruction kernel, a field of view (FOV) of 25 cm, and a 512 × 512 image matrix. The original images were acquired at a slice thickness of 5 mm and subsequently reconstructed into 2 mm and 3 mm slice thicknesses using

Radiant DICOM Viewer software. Consequently, three reconstructed image datasets (2 mm, 3 mm, and 5 mm) were generated for each patient, enabling direct comparison of image quality across different slice thicknesses while maintaining identical acquisition parameters. The research flowchart below summarizes the systematic steps followed in this study:

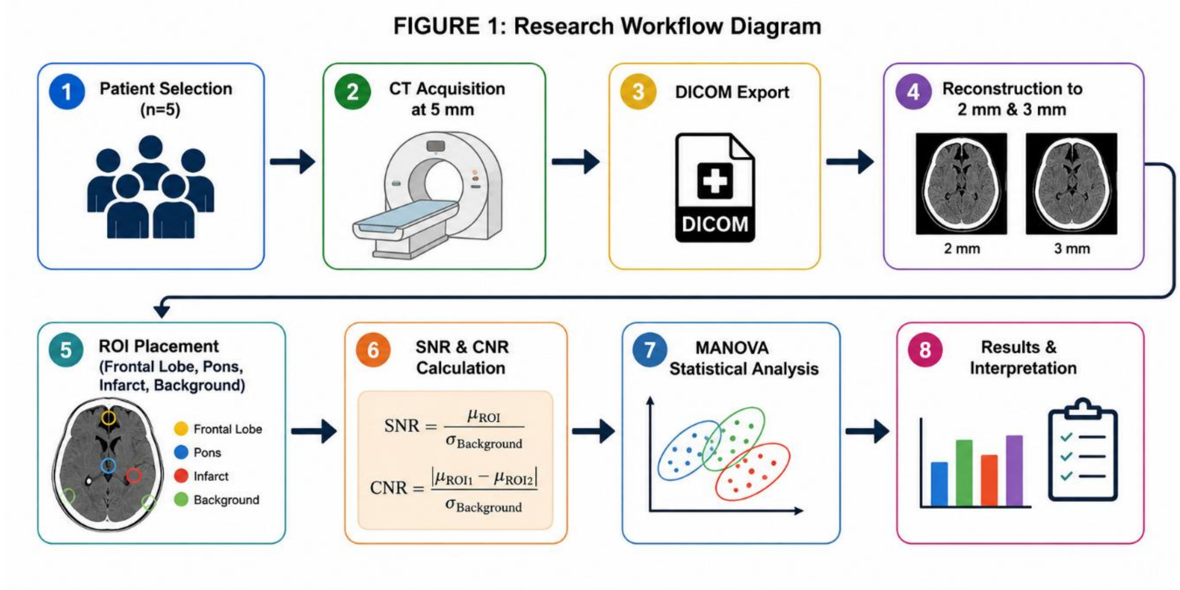
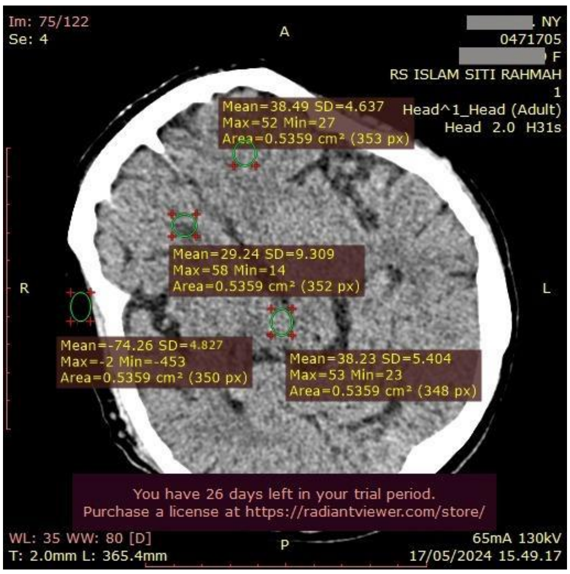


Figure 1. Research Workflow: Steps for CT slice thickness analysis in cerebral infarction patients

RESULTS AND DISCUSSION

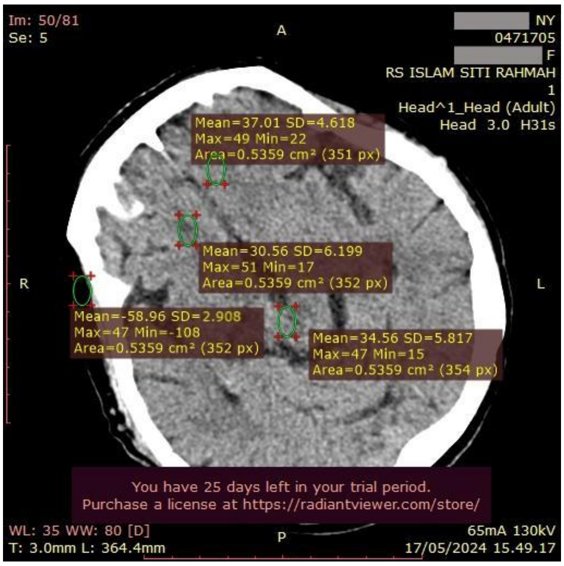
Result

Setelah dilakukan penelitian hasil citra anatomi terhadap 5 orang pasien maka dengan variasi *slice thickness* 2 mm, 3 mm, dan 5 mm pada pemeriksaan *CT-Scan brain* dengan klinis infark, untuk analisa kualitas citra CNR dan SNR dilakukan *Region of interest* (ROI) dengan ukuran 0,5359 cm^2 pada *anatomi Lobus frontal, Pons,* Infark dan *background.* Nilai rata-rata *mean* tertinggi terdapat pada *slice thickness* 3 sampel 5 yaitu 44,39 dan terendah terdapat pada *slice thickness* 5 sampel 1 yaitu 34,41.

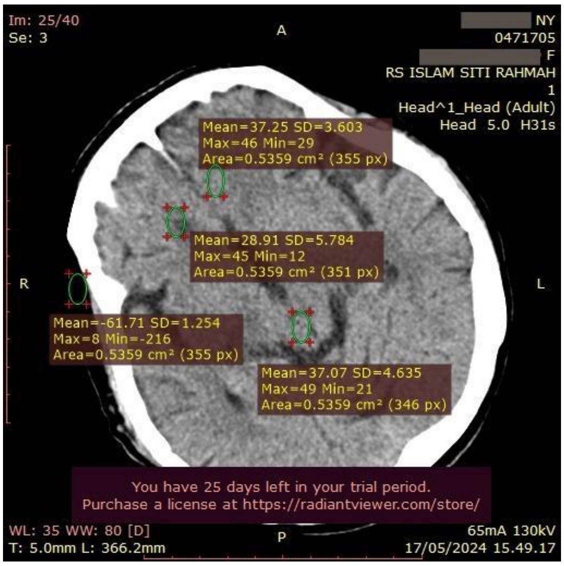


Gambar 1. 1 *Slice Thickness* 2 mm potongan ke 75

Sumber: Radiant DICOM *Viewer*



Gambar 1. 2 *Slice Thickness* 3 mm potongan ke 50
Sumber: Radiant DICOM *Viewer*



Gambar 1. 3 *Slice Thickness* 5 mm potongan ke 35
Sumber: Radiant DICOM *Viewer*

1. Analisis Pengaruh *Slice Thickness* Terhadap CNR

Tabel 1. Mean dan Standart Deviasi

Slice Thickness	Citra	Infark	Lobus Frontal	Pons	Rata-Rata Mean Objek	Standart Deviasi (SD)
	1	29,24	38,49	38,23	35,32	4,827
	2	30	38,25	38,36	35,536	4,827
2	3	29,1	38,09	38,57	35,253	4,68
	4	29,87	38,6	38,18	35,55	4,86
	5	32,89	40,01	36,25	36,383	4,635
	1	30.56	37,01	34,56	34,43	2,908

	2	28,77	37,49	39,1	35,12	2,651
3	3	29,09	37,31	37,44	34,613	2,95
	4	29,61	39,1	35,35	34,686	2,651
	5	26,31	63,3	36	44,39	2,669
	1	28,91	37,25	37,07	34,41	1,254
	2	31,91	38,69	38,77	36,456	1,782
5	3	31,21	38,68	36,03	35,306	1,827
	4	30,36	38,5	36,05	34,97	1,827
	5	28,54	39,58	36,36	36,06	1,519

Setelah dilakukan perhitungan CNR, maka mendapatkan CNR tertinggi yaitu pada *slice thickness* 5 sampel 1 sebesar 76,650 dan CNR terendah terdapat pada *slice thickness* 2 sampel 5 sebesar 20,486. Hal ini ditunjukkan bahwa adanya perubahan nilai CNR akibat dari tebal *slice thickness.*

2. Analisis Pengaruh *Slice Thickness* Terhadap SNR

Nilai rerata mean objek pada jaringan dibagi dengan nilai standar deviasi *background*. Setelah dilakukan perhitungan menggunakan persamaan, didapatkan nilai SNR tertinggi yaitu pada *slice thickness* 5 sampel 1 sebesar 27,440 dan SNR terendah pada *slice thickness* 2 sampel 4 sebesar 7,314 .

Tabel 2. Uji Pengaruh Slice Thickness Terhadap SNR dan CNR

Dependent Variable	Type III Sum Of Squares	Df	Mean Squares	F	Sig.
CNR	3379,209[a]	2	1689,604	31,213	.000
SNR	403,211[b]	2	201,606	23,566	.000
CNR	23514,322	1	23514,322	434,390	.000
SNR	2784,718	1	2784,718	325,504	.000
CNR	3379,209	2	1689,604	31,213	.000
SNR	403,211	2	201,606	23,566	.000
a. R Squared = ,839 (Adjusted R Squared = ,812)					
b. R Squared = ,797 (Adjusted R Squared = ,763)					

Berdasarkan tabel Test of between uji Manova memperlihatkan nilai p dan dua nilai R Squared. Pada tabel nilai signifikasi sebesar 0,000 maka Ho di tolak dan Ha di terima sehingga terdapat pengaruh antara variasi *slice thickness* terhadap CNR dan SNR. Nilai R Squared (a) untuk melihat pengaruh CNR dan R Squared (b) untuk melihat pengaruh SNR.

Tabel 3. Post Hoc

Dependent Variable	ST	Mean
CNR	ST 2	21,906
	ST 3	38,274
	ST 5	68,600
SNR	ST 2	7,475
	ST 3	13,244
	ST 5	20,157

Berdasarkan Tabel *Post Hoc*, dapat ditarik informasi, bahwa terdapat perbedaan yang signifikan secara statistik mengenai *slice thickness* terhadap CNR dan SNR. Hal ini dapat dilihat dari nilai mean dan dapat disimpulkan bahwa nilai *mean* tertinggi adalah nilai yang paling optimal. Nilai mean *slice thickness* 5 mm lebih tinggi jika dibandingkan dengan *slice thickness* 2 dan 3, sebesar 58,600 terhadap CNR dan 20,157 terhadap SNR.

Discussion

The findings of this study conclusively demonstrate that slice thickness is a major determinant of image quality in brain CT examinations for cerebral infarction, as measured by CNR and SNR. The significant effect ($p = 0.000$) and high R^2 values (CNR: 0.839; SNR: 0.797) quantitatively confirm that over 79–84% of the variation in these quality metrics is directly attributable to slice thickness, underscoring its clinical importance as a protocol optimization parameter.

The superior image quality at 5 mm slice thickness observed in this study aligns with the hospital's current standard protocol and is consistent with findings from comparable research. Solong et al. (2023) reported similar results in hemorrhagic stroke CT at Pelamonia Hospital, finding that 5 mm slice thickness yielded the highest CNR and SNR among variations tested. Hutami et al. (2021) demonstrated in a phantom-based study at RSUD Bali Mandara that CNR increases proportionally with slice thickness, corroborating the biological physics underpinning these findings. The consistency across different institutions, patient populations, and pathologies (both infarction and hemorrhage) reinforces the generalizability of this relationship within the Indonesian clinical context.

At 2 mm slice thickness, while spatial resolution is theoretically higher (enabling visualization of finer anatomical structures), the dramatic increase in image noise—reflected by substantially higher standard deviations across all ROI locations—renders the images diagnostically inferior for CNR-dependent assessments of infarction. This noise elevation at thin slices is a well-established CT physics phenomenon, mathematically related to the reduced number of photons sampled per voxel at thinner acquisitions. Abdulkareem et al. (2023) similarly documented that noise increases significantly with decreasing slice thickness in multi-slice CT, impacting diagnostic content particularly in low-contrast pathologies such as cerebral infarction.

The performance of 3 mm slice thickness in this study is noteworthy. While it produced significantly better CNR and SNR than 2 mm, it remained substantially below 5 mm in both metrics. This partially contradicts Baert's (2018) recommendation of 3 mm as optimal for infarction visualization, which may reflect differences in scanner technology, reconstruction algorithms, or the specific imaging parameters employed. It should be noted that Baert's recommendation likely referred to spatial resolution as the primary quality criterion, whereas this study emphasizes noise-dependent metrics (CNR and SNR). In scenarios where spatial resolution is the priority—such as detection of very small lacunar infarcts thinner slices may be preferable despite inferior CNR/SNR, particularly when advanced iterative or deep learning reconstruction is available.

Recent technological advances in CT reconstruction are gradually challenging the traditional trade-off between slice thickness and image quality. Sun et al. (2025) demonstrated that 1 mm deep learning-reconstructed brain CT achieved CNR and SNR values comparable or superior to standard 5 mm FBP reconstructions, effectively decoupling the relationship between slice thickness and image noise. Similarly, Inoue et al. (2024) showed that hybrid iterative reconstruction significantly reduced noise in thin-slice brain CT. While these advances are highly promising, they require sophisticated reconstruction software that may not yet be universally available at regional hospitals in Indonesia such as RSI Siti Rahmah. In such settings, 5 mm slice thickness remains the most practical protocol to achieve optimal CNR and SNR for infarction diagnosis.

From a clinical perspective, the current study validates the existing 5 mm brain CT protocol at RSI Siti Rahmah Padang as producing superior image quality for cerebral infarction cases relative to thinner reconstructions. This provides evidence-based support for maintaining the current protocol while acknowledging the potential future benefit of upgrading to advanced reconstruction algorithms that could enable thinner slice acquisition without compromising image quality. The study also highlights that routine retrospective reconstruction to 2 mm or 3 mm from 5 mm acquisitions does not enhance diagnostic image quality and should not be performed without access to noise-reduction algorithms.

This study has several limitations. The sample size of five patients is relatively small, which limits the statistical power and generalizability of the findings. Future research with larger, multi-center cohorts would provide more robust evidence. Additionally, this study did not assess spatial resolution, low-contrast detectability, or subjective radiologist evaluation scores, which are complementary components of comprehensive image quality assessment. The use of reconstructed (rather than natively acquired) thin slices may also differ from prospective thin-slice acquisitions in terms of noise characteristics. Finally, the absence of advanced reconstruction algorithms at the study site precluded comparison with iterative or AI-based reconstruction approaches.

CONCLUSIONS

Based on the research findings and the MANOVA statistical analysis, the R^2 value for CNR was 0.839, while the R^2 value for SNR was 0.797. These results indicate that variations in slice thickness significantly influence both CNR and SNR values. Specifically, increasing slice thickness resulted in higher CNR and SNR values, thereby improving overall image quality. A 2 mm slice thickness was unable to produce optimal CNR and SNR values. The mean CNR and SNR values at 2 mm were 21.906 and 7.475, respectively. These values were considerably lower than those obtained with 3 mm and 5 mm slice thicknesses. Therefore, the null hypothesis (H_0) was accepted and the alternative hypothesis (H_a) was rejected, indicating that a 2 mm slice thickness does not produce optimal CNR and SNR values. Similarly, a 3 mm slice thickness was less effective in producing optimal CNR and SNR values. The mean CNR and SNR values at 3 mm were 38.274 and 13.244, respectively, which remained lower than those achieved with a 5 mm slice thickness. Accordingly, H_0 was accepted and H_a was rejected, suggesting that although a 3 mm slice thickness provides visually acceptable image quality, it is still insufficient to achieve optimal CNR and SNR values. In contrast, a 5 mm slice thickness produced the highest image quality, with a mean CNR of 58.600 and a mean SNR of 20.157. Consequently, H_0 was rejected and H_a was accepted, demonstrating that a 5 mm slice thickness yields the highest CNR and SNR values and provides the most optimal image quality among the slice thicknesses evaluated in this study.

REFERENCES

Abdulkareem, N., Hajee, S., Hassan, F., Ibrahim, I. K., Al-Khalidi, R. E. H., & Abdulqader, N. A. (2023). Investigating the slice thickness effect on noise and diagnostic content of single-source multi-slice computerized axial tomography. Journal of Medicine and Life, 16, 862–867. https://doi.org/10.25122/jml-2022-0188

Anggarani, N. K. N., Suryatika, I. B. M., & Sutapa, G. (2023). Effect of slice thickness variation on spatial resolution of CT-scan device images at the Bali Mandara Hospital Radiology Installation. Asian Journal of Medicine and Health. https://doi.org/10.9734/ajmah/2023/v21i10901

Baert, A. (2018). Multislice CT (4th ed.). Springer Heidelberg Dordrecht.

Choopani, M., Abedi, I., & Dalvand, F. (2022). Pragmatic approaches to reducing radiation dose in brain computed tomography scan using scan parameter modification. Journal of Medical Signals and Sensors, 12, 219–226. https://doi.org/10.4103/jmss.jmss_83_20

Dewilza, N., Yudha, S., Hanifah, W., Nansih, L. A., & Septiani, R. (2024). Analysis of differences in image quality with variations in slice thickness in CT-scan brain examinations with trauma cases at the Radiology Installation of RSI Siti Rahmah Padang. Jurnal Ilmu dan Teknologi Kesehatan. https://doi.org/10.33666/jitk.v15i2.643

Funama, Y., Shirasaka, T., Goto, T., Aoki, Y., Tanaka, K., & Yoshida, R. (2022). Iterative reconstruction with multifrequency signal recognition technology to improve low-contrast detectability: A phantom study. Acta Radiologica Open, 11. https://doi.org/10.1177/20584601221109919

Harkey, T., Baker, D., Hagen, J., Scott, H., & Palys, V. (2021). Practical methods for segmentation and calculation of brain volume and intracranial volume: A guide and comparison. Quantitative Imaging in Medicine and Surgery, 12(7), 3748–3761. https://doi.org/10.21037/qims-21-958

Hirairi, T., Ichikawa, K., Urikura, A., Kawashima, H., Tabata, T., & Matsunami, T. (2023). Improvement of diagnostic performance of hyperacute ischemic stroke in head CT using an image-based noise reduction technique with non-black-boxed process. Physica Medica, 112, 102646. https://doi.org/10.1016/j.ejmp.2023.102646

Hutami, I. A. P. A., Sutapa, G., & Paramarta, I. (2021). Analisis pengaruh slice thickness terhadap kualitas citra pesawat CT scan di RSUD Bali Mandara. Buletin Fisika, 22(2), 77–83.

Inoue, Y., Itoh, H., Hata, H., Miyatake, H., Mitsui, K., Uehara, S., & Masuda, C. (2024). Noise reduction in brain CT: A comparative study of deep learning and hybrid iterative reconstruction using multiple parameters. Tomography, 10, 2073–2086. https://doi.org/10.3390/tomography10120147

Karina. (2017). Analisis pengaruh variasi slice thickness terhadap kualitas citra CT scan. [Thesis, Indonesia].

Maghfirah, A., Rahim, A., & Fadhlin, A. (2024). Linearity test of CT number and spatial resolution using ACR 464 phantom for image quality assessment on a 16-slice CT scanner. Journal of Technomaterial Physics. https://doi.org/10.32734/jotp.v6i2.12410

Mitani, H., Tatsugami, F., Higaki, T., Kaichi, Y., Nakamura, Y., Smit, E., Prokop, M., Ono, C., Ono, K., Korogi, Y., & Awai, K. (2021). Accuracy of thin-slice model-based iterative reconstruction designed for brain CT to diagnose acute ischemic stroke in the middle cerebral artery territory: A multicenter study. Neuroradiology, 63, 2013–2021. https://doi.org/10.1007/s00234-021-02745-4

Nelson, B., Gomez-Cardona, D., Thorne, J., Huber, N., Yu, L., Leng, S., McCollough, C., & Missert, A. (2024). Multiple kernel synthesis of head CT using a task-based loss function. Journal of Imaging Informatics in Medicine, 37, 864–872. https://doi.org/10.1007/s10278-023-00959-x

Notoatmojo, S. (2018). Metodologi penelitian kesehatan. Rineka Cipta.

Peng, Y., Luo, C., Wang, H., Sun, K., Lin, F., Wang, J., Rao, Y., Fan, R., Gong, L., & Sun, X. (2024). Feasibility of CT attenuation values in distinguishing acute ischemic stroke, old cerebral infarction and leukoaraiosis. BMC Medical Imaging. https://doi.org/10.1186/s12880-024-01340-2

Putu, L., Kusumaningsih, R., Suryatika, I. B. M., Trisnawati, N. L. P., & Irhas, R. (2023). Pengaruh slice thickness terhadap signal to noise ratio (SNR) dari hasil penyinaran

CT Scan di RSUP Prof. Dr. I.G.N.G Ngoerah. Kappa Journal. https://doi.org/10.29408/kpj.v7i2.7675

Rajendran, K., Petersilka, M., Henning, A., Shanblatt, E., Marsh, J., Thorne, J., Schmidt, B., Flohr, T., Fletcher, J., McCollough, C., & Leng, S. (2021). Full field-of-view, high-resolution, photon-counting detector CT: Technical assessment and initial patient experience. Physics in Medicine and Biology, 66. https://doi.org/10.1088/1361-6560/ac155e

Rinaldi, S. F., & Mujianto, B. (2017). Metodologi penelitian dan statistik. Trans Info Media.

Sato, T., & Takagi, T. (2021). Validation of the influence of CT slice thickness on the quantitative accuracy and image quality of single photon emission computed tomography. Asia Oceania Journal of Nuclear Medicine and Biology, 9(2), 148–157. https://doi.org/10.22038/aojnmb.2021.54670.1376

Seeram, E. (2016). Computed tomography: Physical principles, clinical applications, and quality control (4th ed.). Elsevier.

Siregar, E. S. (2020). Analisis dosis radiasi pasien pada pemeriksaan CT scan menggunakan aplikasi Si-INTAN. Buletin Fisika, 21(2), 53–59.

Solong, D. I., Putu, N., Jeniyanthi, R., & Sukadana, I. (2023). Analisis pengaruh variasi slice thickness terhadap kualitas citra pada pemeriksaan CT scan kepala dengan kasus stroke hemorragic di RS TK II Pelamonia Makassar. Journal of Educational Innovation and Public Health. https://doi.org/10.55606/innovation.v1i4.1992

Sun, J., Li, H., Wang, B., Li, J., Li, M., Zhou, Z., & Peng, Y. (2021). Application of a deep learning image reconstruction (DLIR) algorithm in head CT imaging for children to improve image quality and lesion detection. BMC Medical Imaging, 21. https://doi.org/10.1186/s12880-021-00637-w

Sun, J., Yao, H., Han, T., Wang, Y., Yang, L., Hao, X., & Wu, S. (2025). Thin-slice brain CT image quality and lesion detection evaluation in deep learning reconstruction algorithm. Clinical Neuroradiology, 35, 817–825. https://doi.org/10.1007/s00062-025-01542-3

Vromans, J., Bennink, E., Dankbaar, J., Velthuis, B., & De Jong, H. W. A. M. (2026). Robust filtering of thin-slice reconstructions improves lacunar stroke detection in CT perfusion imaging. Medical Physics, 53. https://doi.org/10.1002/mp.70271.