Journal of Vocational Health Studies

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SAFIRE STRENGTH OPTIMIZATION: EFFECT ON TISSUE CONTRAST AND PATHOLOGICAL ASSESSMENT OF BRAIN MSCT WITH NON-HEMORRHAGE STROKE (SNH)

OPTIMALISASI SAFIRE STRENGTH: PENGARUH TERHADAP KONTRAS JARINGAN DAN PENILAIAN PATOLOGI PADA MSCT BRAIN DENGAN STROKE NON-HEMORRHAGE (SNH)

Original Research Article
Penelitian

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ABSTRACT

Background: *Sinogram Affirmed Iterative Reconstruction (SAFIRE) is an Iterative Reconstruction algorithm that combines IR techniques that utilize raw data and image data iterations as parameters that underlie noise regularization in images in the reconstruction process to improve image quality.* ***Purpose:*** *Analyze the effect of variations in SAFIRE strength values on image contrast and pathological evaluation of CT scan brain with clinical Stroke Non-Hemorrhage (SNH).* ***Method:*** *This research is a quantitative analytic study with an experimental approach to analyze the effect of SAFIRE strength values on image contrast and pathological assessment on CT scan brain examination.* ***Result:*** *Statistical test results showed a significant difference (p-value < 0.05) in all variations of SAFIRE strength, with the resulting Contrast-to-Noise Ratio (CNR) value increasing as the SAFIRE strength value used increased. The average CNR improvement was 18.4% on all SAFIRE strength values compared. This increase is affected by a linear decrease of the noise value from one SAFIRE strength value to another. Image contrast improvement also affects the pathological assessment of SNH due to the increased density differences in the hypodense lesion compared to the surrounding tissues.* ***Conclusion:*** *The use of the SAFIRE strength variation significantly affects image contrast values and pathological assessment in the SNH brain MSCT examination.*

ARTICLE INFO

Received 17 November 2022
Revised 06 December 2022
Accepted 15 November 2023
Available online 05 March 2024

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Keywords:
CNR, SAFIRE strength, SNH

ABSTRAK

Latar belakang: *Sinogram Affirmed Iterative Reconstruction* (SAFIRE) merupakan algoritma *Itterative Reconstruction* yang menggabungkan teknik IR, memanfaatkan *raw* data dan *image* data *iterations* sebagai parameter yang mendasari regularisasi *noise* pada citra dalam proses rekonstruksi untuk meningkatkan kualitas citra. **Tujuan:** Menganalisis pengaruh variasi nilai SAFIRE *strength* terhadap kontras citra dan evaluasi patologi CT scan *brain* dengan klinis *Stroke Non-Hemorrhage* (SNH). **Metode:** Penelitian ini merupakan penelitian kuantitatif analitik dengan pendekatan eksperimen untuk menganalisis pengaruh nilai SAFIRE *strength* terhadap kualitas citra pada pemeriksaan CT scan *brain* dengan klinis SNH. **Hasil:** Hasil uji statistik menunjukkan perbedaan yang signifikan (*p-value* < 0,05) pada keseluruhan variasi SAFIRE *strength* dengan nilai *Contrast-to-Noise Ratio* (CNR) yang dihasilkan semakin meningkat seiring dengan peningkatan nilai SAFIRE *strength* yang digunakan. Rata-rata peningkatan CNR sebesar 18,4% pada keseluruhan nilai SAFIRE *strength* yang dibandingkan. Kenaikan tersebut dipengaruhi oleh penurunan nilai *noise* secara linier dari satu nilai SAFIRE *strength* ke nilai lainnya. Kenaikan kontras citra juga berpengaruh pada penilaian patologi SNH akibat perbedaan densitas yang meningkat pada bagian lesi hipodens bila dibandingkan dengan jaringan di sekitarnya. **Kesimpulan:** Penggunaan variasi SAFIRE *strength* memberikan pengaruh signifikan terhadap nilai kontras citra dan evaluasi patologi pada pemeriksaan MSCT *brain* dengan klinis SNH.

Kata kunci:
CNR, SAFIRE *strength*, SNH

Journal of Vocational Health Studies p-ISSN: 2580–7161; e-ISSN: 2580–717x
DOI: 10.20473/jvhs.V7.I3.2024.142-150

INTRODUCTION

Computed Tomography (CT) scan is a radio diagnostic technique progressively becoming more prevalent in clinical settings alongside its advancements. MSCT scanner for radio diagnostic imaging can accurately depict morphological features by analyzing variations or discrepancies in radiation transmission across the targeted organ or body segment. CT scans are a convenient and efficient imaging modality many medical professionals prefer as it provides quick and accurate results. It aids in making definitive diagnoses and can assist in determining the nature and severity of illnesses. Additionally, CT scans have been found to play a significant role in reducing the need for surgeries, as the test results allow for alternative treatments to be recommended, resulting in a decrease in the surgery rate from 13% to 5% (Al-Sharify *et al*., 2020).

The increasing use of MSCT scanner has received serious attention, especially in patient doses. The dose caused by the MSCT scanner is greater than that of other radiology modalities. The United States *National Council on Radiation Protection and Measurements* (NCRP) stated that CT scans contribute to 24% of the radiation dose in medical imaging. Earlier research has demonstrated that the radiation doses in CT scans can differ considerably between patients, hospitals, and countries, reaching up to 17-fold variations. CT radiation is associated with an elevated risk of cancer, as ionizing radiation is a known carcinogen. Therefore, it is essential to reduce the excessive variability in examination methods and minimize exposure to medical imaging (Abuzaid *et al*., 2022).

Several attempts were made to reduce the MSCT dose while maintaining the image quality of the examined object. One method currently widely used in all MSCT to improve image quality without increasing the patient's dose is using an iterative reconstruction algorithm. Several iterative reconstruction algorithms are available, both of which work in image space data such as *Iterative Reconstruction* in *Image Space* (IRIS) and *Adaptive Statistical Iterative Reconstruction* (ASIR), or those that work in raw data, such as *Sinogram Affirmed Iterative Reconstruction* (SAFIRE), *Adaptive Iterative Dose Reduction* (AIDR) 3D, *Hybrid Iterative Reconstruction* (HIR). The SAFIRE algorithm is a recently developed iterative reconstruction algorithm by Siemens that operates based on original data. This algorithm has been shown to significantly reduce noise in CT images and effectively remove spiral CT artifacts, by applying the SAFIRE algorithm in CT image reconstruction, the image quality can be substantially improved, potentially reducing the radiation dose required for CT scans. Additionally, studies have demonstrated that SAFIRE technology can lower CT scan doses without increasing image noise and with minimal impact on image quality (Wang *et al*., 2017).

MSCT brain examination is indicated for various conditions such as suspect neoplasms, brain metastases, stroke (SNH/SH), aneurysms, intracranial bleeding, head atrophy, post-traumatic abnormalities, congenital abnormalities, head injuries, and tumor masses/lesions. SNH or ischemic stroke accounts for 88% of all stroke cases and is caused by blockage or decreased blood flow to the brain. Clinical courses of ischemic stroke are categorized into *Transient Ischemic Attack* (TIA), *Reversible Ischemic Neurologic Deficit* (RIND), stroke in evolution, and completed stroke (Feigin *et al*., 2022; Mendelson and Prabhakaran, 2021; Tabrizi *et al*., 2021).

Based on the 2018 Indonesian Basic Health Research, the prevalence of stroke in Bali is 8.9% and has increased to 10.9 % (Ministry of Health, 2018). *Stroke Non-Hemorrhage* (SNH), commonly known as ischemic stroke, occurs due to ischemia caused by blockages or decreases in blood flow to the brain, interfering with the fulfillment of blood and oxygen needs in brain tissue. The increase in cases of stroke makes it necessary to screen as early as possible to be able to reduce the mortality rate due to stroke. Stroke is the second highest cause of both death and disability on a global scale, with low and middle-income countries bearing the most significant burden of the disease. There were a total of 13.7 million new stroke cases worldwide, with around 87% of these being ischemic strokes (Saini *et al*., 2021). The use of imaging modalities in diagnosing ischemic stroke is crucial as it enables a timely and accurate diagnosis, facilitating prompt treatment initiation. The urgency in utilizing these imaging modalities in the diagnosis of ischemic stroke is critical in achieving better patient outcomes and minimizing long-term disability (Méndez-Gallardo *et al*., 2020).

CT scan brain is considered the gold standard imaging modality for examining stroke, particularly assessing ischemic stroke. It allows for the rapid identification of potential hemorrhagic and ischemic lesions in the brain. It is crucial in the initial evaluation and management of patients suspected to have a stroke. Additionally, CT scan brain is a non-invasive and widely available imaging technique that provides high-quality brain images, making it a valuable tool for diagnosis and treatment planning (Shetewi *et al*., 2020; Ugwuanyi *et al*., 2020). Enforcement of a CT scan diagnosis requires good image quality to avoid misdiagnosis. Good-quality CT scan images are characterized by high *Signal-to-Noise Ratio* (SNR), high *Contrast-to-Noise Ratio* (CNR), and high spatial resolution. SNR refers to the ratio of the signal intensity to the background noise level, while CNR reflects the ability to distinguish between different tissue types based on their contrast differences. Spatial resolution, on the other hand, refers to the ability to distinguish between small objects or details within the image. Achieving high-quality CT scan images requires careful attention to several factors, including the use of appropriate scanning protocols and techniques, the quality of the equipment used, and the skill and experience of the operators, by prioritizing these factors, healthcare providers can ensure that CT scan images are of the highest possible quality, allowing for accurate diagnosis and effective treatment (American College of Radiology, 2020).

The parameter that underlies noise regularization in images is the use of variations of SAFIRE strength (strengths 1 - 5) which can be used in the reconstruction process to improve image quality. Based on the author's observations at three private hospitals in Bali, most of them apply the default SAFIRE strength setting with strength 3 for all types of clinical cases in CT scan brain examinations, including SNH, which is the most frequently performed clinical examination in 3 last month at the time this research was conducted. In other words, there has never been a CT scan brain examination using other variations of SAFIRE strength (strength 1, strength 2, strength 4, and strength 5).

SAFIRE is effective in reducing image noise and improving image quality in a variety of clinical settings. The application of SAFIRE is an urgent matter in research related to SNH using CT scans. SAFIRE is a novel image reconstruction algorithm significantly reduces image noise without sacrificing image quality or diagnostic accuracy. This is particularly important in the case of SNH, where small lesions may be missed or misinterpreted due to image noise, leading to incorrect diagnoses and potentially harmful treatments. In connection with the background previously presented, it is essential to conduct research related to the effects of SAFIRE implementation on tissue contrast and pathology assessment in head CT scans, especially in patients with SNH cases. This research is expected to provide an appropriate protocol for displaying optimal image results.

MATERIAL AND METHOD

This study uses analytical quantitative research with an experimental approach to analyze the effect of the SAFIRE strength value on image quality (image contrast and pathological assessment) at brain CT in February - April 2022 at a private hospital in Bali. The population used in this study was raw data of all radiology patients who had a brain CT scan with suspicious SNH taken using the retrospective method. The sample used was ten patients' brain CT scans with radiological results showing SNH, which were further reconstructed using the SAFIRE strengths 1, 2, 3, 4, and 5 to determine the value of CNR is done by placing the *Region of Interest* (ROI) to compare the SNH value in each sample with gray matter, which is an object adjacent to the pathology assessed using the formula (Formula 1).

$$CNR = \frac{Ib - Is}{\sigma} \quad \text{.........................} \quad (1)$$

The CNR values of 10 MSCT scan brain samples, reconstructed using five variations of SAFIRE strength, were statistically tested using the SPSS 26 program, to find out more about the effect of using variations SAFIRE strength 1 - 5, several statistical tests were carried out on CNR and pathological assessment. The CNR data used a repeated *ANOVA test* to prove the hypothesis and find out more about the differences between variables, followed by the post-hoc *Bonferroni test* to see which SAFIRE strength is better. As further justification for the pathology information on the image, an analysis was carried out from *relative Visual Grading Analysis* (rVGA) data using the *Friedman test* followed by the *Wilcoxon test*. This research was conducted by paying attention to and respecting: a) Human dignity, b) The privacy and confidentiality of research subjects, c) Justice and inclusiveness, and d) The benefits and losses incurred. This research has undergone an ethical review and has been declared compliant with the ethical clearance Letter with reference number 013/KEP/AB/I/2022.

RESULT

Differences in images that have been reconstructed using SAFIRE strength variations 1 - 5 can be observed and assessed quantitatively at the signal intensity and qualitatively visually by radiologists to observe the contrast, sharpness, and detail of the resulting imagery. The Figure 1 shows the differences in CT scan brain images with variations in SAFIRE values applied to patients with clinical SNH. Figure 1(a) shows a CT image without SAFIRE, which shows several noises in the overall image *Field of View* (FOV). Subsequent Figure 1(b) until Figure 1(f) shows CT images reconstructed using SAFIRE at strengths 1 through 5. Increasing the strength value appears to decrease the amount of noise visualized in the CT images.

CNR measurement

CNR measurement was done by comparing adjacent objects on the brain MSCT image. In this CNR measurement, we compared the SNH lesions in each sample with the *Gray Matter* which is an object adjacent to the pathology assessed using the formula of CNR (can be seen in Formula 1). The CNR values of 10 brain MSCT samples, which were reconstructed using five variations of SAFIRE strength, were then statistically tested using the SPSS 26 version (Table 1).

The Table 1 shows that the higher the SAFIRE strength variation used, the greater the average contrast value of the resulting image. Better tissue contrast values allow small objects on brain MSCT images, especially hypodense lesions in patients with SNH, to be seen more clearly. To find out the significance of the difference in the variation studied, a hypothesis test has been carried out.

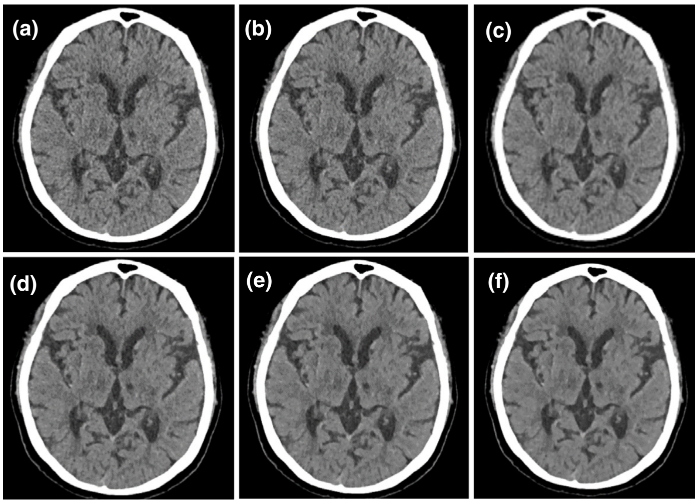

Figure 1. Reconstruction results (a) without SAFIRE, (b) with SAFIRE strength 1, (c) with SAFIRE strength 2, (d) with SAFIRE strength 3, (e) with SAFIRE strength 4, (f) with SAFIRE strength 5

Table 1. Distribution of tissue contrast (CNR) values between SAFIRE strength variations

SAFIRE strength	Number of samples (N)	Range	Min	Max	Means	std. Deviation
SAFIRE strength 1	10	16.20	3.77	19.97	12.31	6.28
SAFIRE strength 2	10	22.54	3.90	26.44	14.07	8.13
SAFIRE strength 3	10	31.93	4.43	36.36	15.82	9.75
SAFIRE strength 4	10	50.82	4.11	54.93	19.90	14.56
SAFIRE strength 5	10	48.71	5.14	53.85	24.12	16.49

Table 2. CNR normality test results

CNR	*Shapiro-wilk*
	p-value
SAFIRE strength 1	0.257
SAFIRE strength 2	0.335
SAFIRE strength 3	0.279
SAFIRE strength 4	0.064
SAFIRE strength 5	0.392

Table 3. Pairwise comparisons indicator between SAFIRE strength variations

Pathological assessment	*p-value*	Annotation
SAFIRE strength 1 - SAFIRE strength 2	0.131	not significantly different
SAFIRE strength 1 - SAFIRE strength 3	0.054	not significantly different
SAFIRE strength 1 - SAFIRE strength 4	0.043	significantly different
SAFIRE strength 1 - SAFIRE strength 5	0.009	significantly different
SAFIRE strength 2 - SAFIRE strength 3	0.128	not significantly different
SAFIRE strength 2 - SAFIRE strength 4	0.077	not significantly different
SAFIRE strength 2 - SAFIRE strength 5	0.005	significantly different
SAFIRE strength 3 - SAFIRE strength 4	0.069	not significantly different
SAFIRE strength 3 - SAFIRE strength 5	0.006	significantly different
SAFIRE strength 4 - SAFIRE strength 5	0.139	not significantly different

The results of the *Shapiro-Wilk normality test* (Table 2) on all test variables show normal data distribution. As further justification for assessing the significance of differences in all test variables, a *One-Way ANOVA test* was performed on the tissue contrast values of the reconstructed image using five variations of SAFIRE strength while still paying attention to the results of the data *Homogeneity test*. *Mauchly's indicator* shows a value of 0.005, so the homogeneity is not assumed. Furthermore, because the data used is not homogeneous, the indicators used to assess the effect on the value of tissue contrast in images reconstructed using five variations of SAFIRE strength are the results of the *Greenhouse-Geisser* indicator.

The *Greenhouse-Geisser* indicator showed a *p-value* of 0.006 (Table 3), which means there is a significant difference in the value of tissue contrast in the overall SAFIRE strength compared to brain MSCT with SNH. To determine the significance of the difference between each of the variables tested and to assess the variation that best displays tissue contrast, the pairwise comparisons indicator was used to find out more about the differences between variations.

Based on Table 3, the reconstructed image using the SAFIRE strength 1 variation when compared to the SAFIRE strength 2 variation, the SAFIRE strength 2 variation when compared to the SAFIRE strength 3 variation, and the SAFIRE strength 4 variation when compared to the SAFIRE strength 5 variation has a *p-value* > 0.05 which means that there is no significant difference in the tissue contrast value of the brain MSCT image from the clinical SNH. In contrast, in the reconstructed image using other SAFIRE strength variations (SAFIRE strength 1 variation when compared to SAFIRE strength 3 variation, SAFIRE strength 1 variation when compared to SAFIRE strength 4 variation, SAFIRE strength 1 variation when compared to SAFIRE strength 5 variation, SAFIRE strength 5 variation SAFIRE strength 2 when compared to the SAFIRE strength 4 variation, variation of SAFIRE strength 2 when compared with variation of SAFIRE strength 5, variation of SAFIRE strength 3 when compared with variation of SAFIRE strength 4, and the SAFIRE strength 3 variation when compared to the SAFIRE strength 5 variation) when compared and assessed to have a *p-value* < 0.05 which means that there was a significant difference in the tissue contrast value of the brain MSCT image with SNH.

Pathological assessment

Assessing the pathological information, rVGA was carried out by a radiologist as a respondent. The assessment was carried out by comparing the reconstructed images using variations of SAFIRE strength 1, strength 2, strength 3, strength 4, and strength 5 can be seen in Table 4.

The tendency of radiologists to give a score of 3 "very clear" is greater, as many as 7 assessment on the SAFIRE strength 4 and SAFIRE strength 5 variations out of a total of 10 assessments (70%), only 3 assessment for a value of 2 "clear" out of a total of 10 assessments (30%) and there is no rating 1 "not/less clear" for the SAFIRE strength 4 and SAFIRE strength 5 variations out of a total of 10 assessment (0%) which means that the image reconstructed with these variations can show SNH lesions more clearly than other SAFIRE strength variations. The *Friedman test* (Table 5) was conducted to assess the significance of differences in overall SAFIRE strength variations.

Table 4. Pathology assessment of brain MSCT between variations of SAFIRE strength

SAFIRE	Score (Number of assessment)	Annotation
SAFIRE strength 1	**1** (5)	**1** = "No/Less Clear" **2** = "Clear" **3** = "Very Clear"
	2 (5)	
	3 (0)	
SAFIRE strength 2	**1** (1)	
	2 (9)	
	3 (0)	
SAFIRE strength 3	**1** (0)	
	2 (7)	
	3 (3)	
SAFIRE strength 4	**1** (0)	
	2 (3)	
	3 (7)	
SAFIRE strength 5	**1** (0)	
	2 (3)	
	3 (7)	

Table 5. *Friedman test* results based on rVGA

SAFIRE	N	Mean rank	*p-value*
SAFIRE strength 1	10	1.50	<0.0001
SAFIRE strength 2	10	2.20	
SAFIRE strength 3	10	3.15	
SAFIRE strength 4	10	4.05	
SAFIRE strength 5	10	4.10	

The Table 5 shows the significance of the difference between the 5 variations of SAFIRE strength being compared. All images reconstructed using 5 variations of SAFIRE strength, which is assessed visually, have a *p-value* < 0.05 which means there is a significant difference in the pathological assessment of the brain MSCT with SNH, to determine which variation of SAFIRE strength is better at displaying anatomical and pathological information, it can be seen from the mean rank value. The higher the variation of SAFIRE strength used, the greater the mean rank. The data was then tested using the *Wilcoxon test* (Table 6) to find out more about the differences between each variation.

The Table 5 shows the reconstructed images using variations of SAFIRE strength 3 and SAFIRE strength 4 when compared with SAFIRE strength 5, which are visually assessed as having a *p-value* > 0.05 which means there is no significant difference in pathology assessment in brain MACT with SNH. In contrast, when compared and assessed visually, the images reconstructed using other SAFIRE strength variations show significant differences.

Table 6. Pairwise comparisons indicator between SAFIRE strength variations

SAFIRE comparison	*p-value*	annotation
SAFIRE strength 1 - SAFIRE strength 2	0.046	significantly different
SAFIRE strength 1 - SAFIRE strength 3	0.011	significantly different
SAFIRE strength 1 - SAFIRE strength 4	0.006	significantly different
SAFIRE strength 1 - SAFIRE strength 5	0.003	significantly different
SAFIRE strength 2 - SAFIRE strength 3	0.046	significantly different
SAFIRE strength 2 - SAFIRE strength 4	0.005	significantly different
SAFIRE strength 2 - SAFIRE strength 5	0.005	significantly different
SAFIRE strength 3 - SAFIRE strength 4	0.046	significantly different
SAFIRE strength 3 - SAFIRE strength 5	0.102	not significantly different
SAFIRE strength 4 - SAFIRE strength 5	1.000	not significantly different

DISCUSSION

CT scan employs a fundamental principle involving the movement of a fixed rotating X-ray tube that continuously emits X-rays. At the same time, the patient's table moves, resulting in the acquisition of multiple slices from a single motion of the patient (Jung, 2021). The X-ray radiation beam will experience a decrease in intensity exponentially with the thickness of the object through which it passes. The radiation beam's intensity reduction beam occurs because of the interaction process of radiation in the form of absorption and scattering, the probability of which is determined by the type of object and the emitted radiation. CT scanning is a significant source of radiation exposure for medical patients, contributing a considerable amount to man-made radiation dose. Despite the advantages of CT imaging and its widespread use, the potential health risks associated with exposure to ionizing radiation from CT scans are a major concern (Abuelhia and Alghamdi, 2020).

MSCT imaging involves a different radiation dose compared to conventional radiography. This is due to high collimation or thin slices, resulting in a larger tissue volume being exposed to radiation from almost all angles during rotation. The radiation dose received by the patient can be estimated using parameters such as CTDI and DLP. CTDI refers to the average absorbed dose over the entire z-axis that is irradiated and adjacent or can also be represented as a homogeneous phantom absorbed dose (DePew *et al*., 2022). *Computer Tomography Dose Index* (CTDI) is a CT scan X-ray dose on a single slice and is usually measured using a standard phantom cylinder. One of the important parameters measured in irradiation is the electrical parameters and parameters of the X-ray generator, namely voltage and current strength. This parameter will affect the intensity of radiation the patient receives (Jung, 2021). CTDI is calculated not from the dose profile for several scans but only with one scan. CTDI is calculated from the integrity of the dose profile curve once scanned divided by the collimation width or slice width (Retnoningsih and Anam, 2012; Damilakis, 2021). DLP, the quantity generated on a CT scan examination, shows the absorbed dose resulting from the entire scan process. The DLP value is obtained from the results of the CTDIvol multiplied by the scanning length in cm. ICRP world body issued recommendation Number 26 concerning a comprehensive dose limitation system, which states that activities involving ionizing radiation must comply with the principles of justification, optimization, and limitation. External radiation control can be carried out by paying attention to distance, time, and radiation shielding (Rahman, 2020).

Good image appearance on MSCT depends in the quality of the resulting image so that the clinical aspects of the image can be used to make a diagnosis. In MSCT, several parameters are known for controlling the optimal output image exposition, such as range, slice thickness, exposure factor, FOV, gantry tilt, matrix reconstruction, algorithms/filter kernel reconstruction, window width, window level, pitch, and coverage. The parameters applied will be able to affect the quality of the CT scan image that will be produced. The image quality in question is in the form of spatial resolution, contrast resolution, noise, and artifacts (Bigdeli *et al*., 2014; Tompe and Sargar, 2021).

Iterative reconstruction refers to iterative algorithms that are used to reconstruct 2D and 3D images of certain imaging techniques, one of which is the CT scan modality to reconstruct images from the projection of an object. With iterative reconstruction, a correction loop is included in the image reconstruction scheme (Örgel, 2020; Thibault *et al*., 2007). SAFIRE is an iterative reconstruction algorithm that combines IR techniques that utilize raw data and image data iterations. This technique allows noise reduction, artifact removal, and reduced processing time (Lee, 2018). Algorithm reconstruction is a mathematical procedure used in reconstructing images. The appearance and characteristics of the CT scan image depend on the strength of the selected algorithm, the higher resolution of the resulting image. In this method, images such as bone, soft tissue, and other tissues can be clearly distinguished on the monitor screen (Moscariello *et al*., 2011; Singh, 2020).

SAFIRE performs an initial reconstruction using raw data from the FBP algorithm, after which the raw data will enter the iterative loop process twice. The first loop will generate new synthetic raw data (derived from the forward projection process). The second loop occurs in the image space, where noise is removed from the image through a statistical optimization process. Noise can be estimated locally and eliminated using dynamic raw database modeling; during the iteration process, the image noise in different directions in each image pixel will be adjusted to the space-variant function. SAFIRE can reconstruct up to 20 images per second (Bushberg *et al*., 2012; Wang, 2014).

The CNR value is a measure of how far the signal can be distinguished from the background. The greater the contrast value, the more easily the signal will be distinguished from the background (Alsleem and Almohiy, 2020; Desai *et al*., 2010). The results of the *Hypothesis test* (*Greenhouse-Geisser*) on the CNR value show a *p-value* <0.05, which means that there is a significant influence on the entire SAFIRE value variable tested. On the CNR indicator, the effect of applying the SAFIRE value can be seen from the value of the pairwise comparisons. CNR values compared to SAFIRE variations that differ by 1 value (1 - 2, 2 -3, 3 - 4, 4 - 5) have no significant effect. The comparison between 2 different steps (1 - 3, 2 - 4) also produces an image that is not significant in the CNR value, but SAFIRE 3 - 5 produces a different value along with the resulting noise reduction. When viewed from the increase in the CNR value that occurred with the lowest CNR value on SAFIRE strength 1 (12.31%) and the highest on SAFIRE strength 5 (24.12%), the average increase in the overall value of SAFIRE strength used was 18.4 %.

The increase in CNR is in line with the increase in SNR in each variation, which is affected by a linear decrease in the noise value from 1 SAFIRE strength value to another with the highest CNR value, the SAFIRE strength 5 value on SNH is considered the best for displaying pathology with the highest signal differentiation with surrounding tissue from the others. However, it has a value that is not significantly different from SAFIRE 4. CNR value increases with each increase in the use of the SAFIRE value, which will increase the visibility of the SNH pathology displayed on the MSCT image assessed by the radiologist. This can be seen from the pathology score, which was assessed with rVGA by the radiologist.

Image reconstructed using variations of SAFIRE strength 3 and SAFIRE strength 4 when compared with SAFIRE strength 5 which were assessed visually showed that the interpretations of brain MSCT anatomy and pathology information with SNH on variations of SAFIRE strength 3, 4, and 5 did not show a significant difference compared to the description of the brain MSCT anatomy and pathology information with SNH in the SAFIRE strength 1 and SAFIRE strength 2 variations. Although there was no significant difference (in variations 3, 4, and 5), it can be seen strength 5 was stated to have the highest mean rank value (4.10) which means that the SAFIRE strength 5 score gets the best score in displaying SNH pathology.

SNH pathology assessment, which focuses on the brain parenchyma, is strongly influenced by the SAFIRE strength value used. This is in accordance with the application of Iterative Reconstruction on CT scans, one of which is brain MSCT for parenchymal assessment (Nagayama *et al*., 2018). The application of IR is able to provide better tissue contrast in gray-white matter without increasing noise in CT images produced (Nagayama *et al*., 2017) with the increase that occurred, especially in the application of SAFIRE strength 3 - strength 5 in the application of the reconstruction algorithm, it is possible to combine the application of SAFIRE strength 4 and strength 5 (besides SAFIRE 3 which has been used in routine protocols) with a decrease in the use of tube voltage (low voltage application) for may add to the significance of tissue contrast enhancement in the pathology to be evaluated.

The application of a combination of low voltage and IR has been applied in several previous studies, one of which was in the application of a CT scan brain in pediatric patients (Park *et a*l., 2017; Wang, 2021), where the increase in the contrast of the gray-white matter tissue increases in the application of 100kV when compared to 120 kV. In addition to the increased tissue contrast, images with 100 kV show a lower dose by half (30 mGy- CTDIvol) when compared to 120 kV (60 mGy - CTDIvol).

CONCLUSION

Based on the results and discussion in this research, it can be concluded that using the SAFIRE strength variation significantly affects image contrast values and pathological assessment in the SNH brain MSCT examination. The resulting CNR values increase as the SAFIRE strength variation is used with an average increase of 18.4% for CNR on the overall SAFIRE strength value used, which is influenced by a linear decrease in the Noise value from one SAFIRE strength value to another SAFIRE strength. The increase in CNR influences improving the visibility of SNH pathology. SAFIRE strength 5 obtained the best score in displaying SNH pathology on the brain MSCT examination.

The application of the use of the SAFIRE strength variation that is appropriate to the patient's clinical, specifically in the brain MSCT examination with SNH, it is recommended to use the SAFIRE strength 5 in the implementation of the reconstruction algorithm to reduce noise in the image to be diagnosed so that the hypodense lesion can be visualized more clearly, specifically for pathology which seems a small Lacunar Infarction. In addition, a combination of the application of SAFIRE strength 4 and 5 (in addition to SAFIRE strength 3, which has been used in routine protocols) with a decrease in the use of tube voltage (or application of Low Voltage) is suggested to be able to add to the significance of increasing tissue contrast in the pathology to be evaluated and to reduce the dose up to half. Further research can be continued by examining the significance of the application of SAFIRE strength 4 and 5 with the combination of application of low voltage and kV value recommendations for MSCT brain examination with clinical SNH required for pediatric and adult patients.

ACKNOWLEDGMENTS

The researcher would like to thank all parties involved in this research process. The authors state there is no conflict of interest with the parties involved in this study.

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