KPJ 8(1) (2024)

KAPPA JOURNAL

Physics & Physics Education

https://e-journal.hamzanwadi.ac.id/index.php/kpj/index

The Effect of Time Repetition Variation on Brain MRI Imaging Quality on T2 Weighted Sequences A

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Received: 28 December 2023
Revised: 16 April 2024
Accepted: 30 April 2024

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DOI: https://doi.org/10.29408/kpj.v8i1.24885

Abstract: Magnetic Resonance Imaging (MRI) is an imaging technique used to produce images of parts of the human body by utilizing a strong magnetic field. The examination that is often carried out is a brain examination. This research was conducted at Bali Mandara Hospital. To find out the condition of the brain, an MRI examination can be done. MRI can produce images known as sequences which produce T1 Weighted Image (T1WI), T2 Weighted Image (T2WI), resulting in visible images with different intensities. To obtain T2WI, the time echo (TE) and time repetition (TR) must be long to give the fat and water a chance to decay, so that the fat and water contrast can be visualized well. This research aims to determine the effect of TR variations on SNR values, and determine the best TR to produce good image values. To generate T2WI SNRs on brain MRI. This street vendor activity uses a Phillips 1.5 Tesla type MRI aircraft. Data collection was obtained from twenty patients with 3 variations of TR values starting from 3,500 ms, 5,500 ms and 7,500 ms by obtaining a total of 60 images. Evaluate tissue SNR values by measuring ROI directly on the MRI device. SNR value analysis was performed on cerebrospinal fluid (CSF) tissue, spinal cord. Sequentially the SNR values obtained were 174.24, 211.22 and 244.51 in the CSF tissue 78.53, 80.64 and 84.81 in the spinal cord tissue. This street vendor activity has shown the result that the longer the TR value is given, the SNR value will increase. This is because long TR values are able to evaluate networks in more slices and provide better noise signal values. The TR variation of 7,500 ms can produce the highest SNR value so that the resulting image is very good.

Keywords: MRI, brain, SNR, TR, variations

Introduction

Magnetic Resonance Imaging (MRI) is an imaging technique used mainly in the medical world to produce high-quality images of the inside of the human body (Hornak, 1996) . Unlike other diagnostic tools, MRI does not produce ionizing radiation because the strength of the MRI machine is determined by the strength of the magnetic field. The development of the MRI aircraft is based on the size of the magnetic field strength which varies from 0.064 to 1.5 Tesla, even the newest one currently is the MRI with 4 Tesla. The magnitude of the magnetic field strength will affect imaging capabilities such as image resolution results and the length of scanning time. The advantages of MRI are that it is more sensitive for detecting abnormalities in soft tissue such as the brain, spinal cord and musculoskeletal system, is able to provide a clearer picture of anatomical details, and is able to carry out diffusion, perfusion and spectroscopic examinations (Hardiyanti, 2017) . MRI is able to produce images with various cuts such as coronal, sagittal, axial and oblique cuts without much manipulation of the patient's body position so that the

How to Cite:
Karang, A. R. D. D. A., Sutapa, G. N., & Negara, I. P. S. D. (2024). The Effect of Time Repetition Variation on Brain MRI Imaging Quality on T2 Weighted Sequences A. *Kappa Journal, 8*(1), 70-74. https://doi.org/10.29408/kpj.v8i1.24885

image results are very suitable for soft tissue diagnostics (Hardiyanti, 2017).

MRI examinations used to analyze body tissue include MRI examinations of the brain, head, neck, thorax, abdomen, pelvis, vertebrae, upper extremities and lower extremities. One of the MRI examinations that is often performed is a brain examination. The brain is the center of the entire body. The human brain controls all body functions. If the brain is healthy it will encourage bodily health and will support mental health, conversely if the brain is disturbed then bodily and mental health can be disrupted.

To find out the condition of the brain, an MRI examination can be done. MRI can produce images known as sequences which produce T1 Weighted Image (T1WI), T2 Weighted Image (T2WI), resulting in visible images with different intensities. To obtain T2WI, the time echo (TE) and time repetition (TR) must be long to give the fat and water the opportunity to decay, so that the fat and water contrast can be visualized well (Westbrook C. , 1998) . According to Moeller (2007), a TR value with a range of 3000-8000 ms and a TE value of 100-200 ms will produce an image with a T2WI sequence (Moeller, 2007) . Meanwhile, according to Westbrook, in 2014 the TR value required was more than 4000 ms and the TE value was more than 90 ms. The differences in TR and TE in T2WI images greatly influence the signal value and image contrast as well as the time required to produce an MRI image (Westbrook C. , 2014) . SNR is one of the benchmarks for determining MRI image quality. SNR affects signal intensity on MRI

In previous research conducted by Miskah Nur in 2014 regarding the effect of TR variations on image information in lumbar examinations, it was stated that TR 500 ms produced better images and was considered more optimal than variations of TR 300 ms and 400 ms in lumbar examinations with a T2WI sequence SE. Previously this was also carried out by Rizky Hetiyanto in 2018 regarding differences in anatomical image information for cervical MRI examinations in the sagittal TSE T2WI series using TR variations of 3100 ms, 3400 ms, 3600 ms and 3900 ms. The results of this research are images with a TR value of 3400 ms which are better than other TR variations.

Based on the results of two previous studies, there are differences in results, where in Miskah Nur's research in 2014 the longest TR value produced the best image, but in Rizky Hetiyanto's research in 2018 it was not the longest TR value that produced the best image. There has been no research regarding the influence of TR variations on brain examination, based on the results of direct field observations, there was repeated image taking at the request of the radiologist. Therefore, this study aims to determine the effect of TR variations on SNR values and determine the best TR variations to produce brain MRI images.

Method

The research method used is quantitative analytics in the form of experiments and direct field observations. In collecting data from 20 patients with TR variations, 60 image data will be obtained for analysis. To obtain optimal SNR values, a segmentation method is used in the form of region of interest (ROI). ROI determination can be done directly on the computer. ROI segmentation is performed on CSF (Cerebro Spinal Fluid), spinal cord, and background as noise in the image results. Analysis of the results of the data was carried out on the average signal in the CSF, spinal cord, standard deviation of background noise. The SNR value is obtained from the division between the average signal in the CSF, spinal cord and the standard deviation of background noise. The results of the analysis of the SNR data will determine the quantity of head imaging, so that the optimal value of the TR variation can be determined.

The research method used is quantitative analytics in the form of experiments and direct field observations. Where in taking data from 20 patients with TR variations, 60 images of data will be obtained to be analyzed. The TR variations given are 3500 ms, 5500 ms and 7500 ms. As well as several other parameters which are constant slice thickness of 5 mm, bandwidth of 218 Hz, TE parameter of 110 ms, matrix of 400 x 400, FOV of 240 x 240, flip angle of 90°, NEX of 1, slice orientation is sagittal and ETL of 11.

To obtain an optimal SNR value, a segmentation method in the form of a region of interest (ROI) is carried out. The determination of ROI can be done directly on the computer. ROI segmentation was carried out on CSF (Cerebro Spinal Fluid) tissue, spinal cord, and background as noise in the resulting image. Analysis of the data results was carried out on the average signal in the CSF, spinal cord, standard deviation of noise in the background. The SNR value is obtained from the division between the average signal in the CSF, spinal cord and the standard deviation of noise in the background as shown in the equation below (Weisphaut, 2006).

$$\text{SNR} = SNR = \frac{\bar{S}_{(signal)}}{N_{(noise)}} \quad (1)$$

S is average signal of several networks using the ROI method and N is noise outside the head image area resulting from ROI. The results of the analysis of the SNR data will determine the quality of the head imaging, so that the optimal value of the TR variation can be determined.

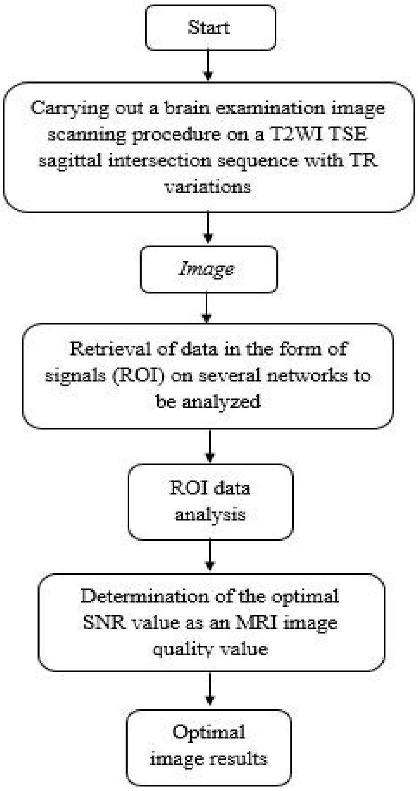

Figure 1. Research scheme

Result and Discussion

Three variations of TR were performed on brain MRI examinations on T2WI sequences, namely 3500 ms, 5500 ms and 7500 ms. The results of the inspection image obtained, segmentation analysis of the region of interest (ROI) was carried out (Aditya, 2017). Tissue ROI measurements were carried out in all patients for three images of each TR variation in the CSF, spinal cord and background areas. Figure 2 shows an analysis of the first patient ROI measures on the evaluated tissue and the ROI on the background.

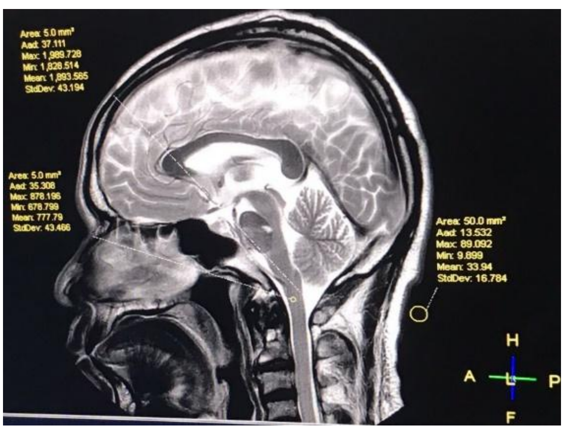

Figure 2. Tissue ROI

Measurement of signal data in CSF tissue, spinal cord and standard deviation of noise in the background using the ROI method is used to obtain SNR values using equation 1 for each TR variation. The results of calculating the average SNR value from 20 patients are shown in table 1.

Tabel 1 Average SNR results

TR Variaton (ms)	Average SNR results	
	CSF	Medulla Spinalis
3.500	174.24	78.53
5.500	211.22	80.64
7.500	244.51	84.81

A graph of the relationship between TR (time repetition) variations and SNR (signal noise ratio) values can be seen in Figure 3

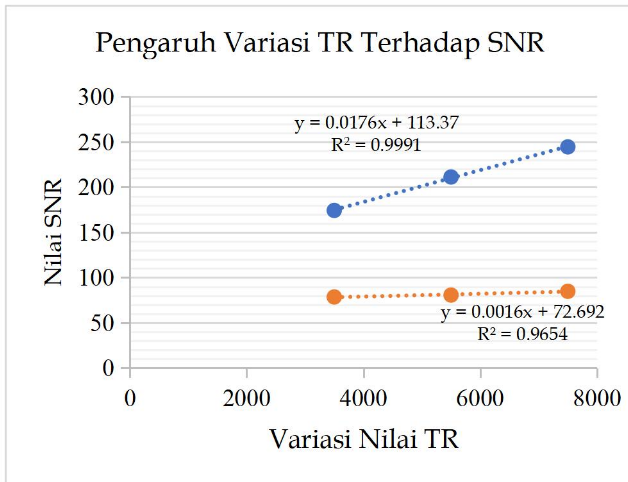

Figure 3 Graph of the relationship between TR variations and SNR values.

In this study, TR variations of 3500 ms, 5500 ms and 7500 ms were carried out. Based on the results of the calculation analysis, the SNR value produced in each network appears to be increasing in proportion to the increase in variations in the TR value. The longer the TR given, the greater the resulting SNR value will be. This can be seen in Figure 3, which is a graph of the results of calculating the average SNR value for each patient examination image. In the CSF network, the average SNR value for TR 3500 ms was 182.00, for TR 5500 ms it was 219.60 and for TR 7500 ms it was 256.12. In spinal cord tissue, the average SNR value for TR 3500 ms was 82.61, for TR 5500 ms it was 85.34 and for TR 7500 ms it was 90.13. The highest SNR value is found in the TR variation of 7500 ms. According to

Westbrook (2002), TR is a parameter that controls the amount of longitudinal magnetization that is recovered before administering the next RF pulse. A long TR allows recovery so that more will experience transverse magnetization in the next RF pulse (Westbrook C. , 2002). A long TR will increase the SNR and a short TR will decrease the SNR. This can be seen in table 3 and the results of the average SNR value calculation which shows an increase in the average SNR value with different TR variations. The average SNR value per organ increases along with the increase in the TR value because the longer the TR, the more the signal increases.

There is a very significant difference in SNR values in the CSF tissue and spinal cord, this is because each tissue has a different number of hydrogen atoms. CSF is a clear fluid that is in and around the brain and spinal cord, while spinal cord tissue is a collection of nerve fibers that run along the spine, which stretches from the bottom of the brain to the lower back. CSF tissue has a greater SNR value than the SNR value of spinal cord tissue because there are more hydrogen atoms in the CSF tissue so that when the MRI tool is activated, more signals are captured by the coil from that tissue. The difference in signals captured by the receiving coil is closely related to the density conditions of a particular network. Hydrogen protons in water ($H2O$) which are found in tissues rich in water, will provide greater excitation energy, because in these tissues the H atoms are larger than the O atoms, the ratio is 2:1 (Nugroho, 2009). Therefore, CSF tissue has a greater SNR value compared to spinal cord tissue.

To determine the TR variation that produces the best SNR value, the Friedman test is carried out. Based on the Friedman test, the mean rank SNR value in the CSF network was obtained, namely the TR 3500 ms variation was 1.10, the TR 5500 ms variation was 1.95, and the TR 7500 ms variation was 2.95. In the spinal cord tissue, the TR 3500 ms variation was 1.73, the TR 5500 ms variation was 1.80, and the TR 7500 ms variation was 2.48. It can be seen that the SNR value in CSF and spinal cord tissue is good when giving a TR variation of 7500 ms. This is in accordance with theory where if the mean rank SNR value is close to 5, it indicates that an object can be recognized or detected well. However, if the SNR value is close to 0, then the object will be difficult to detect (Bushberg, 2012). This statement is supported by previous research conducted by Miskah Nur in 2014 which stated that the longer the TR time given, the greater the resulting mean rank and the image produced from the longest TR is the best image. However, this research is not in line with the results of research conducted by Rizky Hetiyanto in 2018 which stated that it is not the longest TR value that is capable of producing the best image.

Conclusion

Based on the results of the research that has been carried out, the following conclusions can be drawn is from the results of measuring the ROI value which produces SNR in the CSF, spinal cord and background areas, it can be concluded that there is a difference between TR variations on SNR, namely that the greater the TR value given, the greater the resulting SNR value. And A TR variation of 7,500 ms can produce the highest SNR value so that the resulting image is very good.

Acknowledgments

I would like to thank the radiology installation at the Bali Mandara General Hospital for their assistance for approximately one month in the process of collecting data for this field work practice report.

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