Signal to noise ratio and anatomical information of T1-weighted spin echo and T1-weighted SPIR in post-contrast brain MRI metastases case

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Abstract. Brain MRI examination using contrast media can improve detection of brain metastases. The fat saturation technique is recommended to suppress large amounts of signals from fat and improve contrast enhancement. The purpose of this study was to determine the differences in SNR values and anatomical image information on post-contrast Brain examination between T1-Weighted Spin Echo and T1-Weighted SPIR sequences in metastatic cases. The study is a quantitative experimental. The results of the study were obtained based on Radiologist’s assessment and SNR measurement from gray matter, white matter, ventricular, cerebrospinal fluid, and pathological lesions. Analysis of this research data using the Wilcoxon sign rank test statistic. There is a significant difference between the SNR value of the two sequences. The results in anatomical information showed no difference. T1W sequence Spin echo had better visualization in gray matter, and white matter, while T1W SPIR sequence had advanced in pathological lesions appearance.

1. Introduction
According to data from Riset Kesehatan Dasar (Risksdas) in Indonesia, the mortality rate due to various non-contagious diseases (heart, stroke, cancer, high blood pressure, diabetes) reached 59% of all deaths. Cancer is a chronic disease that continues to increase and is the second leading cause of death in the world, thus cancer is a concern for past few decades along with the increasing number of chronic diseases in the world. In 2008 there are 7.6 million people in the world died of cancer, 70% of them occur in low and middle-income countries where 30% can be prevented [1]. New cases of cancer in the world have reached nearly 12.7 million and will increase to 21.4 million in 2030. 5.6 million of them occur in developed countries while 7.1 million occur in developing countries [2]. Cancer is a leading cause of death worldwide. Due to growing aging population and high prevalence of exposure to known risks factors [3], an increase in cancer burden has been observed and it is expected to almost double by 2030 despite the advances in timely diagnosis and medical treatment [4]. Lung, breast, colorectal, digestive and prostate cancer is type of cancer that contribute for the highest mortality [5]. Metastasis is spread of cancer cells from the primary tumor to the surrounding tissue and to distant organs and is a major cause of cancer morbidity and mortality. About 90% of metastasis are estimated to be the cause of cancer deaths and around 1.500 people continue to die every day due to cancer,
which proves that failure to manage disease after spreading throughout the body [6].

Until now Magnetic Resonance Imaging (MRI) is still considered the best imaging modality when compared to other advanced modalities, because it is able to image the network with a high degree of accuracy. MRI is a drawing technique of cross-section of the body based on the principle of magnetic resonance in the nucleus of a hydrogen atom. MRI drawing techniques are relatively complex, because the resulting image depends on the number of parameters. MRI modality has the ability to draw coronal, sagittal and axial images without much manipulating the patient's body. If the selection of parameters is correct, the detailed quality of the human body will be clear. For this reason, it is necessary to understand things that related to MRI examination procedure. MRI is sensitive to detect some abnormalities in soft tissues such as the brain, spinal cord and musculoskeletal. MRI is able to give a clearer picture of anatomical detail and do diffusion, perfusion and spectroscopic examinations. MRI also does not use ionizing radiation [7]. Extensive use of sequences of T1-weighted images (T1WI) for neurological imaging is useful for evaluating anatomical structures. Acquired with the administration of contrast media, T1WI has improved the detection of brain metastases. Spin-echo (SE) is the most commonly used pulse sequence for T1WI.

According to Westbrook [8], Fat Suppression is one of the fat suppression techniques, fat suppression pulse is only used when applied (especially fat), and is not effective if applied to the air. Fat saturation is recommended to suppress signals in large quantities from fat and the acquisition can be proven in the contrast media enhancement image. Fat saturation is also useful to avoid misregistration of artifacts, so it can be used in various kinds of imaging sequences.

Jing Wuu [9] states that there are several techniques that can be used to suppress fat signals, one of which is Spectral Pre-saturation with Inversion Recovery (SPIR) which when compared with conventional STIR will apply an inverse pulse of 100° - 140°, then followed by giving actual pulse. Unlike SPIR, Spectra Attenuation with Inversion Recovery (SPAIR) still uses a 180° angle as an inverse pulse but is applied to the attenuation pulse. Both SPIR and SPAIR can be applied to all types of sequences, very different from STIR because it is a complete sequence [9].

According to Kartawiguna [10], the purpose of an MRI examination is to get an image of diagnostic information quickly. To achieve that goal, it must understand an image very well. Optimal quality of MRI is determined by three characteristics, namely spatial resolution, signal to noise (SNR), contrast to noise ratio (CNR). Spatial resolution is the ability to distinguish between two points separately and clearly, and serves to see the sharpness of the image in identifying small objects. SNR is a comparison between the magnitude of the amplitude of the signal and the amplitude of the noise, the SNR value is used as a criterion to determine image quality. Because the increase in SNR value is followed by an increase in image quality. High SNR can be utilized to produce images with good spatial resolution because SNR is influenced by the strength of the magnetic field. CNR is the difference between SNR organs that are close together.

The use of Gadolinium (Gd) contrast media on MRI examination serves to evaluate abnormalities of tumor, inflammation and infection. Gd-DTPA contrast media will shorten the relaxation time of hydrogen proton T1 on the tissue, thus it will increase the signal intensity at T1 weighting which effects in enhancement especially on pathological tissues. Therefore, gadolinium is called T1 enhancement agent [8]. Gd-DTPA is used on MRI Brain examinations for metastatic cases, SPIR represents an adjunct to T1-weighted images, because of its ability to increase conspicuity lesions, especially in cases of spinal metastatic disease and infection. More experience is needed to determine unclear images, for time savings of several sequences (post Gd-DTPA T1 or SPIR pre contrast).

Based on initial observations of researcher, the contrast MRI Brain examination protocol used the T1 Axial SPIR, T1 Coronal SPIR, and T1 Sagittal SPIR post contrast sequence. This attracted the interest of researcher to conduct research about the use of fat suppression SPIR post-contrast on MRI Brain examination with Metastases cases. Furthermore, the researcher wanted to examine " Signal to Noise Ratio and Anatomical Information of T1-Weighted Spin Echo and T1-Weighted SPIR in Post-contrast Brain MRI Metastases Case".
2. Experimental method

The type of research used is quantitative experimental designs research with a one-shot case study approach. The population in this research were all patients MRI Brain Post contrast examination and assistance from 3 radiology specialists to provide an assessment of anatomical images. The experiment was conducted to determine the SNR differences and MRI Brain post contrast anatomical image information in the case of metastases with T1W Spin Echo and T1W SPIR sequences and to find out the optimal image on anatomic image information between T1W Spin Echo and T1W SPIR.

3. Result and discussion

Data collection that has been done and obtained 40 images from 10 research samples. To see the difference in SNR values and Brain MRI image information in the case of metastases resulting from the use of T1W Spin Echo and T1W SPIR sequences, the researcher will describe the image of one study sample as follows: Brain axial MRI image results appear as shown in Figure 1 and Figure 2.

![Figure 1. MRI Brain Axial image results appear lesions T1W SPIR](image1.png)
![Figure 2. MRI Brain Axial image results appear lesions T1W SE](image2.png)

MRI Brain scanning results in metastatic cases using the T1W Spin Echo sequence with T1W SPIR above were obtained from one of the study samples. Based on the visualization of the image above, it shows that there are differences in the contrast of pathological lesions in the T1W SPIR sequence. Furthermore, from the visualization of the image it is also known that the T1W Spin Echo sequence is capable of producing images with sulcus and gyrus boundaries that are firmer than the T1W SPIR sequence.

The image results are then assessed by 3 Radiology Specialists as research respondents with the condition that they have the ability to possess knowledge in the MRI field for more than 5 years. Respondents filled out questionnaires in the form of a check list consisting of anatomical criteria for each image using a T1W Spin Echo sequence with T1W SPIR. The anatomical criteria in this study consisted of White matter, Gray matter, ventricles, Cerebrospinal Fluid, and pathological lesions. Then the respondents filled out the questionnaire with an assessment using a score (score 1 = unclear, 2 = clear, 3 = very clear). From the results of the questionnaire grouped based on the techniques used in the images that have been valued.

The results of this study were carried out statistical tests using SPSS, namely the Cohen’s Kappa test to determine the level of agreement and objectivity among respondents, namely respondent 1, respondent 2 and respondent 3. The results of the Cohen’s Kappa test show that there is an agreement of perceptions between the first and second reviewers with a Kappa value of 0.485. The three reviewers did not have sufficient reliability because the kappa value was <0.600, so for the next statistical test the researcher only used data from one reviewer with the largest Kappa value. The data that the researcher uses is the image information data from the first and second reviewers. The first reviewer was chosen because the reviewer was the most senior doctor of the three reviewers.
Test of Statistics on Anatomical and SNR Information on T1W Spin Echo and T1W SPIR sequences.

3.1. Image information assessment
The next statistical test is the normality test. The normality test is done to see whether there is a difference between the two groups in pairs. From the data taken the distribution of the two groups of data is not normal, because the sample is less than 30, the normality test used is the Wilcoxon test. The following are the results of the non-parametric Wilcoxon statistical test between T1W Spin Echo and T1W SPIR in the anatomy area which can be seen in table 1.

| Anatomy area  | P value  | Results          |
|---------------|----------|------------------|
| Grey Matter   | 0.414    | There is no difference |
| White Matter  | 0.096    | There is no difference |
| Ventricle     | 0.025    | There is a difference |
| CSF           | 1.000    | There is no difference |
| Pathological lesion | 0.107 | There is no difference |

Based on Table 1, the results of the Wilcoxon test for anatomical information (p> 0.05), which means that there is no significant difference with the use of T1W Spin Echo and T1W SPIR sequences. The results of the p value showed no difference between the two sequences found in each organ, namely 0.041 in Gray Matter, 0.096 in White Matter, 1.000 in CSF, and 0.107 in pathological lesions, whereas the results showed that there were differences between the two sequences in the organ ventricle with p value of 0.025. In table 2 can be seen the results of the Wilcoxon test as a whole anatomy:

| Anatomy area               | Mean rank | Results          |
|----------------------------|-----------|------------------|
| GM, WM, VNT, CSF, PL       | 0.518     | There is no difference |

Based on the results of the non-parametric statistical test of Wilcoxon in the entire anatomical area, it was found that the significance level for the whole area was p value 0.518 (p> 0.05) which means that there was no significant difference in the T1W Spin Echo sequence with T1W SPIR in the entire anatomical area. To see a better sequence, mean rank results were obtained from the Wilcoxon test. Mean rank results in each anatomical area can be seen in the table 3.

| Sequence                  | Anatomy Area |
|---------------------------|--------------|
|                            | GM WM VNT CSF PL |
| T1W Spin Echo            | 2.25 3.60 0.00 1.50 3.50 |
| T1W SPIR                  | 1.50 3.00 3.00 1.50 4.83 |
Based on the results of Wilcoxon's mean rank analysis in table 3, in the sequence T1W Spin Echo each mean rank values in the anatomical area are, 2.25 in Gray Matter, 3.60 in White Matter, 0.00 in Ventricles, 1.50 in CSF, and 3.50 in pathological lesions. In the T1W SPIR sequence each mean rank values in the anatomical area are, 1.50 in Gray Matter, 3.00 in White Matter, 3.00 in Ventricle, 1.50 in CSF, and 4.8 in pathological lesions.

This shows a comparison of the T1W SPIR sequence having a higher value in the area of anatomy of Pathological Lesions than using the T1W Spin echo sequence. While in the other anatomic areas Gray Matter, White Matter is higher in value in the T1W Spin echo sequence. To find out a sequence that is better at revealing the overall anatomy, here is a table 4 of mean Wilcoxon test ranks throughout the anatomy:

| Sequence          | Mean rank |
|-------------------|-----------|
| T1W Spin Echo     | 12.90     |
| T1W SPIR          | 12.21     |

Based on the results of the mean rank of the Wilcoxon test in the entire anatomic area, it was found that the T1W Spin Echo sequence had a higher value than the T1W SPIR sequence with a mean value of 12.90, which means that the sequence T1W Spin echo is a better sequence in revealing anatomic area. According to Melhem (1998) [11] that T1SE imaging revealed more lesions and higher CNR than T1IR imaging. This is in accordance with the magnitude of TR 600 on T1W SE and TR 450 T1W SPIR. T1W Spin Echo imaging shows an increased level of lesion signal intentions higher than T1 SPIR imaging. In the opinion of researchers, the use of fat saturation in the case of metastases is able to clarify the lesion between the surrounding tissues, because the RF pulses in the SPIR are set in the range of 100 ° -180 °. Each transverse magnetization component of RF pulses is reduced by spoilers’ gradients. Residual (inverted) longitudinal magnetization of fat is allowed to grow back through T1 relaxation for the next 100-200 msec. With the use of T1W SPIR enhanced lesions turn white between black fat

3.2. SNR Assessment
The next statistical test is the normality test. The normality test is done to see whether there is a difference between the two groups in pairs. Shown in table 5 the results of the data normality test.

| Sequence          | P value | Information |
|-------------------|---------|-------------|
| T1W1 Spin Echo    | 0,000   | Abnormal    |
| T1W1 SPIR         | 0,000   | Abnormal    |

The Table 6 is the results of the Wilcoxon non parametric statistical test between T1W Spin Echo and T1W SPIR in the area of the anatomy that can be seen:
Table 6. Results of Wilcoxon test SNR value with the use of T1W Spin Echo and T1W SPIR sequences

| Anatomy Area          | P value | Results               |
|-----------------------|---------|-----------------------|
| Grey Matter           | 0.005   | There is no difference|
| White Matter          | 0.005   | There is no difference|
| Ventricle             | 0.005   | There is no difference|
| CSF                   | 0.005   | There is no difference|
| Pathological Lesion   | 0.047   | There is no difference|

Based on Table 6, the results of the Wilcoxon test for SNR values (p > 0.05), which means there are no significant differences with the use of T1W Spin Echo and T1W SPIR sequences. The results of the p value showed that there were differences between the two sequences in each organ, namely 0.005 in Gray Matter, 0.005 in White Matter, 0.005 in CSF, and 0.047 in pathological lesions.

Results of Mean Rank value of signal to noise ratio in Overall Anatomy were analyzed by looking at mean rank value to find out better image quality between T1W Spin echo and T1W SPIR sequences. Based on the results of the test, mean rank values were obtained as follows:

Table 7. Results of analysis of mean Wilcoxon test rank

| Sequence     | Anatomy Area |
|--------------|--------------|
| T1W Spin Echo| GM 0.00 WM 0.00 VNT 0.00 CSF 0.00 PL 8.00 |
| T1W SPIR     | GM 5.50 WM 5.50 VNT 5.50 CSF 5.50 PL 5.22 |

Based on the results of Wilcoxon's mean rank analysis in table 7, in the sequence T1W Spin Echo each mean rank in the anatomical area, 0.00 in Gray Matter, 0.00 in White Matter, 0.00 in Ventricle, 0.00 in CSF, and 8.00 in pathological lesions.

In the T1W SPIR sequence each mean rank values in the anatomical area are, 5.50 in Gray Matter, 5.50 in White Matter, 5.50 in Ventricle, 5.50 in CSF, and 5.22 in pathological lesions. This shows a comparison of the sequence T1W Spin Echo has a higher value in the anatomical area of Pathological Lesions than using the T1W SPIR sequence. Whereas in the other Gray Matter anatomy area, White Matter is higher in value on the T1W SPIR sequence. To find out a sequence that is better at revealing the overall anatomy, here is table 8 of mean Wilcoxon test ranks throughout the anatomy:

Table 8. Results of mean rank Wilcoxon test for overall anatomy

| Sequence     | Anatomy Area |
|--------------|--------------|
| T1W Spin Echo| 0.00         |
| T1W SPIR     | 25.50        |

Based on the results of the mean rank of the Wilcoxon test in the entire anatomic area, it was found that the T1W SPIR sequence had a higher value than the T1W Spin echo sequence with a mean value of 25.50, which means that the T1W SPIR sequence was a better sequence in revealing anatomic areas.

4. Conclusion
Based on the results and discussion of the research that has been carried out it can be concluded that the results of the research of anatomical image information have a significant difference between the SNR value of the two sequences. The results in anatomical information showed no difference. T1W
sequence Spin echo had better visualization in gray matter, and white matter, while T1W SPIR sequence had advanced in pathological lesions appearance.

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