Analysis of TE Variations on SNR and CNR Values in Lumbar MRI T2WI Sequences at Bali Mandara Regional General Hospital

ABSTRACT

Aim: This study aims to evaluate the effect of echo time (TE) variation on MRI image quality, which is measured using Signal to Noise Ratio (SNR) and Contrast to Noise Ratio (CNR). The focus of the study was on lumbar MRI examinations at RSUD Bali Mandara using a Philips 1.5 Tesla MRI machine.

Study Design: This research used an experimental design with a quantitative approach. The study was conducted in the MRI unit at RSUD Bali Mandara from January to October 2024.

Methodology: The study involved 30 patients who underwent lumbar MRI examinations. Four TE variations (80 ms, 90 ms, 100 ms, and 110 ms) were applied to analyze SNR and CNR in corpus, discus, and cerebrospinal fluid (CSF) tissues using the ROI (Region of Interest) method. Data were analyzed using IBM SPSS statistical software to evaluate the effect of TE variations on image quality. The MRI machine used was the Philips Achieva 1.5 Tesla with standard lumbar imaging protocol parameters.

Results: Increasing the TE value significantly decreased SNR and CNR values. A TE of 80 ms provided the highest SNR and CNR values compared to other TE variations. This indicates that shorter TE produces better image quality.

Conclusion: Good MRI image quality is determined by high SNR and CNR values. This study recommends using an 80 ms TE in lumbar MRI imaging protocols to improve the accuracy of clinical interpretations.

***Keywords**: MRI, lumbar, SNR, CNR, TE*

1. INTRODUCTION

Magnetic resonance imaging (MRI) technology has made significant contributions to the development of diagnosis and treatment of various medical conditions, especially in the musculoskeletal system and spine. (Santiago et al., 2022) MRI allows visualization of human body parts without invasive procedures, providing detailed images of anatomical structures and existing pathologies (Nizar and Katili, 2019).

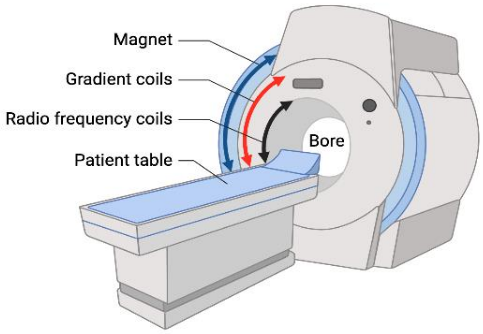

Figure 1. MRI machine

One important factor in the use of MRI is the setting of certain parameters, such as echo time (TE), which affects the quality of the resulting image. (Muzamil et al., 2023)This parameter plays a role in determining the signal to noise ratio (SNR) and contrast to noise ratio (CNR), which are key indicators for assessing the quality of MRI images. SNR measures the comparison between signal and noise, while CNR assesses the difference between pathological areas and healthy tissue (Weishaupt et al., 2006).

Research conducted by (Brinjikji et al., 2015) showed that MRI imaging of the lumbar organs has a success rate of between 76% -91.2%, which reflects its effectiveness in visualizing the structure of the spine, intervertebral discs, and surrounding soft tissues. Other studies, such as those conducted by (Nizar and Katili, 2019)and (Prastowo et al., 2013), confirmed that variations in MRI parameters, including TR and TE, have a significant impact on image quality. By optimizing these parameters, image quality can be improved, which in turn improves diagnostic accuracy, especially in cases of disc herniation and spinal stenosis.

In line with these findings, this study will focus on analyzing the effect of variations in TE parameters on SNR and CNR values in lumbar MRI imaging. Through the identification and optimization of these parameters, it is hoped that the resulting MRI images will have better quality, thus supporting more accurate diagnoses and more effective treatment for patients with spinal problems. This study aims to understand the effect of TE parameters on MRI image quality by analyzing SNR and CNR values, as well as contributing to the development of more advanced medical imaging technology, especially in the fields of orthopedics, neurology, and radiology.

Thus, this study not only continues previous findings but also provides a deeper focus on TE parameters, which are expected to result in more significant developments in MRI imaging quality.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Study area

The study was conducted at the Radiology Installation of Bali Mandara Regional General Hospital (RSUD), located at Jl. Bypass Ngurah Rai No.548, Sanur Kauh, South Denpasar, Denpasar City, Bali.

2.1.2 Study site

The tools and materials used in this study include MRI aircraft with Phillips brand specifications, superconducting magnet type, with a power of 1.5 T, and computer devices used for patient data processing, parameter settings, and image analysis.

2.1.3 Study design

This study uses an experimental research design to evaluate the effect of TE variation on SNR and CNR values in lumbar MRI examinations.

2.1.4 Study population

Patients undergoing lumbar MRI examination at Bali Mandara Hospital.

2.1.5 Sample size determination

The independent variable of this research is the TE parameter variation (80 ms, 90 ms, 100 ms, and 110 ms). The dependent variables are SNR and CNR values. *Other parameters that are made constant,* Control Variables Parameters that are made constant, such as slice thickness of 5 mm, bandwidth 218 Hz, TR 2965.27 ms, matrix 400 × 400, FOV 240 × 240, flip angle 90°, NEX 2, and sagittal slice orientation.

2.2 Methods

2.2.1 Sampling techniques

Data collection was conducted using the following steps:

- Preparation Stage: Patients were given an explanation of the MRI procedure and asked to remove metal/magnetic objects before entering the MRI room.
- Scanning Stage: Filling in patient data on the computer system, followed by setting parameters according to the protocol and scanning the lumbar using the TE variation under study.
- Data Retrieval: 120 images from 30 patients were analyzed, involving ROI (region of interest) segmentation of the corpus, discus, CSF, and background as noise.

2.2.2 Study instruments

The research procedure consisted of the following stages:

- Preparatory Stage: The patient is given an explanation of the MRI examination procedure. The patient is asked to remove all metal/magnetic objects and, if necessary, change into special clothing.

The radiographer prepared the head coil to capture the RF signal and headphones to reduce noise. The patient is positioned supine on the gantry of the MRI scanner.

- Image Scanning Stage: Patient data is entered into the computer system. Parameters such as TR, slice thickness, bandwidth, matrix, FOV, flip angle, NEX, and slice orientation were adjusted as per the protocol. Scanning was performed with variations in TE parameters (80 ms, 90 ms, 100 ms, 110 ms).
- Data Capture Phase: Data was taken from 30 patients resulting in 120 images analyzed. ROI segmentation was performed on corpus, discus, CSF, and background to calculate SNR and CNR values.

2.2.3 Data collection method

SNR and CNR measurements:
SNR is calculated by dividing the average signal in the corpus, discus, or CSF by the standard deviation of the noise. CNR is calculated by comparing the difference between the average tissue signal and the average noise, divided by the standard deviation of the noise. Statistical Test: Data were analyzed using SPSS with ANOVA test at 0.05 significance level to evaluate the effect of TE variation on SNR and CNR. (Usmadi, 2020)

2.2.4 Data management

- H_0: TE variation does not affect SNR and CNR values on MRI.
- H_1: TE variation affects SNR and CNR values on MRI.

The results of the F ANOVA test are compared with the critical value of Ftable to determine whether TE variation has a significant effect on SNR and CNR values. If Fcount > Ftable then H0 is rejected, indicating a significant effect. (Tannady & Munardi, 2015)

3. RESULTS AND DISCUSSION

This study involved 30 patients, consisting of 17 men and 13 women, with an age range of 25 to 75 years. The analysis was performed with Region of Interest (ROI) segmentation on Corpus, Discus, CSF, and background tissues to measure SNR and CNR values. (Ejaz et al., 2022)

3.1 Effect of TE Variation on SNR

Based on the research conducted, the average SNR value for each TE was calculated and can be seen in Table 1. This table displays a graph between TE variation and average SNR. (Nabaa A., 2023)

Table 1. average SNR value

TE variation (ms)	Average result SNR		
	Corpus	*Discus*	CSF
80	147,894	71,164	284,988
90	122,818	58,504	251,838
100	105,830	49,694	229,635
110	87,771	39,248	197,095

In Table 1, it can be observed that the SNR value generated in each network decreases as the TE value varies and from the average results, the following graph is obtained.

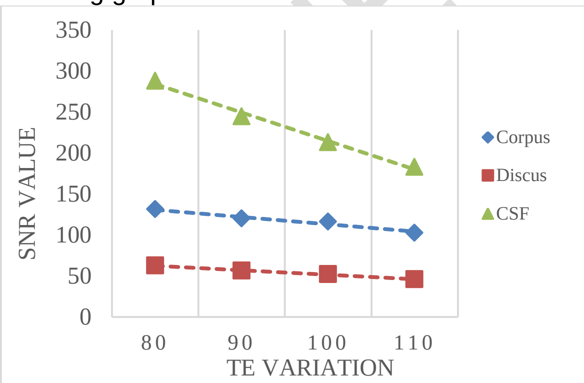

Figure 2 graph of the effect of TE variation on SNR

Figure 2 shows that the SNR value decreases as the TE value increases, this occurs in every network evaluated, this is due to the decrease in TE while the applied TR remains constant, thus not changing the time. (Muzamil et al., 2023) The highest SNR value is observed at the lowest TE variation. The analysis shows that the highest SNR value occurs at 80 ms TE.

To analyze the effect of TE variation on SNR value, anova F test was conducted, before the test was conducted it was ensured that the data met the assumptions of normality and homogeneity (sig > 0.05). The anova test showed that TE variation significantly affected SNR in corpus, discus, and CSF tissues (F < 0.05). Based on the analysis results, the F_{count} value was greater than F_{table} at the 0.05 significance level, indicating rejection of H_0 and acceptance of H_a. (Junaidi, 2010). This indicates that increasing TE contributes to an increase in SNR values in all analyzed tissues. These results support the hypothesis that TE variation has a significant effect on SNR, with a pattern of signal enhancement in corpus, discus, and CSF tissues as TE values increase.

3.2 Effect of TE Variation on CNR

The average CNR value for each TE was also calculated, which can be seen in Table 2 and displays the graphical relationship between TE variation and average CNR.

Table 2. average CNR value

TE variation	Average result CNR		
(ms)	*Corpus*	*Discus*	CSF
80	147,370	70,641	284,464
90	122,332	58,018	251,352
100	105,383	49,247	229,188
110	89,973	40,442	202,581

It can be seen in Table 2 that the CNR value produced in each network decreases along with the increase in TE value variation (Muzamil et al., 2018). And from these average results, the following graph is obtained.

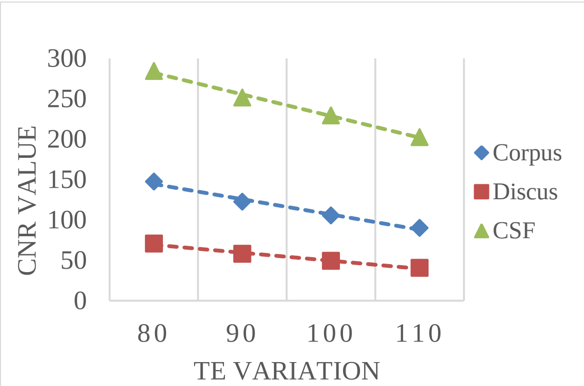

Figure 3 graph of the effect of TE variation on CNR

Figure 3 shows that the CNR value also decreases as the TE value increases, providing a shorter TE will increase the number of signals received and increase the CNR value, which ultimately affects the CNR (Hidayah et al., 2015). The highest CNR values were observed at lower TE variations. The analysis shows that the highest CNR value occurs at 80 ms TE. The measurement results show that the SNR and CNR values decrease as the echo time (TE) increases. Before the anova test, normality and homogeneity tests were conducted, which showed that the data met the statistical assumptions (sig > 0.05).

Anova test results showed that TE variation significantly affected CNR in corpus, discus, and CSF tissues (F < 0.05). An Fcount value that is greater than Ftable at a significance level of significance level of 0.05 indicates rejection of H0 and acceptance of Ha. This indicates that increasing TE significantly contributed to the increase in CNR values in the analyzed tissues. The results of this analysis are consistent with the hypothesis that TE variation significantly affects CNR, with a pattern of improvement similar to the effect of TE on SNR. (Ma et al., 2022)

4. CONCLUSION

This study shows that variations in echo time (TE) have a significant effect on the signal to noise ratio (SNR) and contrast to noise ratio (CNR) values in corpus, discus, and CSF tissues. The analysis shows that increasing TE tends to decrease SNR and CNR values, while shorter TE increases the received signal, contrast differences between tissues, and reduces noise, resulting in better image quality. The highest SNR and CNR values were found at a TE of 80 ms, indicating that this TE is good for producing high quality images, supporting diagnostic accuracy, and detection of small structures and lesions in MRI imaging.

5. RECOMMENDATIONS

For future input so that there is further development related to this research, it is expected that it is better to conduct research on other organs and of course with different parameter variations to get results that will be even more optimal. When taking ROI, it is expected to be more thorough in order to get the best data.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models and text-to-image generators have been used during writing or editing of this manuscript.

CONSENT

All authors declare that a 'written informed consent was obtained from all the patient;

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