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DIAGNOSIS OF VASCULAR LESIONS IN THE BRAIN – COMPARING T_2 AND FLAIR SEQUENCES

Amina Kubat,
MA of Radiologic Technology

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ABSTRACT

Introduction: Vascular brain lesions refer to brain damage caused by problems with blood vessels and can include various disorders such as stroke, aneurysms, blood clots, and others. Because different brain tissues have different characteristic relaxation times, T_2 and the FLAIR sequence can also be used to deal with different tissue stresses. the T_2 sequence provides high intensity while the FLAIR sequence achieves complete saturation of cerebrospinal fluid. The objectives of this study are to compare the visualization of vascular lesions using T_2 and the FLAIR sequence and to determine which sequence provides a better depiction and additional information about vascular lesions.

Research Methods: The study was designed as a retrospective descriptive study, conducted at the Private Healthcare Institution 'Medical Center' in Travnik using an MRI machine: MRI Siemens Avanto A + Tim + Dot System, with a strength of 1.5 T. The study involved 50 patients diagnosed with vascular lesions.

Results: In the age group from 50 to 59 years, 7 patients with FAZEKAS 0 – 1 (46.66%), 4 patients with FAZEKAS 1 (26.66%), 3 patients with FAZEKAS 2 (20%) and one patient with FAZEKAS 3 (6.66%) were diagnosed. In the age group from 60 to 69 years, 6 patients with FAZEKAS 0 – 1 (28.57%), 6 patients with FAZEKAS 1 (28.57%), 6 patients with FAZEKAS 2 and 3 patients with FAZEKAS 3 (14.28%) were diagnosed. In the 70 to 79 age group, 2 patients were diagnosed with FAZEKAS 0 – 1 (14.28%), 5 patients were diagnosed with FAZEKAS 1 (35.71%), 5 patients were diagnosed with FAZEKAS 2 (35.71%) and 2 patients were diagnosed with FAZEKAS 3 (14.28%).

Discussion: Several studies have been conducted to evaluate the sensitivity of T_2 and FLAIR sequences in the diagnosis of vascular lesions in the brain. In the mentioned studies, it was found that the FLAIR sequence possesses superior capabilities in identifying and better displaying vascular lesions compared to healthy brain tissue. After measuring lesions in all 50 patients enrolled in the study, they were divided by size into three different groups:

a. Lesions smaller than 10 millimeters;
b. Lesions larger than 10 millimeters and smaller than 20 millimeters;
c. Lesions larger than 20 millimeters.

After statistical processing of the examined sample within this study, it was found that the FLAIR sequence provides a better representation of vascular lesions in the brain compared to the T_2 sequence in all three different groups, and it is concluded that the differences are statistically significant in favor of the FLAIR sequence in all three observed lesion sizes.

The prognostic value of FLAIR vascular hyperintensity still needs to be investigated. Future studies will determine in which settings the presence of FLAIR vascular hyperintensity can be used as valuable information for the clinician. FLAIR vascular hyperintensities indicate a risk of persistent vascular stenosis or occlusion, associated with an increased risk of future stroke. They also help identify patients with favorable collateral blood flow, who could benefit from aggressive revascularization therapy.

Conclusion: Statistically, there was a difference in the better presentation of vascular lesions on the FLAIR sequence compared to the T_2 sequence. In some cases, a T_2 sequence may be sufficient but in most cases a FLAIR sequence is preferable. Although the noise level is higher on the FLAIR sequence compared to the standard T_2 sequence, the FLAIR sequence is more useful in detecting vascular lesions.

Keywords: MRI, FAZEKAS scale, relaxation time.

INTRODUCTION

Magnetic resonance imaging (MRI) plays a significant role in the diagnosis of vascular lesions in the brain, which is manifested in the ability to classify and detect brain pathophysiology in order to adequately and timely conduct therapeutic treatments.

T_2 sequence in magnetic resonance imaging (MRI) refers to a sequence used to obtain images of the body based on the difference in relaxation times of excited magnetizations of different tissues. The mentioned sequence utilizes spin-echo technology, which employs a pair of different radiofrequency pulses to manipulate the magnetization in tissues, and then collects the signals emitted during the return of magnetization to its baseline state. [2] T_2 sequences are often used for detecting pathologies that lead to water accumulation in tissues, such as edema and inflammation, as these tissues tend to appear as brighter areas on the images. If it is a pathological lesion localized near the cerebrospinal fluid, there is a simultaneous increase in signal intensity from both the cerebrospinal fluid and the lesion itself. This phenomenon on the T_2 sequence may lead to poorer visualization and localization of pathological changes.

Fluid – attenuation inversion recovery (FLAIR) sequence is an MRI sequence used to visualize structures in the brain and other tissues. FLAIR sequence allows the visualization of pathological lesions in the brain, such as multiple sclerosis, dementia, and tumors, in a way that reduces the signal originating from the cerebrospinal fluid (CSF) surrounding the brain.[2] T_2 Cerebrospinal fluid usually creates a strong signal on standard T_2 sequences that can make it difficult to visualize pathological lesions near it. FLAIR sequence uses a special radiofrequency pulse sequence that nullifies the signal from the

cerebrospinal fluid (CSF), allowing for the visualization of pathological lesions nearby. This sequence involves the application of the so-called "inverse" radiofrequency sequence that "reverses" the polarization of water molecules, after which the standard spin – echo sequence for signal collection is applied. As a result, images obtained by FLAIR sequences show pathological lesions as clearly visible, while cerebrospinal fluid is displayed as a darker signal. This allows for better visualization of structures in the brain and other tissues, which is particularly useful in the diagnosis of neurological conditions.

The FAZEKAS scale is used for the simple quantification of the amount of T_2 of white matter hyperintense lesions, which are usually attributed to chronic small vessel ischemia, although not all of these lesions can be associated with this cause.[3]

The FAZEKAS scale divides white matter into periventricular and deep white matter. Each of the following regions is assigned a degree according to the size and confluence of the lesions[3]:

a. Periventricular white matter (PVWM): 0 - absent, 1 - pencil-thin "caps" or lining, 2 - smooth "halo," 3 - irregular periventricular signal extending into the deep white matter;
b. Deep white matter (DWM): 0 – absent, 1 – punctate foci, 2 – beginning of confluence, 3 – large confluent areas.

It is important to note that the etiology of PVWM and DWM changes differs. Periventricular white matter (PVWM) refers to a combination of demyelination, granular ependymitis and subependymal gliosis, as well as small blood vessel ischemia. Deep white matter (DWM) is by nature a chronic ischemia of small blood vessels. It is also important to note that the deep white matter component result is useful for assessing patients with possible dementia and that this component is often referenced.

This research is structured in order to meet the following objectives:

1. To assess the sensitivity, specificity, positive and negative predictive value, and accuracy of the T_2 sequence in diagnosing the presence, location, and size of vascular lesions in the brain.
2. To assess the sensitivity, specificity, positive and negative predictive value, and accuracy of the FLAIR sequence in diagnosing the presence, location, and size of vascular lesions in the brain.
3. Determine differences in sensitivity, specificity, positive and negative prognostic value and accuracy between T_2 and FLAIR sequence in the diagnosis of the presence, location and size of vascular lesions.

RESEARCH METHODS

The study was conducted as a retrospective descriptive study, including patients who were included into the study in the period from 01. 01. 2023 to 01. 10. 2023 at the Private Health Institution "Medical Centar" in Travnik. The study included patients:

a. Who are in the age group from 50 to 80 years;
b. Who are referred to an MRI examination by a neurologist specialist for headaches, tremors, tinnitus, limb stiffness, dizziness and initial atherosclerotic changes;
c. Those in whom there is a suspicion of present vascular lesions, based on a previously performed computed tomography of the neurocranium;

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d. Those in whom the computed tomography of the neurocranium does not explain the present clinical picture, such as the absence of verbal contact, a shallower left nasolabial fold on the face, a lowered left corner of the mouth, and other neurological deficits;

e. In cases where computed tomography of the neurocranium indicates an intracerebral hematoma, urgent MRI of the neurocranium is indicated.

Magnetic resonance imaging of the neurocranium was performed on the machine at the Private Healthcare Institution 'Medical Center' in Travnik: MRI Siemens Avanto A + Tim + Dot System. The applied sequences are: axial, sagittal and coronal T_2 TSE, axial T_2 SE, flair, DWI and SWI.

STATISTICAL DATA PROCESSING

In all 50 patients, Both the T_2 sequences and FLAIR sequences were T_2 also interpreted in axial view to the size of vascular lesions (≤ 10 mm, 10 mm ≤ ≥ 20 mm, ≤ 20 mm). This interpretation was analyzed using descriptive statistics, which included the determination of the mean value of "*Mean*", the standard deviation "*Standard deviation*", the standard deviation of the mean value of "*Std. Error Mean*". The Student's t-test for equality and Levene's test were used to compare the means among the measurements. Statistical software SPSS, version 28.0 was used to process the aforementioned data.

RESULTS

In a retrospective descriptive study, 50 patients were included, namely 25 (50%) female and 25 (50%) male, aged 50 to 79 years, mean age 66.02 years. When it comes to patient age, 30% of patients are aged 50-59 years, 42% are aged 60-69 years, and 25% are aged 70-79 years.

In all 50 patients enrolled in the study (Chart 1), vascular lesions or changes in microcirculation were diagnosed: in 15 patients FAZEKAS 0 – 1 (30%), in 15 patients FAZEKAS 1 (30%), in 14 patients FAZEKAS 2 (28%) and in 6 patients FAZEKAS 3 (12%).

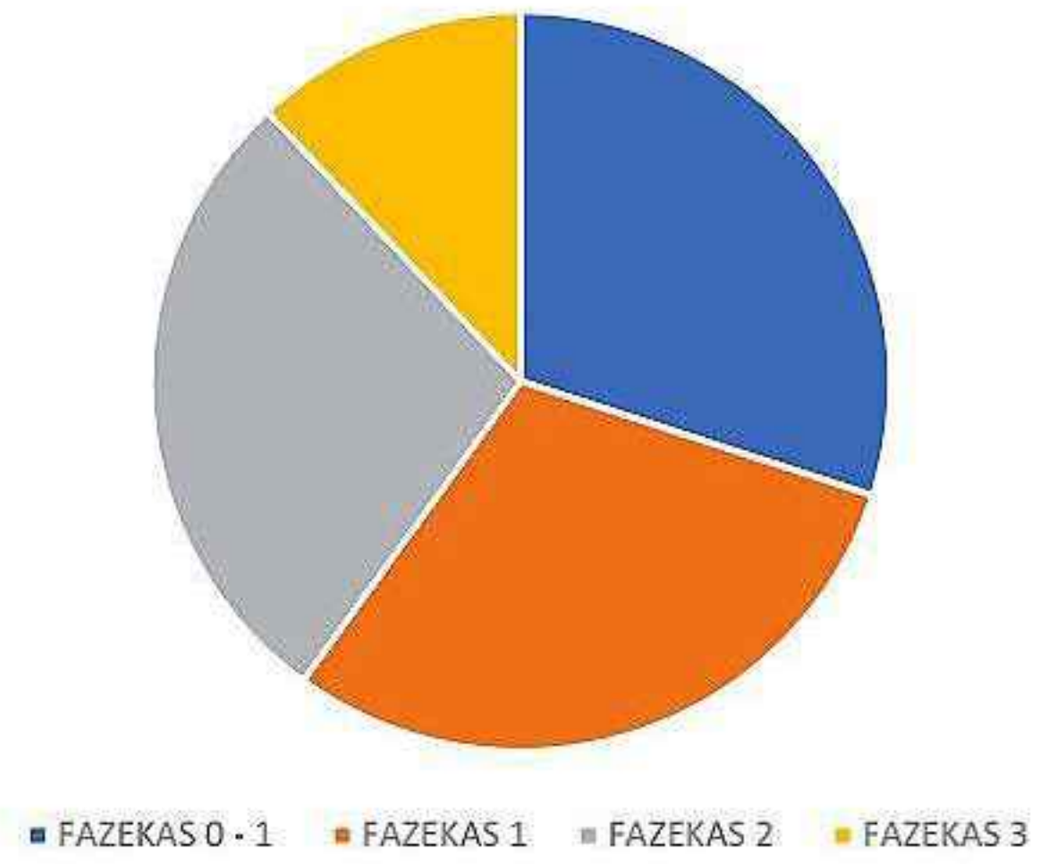

Chart 1 Diagnosis of vascular lesions

In the age group from 50 to 59 years, to which 15 patients belong, 7 patients with FAZEKAS 0 – 1 (46.66%), 4 patients with FAZEKAS 1 (26.66%), 3 patients with FAZEKAS 2 (20%) and one patient with FAZEKAS 3 (6.66%) were diagnosed.

In the age group from 60 to 69 years, to which 21 patients belong, 6 patients with FAZEKAS 0 – 1 (28.57%), 6 patients with FAZEKAS 1 (28.57%), 6 patients with FAZEKAS 2 and 3 patients with FAZEKAS 3 (14.28%) were diagnosed.

In the 70 to 79 age group, to which 14 patients belong, 2 patients were diagnosed with FAZEKAS 0 – 1 (14.28%), 5 patients were diagnosed with FAZEKAS 1 (35.71%), 5 patients were diagnosed with FAZEKAS 2 (35.71%) and 2 patients were diagnosed with FAZEKAS 3 (14.28%).

Presented lesions smaller than 10 millimeters

In all 50 patients enrolled in the study, vascular lesions in the brain smaller than 10 millimeters were measured and counted. Based on the provided data, the arithmetic mean was calculated, which shows that the FLAIR sequence has a higher arithmetic mean than the T_2 sequence (Table 1).

	Sequence	N	Mean	Std. Deviation	Std. Error Mean
Lesion <10mm	T2	50	--3.96	2,755	.390
	FLAIR	50	8.06	3.899	.551

Table 1 Presented lesions smaller than 10 millimeters

Based on the calculated arithmetic mean from the previous table and the T-test (Table 2), it is concluded that the difference is statistically significant in favor of the FLAIR sequence in observing lesions smaller than 10 millimeters, i.e. the FLAIR sequence had statistically significantly better results compared to the T_2 sequence.

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Table 2 T – test of lesions smaller than 10 millimeters

Lesion <10mm				
Equal variances not assumed	Equal variances assumed			
	3.230	F	Levene's Test for Equality of Variances	
	.075	Sig.		
-6.073	-6.073	t	t-test for Equality of Means	
88.169	98	DF		
000	000	Sig. (2-tailed)		
-4.100	-4.100	Mean Difference		
.675	.675	Std. Error Difference		
-5.442	-5.440	Lower	95% Confidence Interval of the Difference	
-2.758	-2.760	Upper		

Presented lesions larger than 10 millimeters and smaller than 20 millimeters

In all 50 patients enrolled in the study, vascular lesions in the brain larger than 10 millimeters and smaller than 20 millimeters were measured and counted. Based on the provided data, the arithmetic mean was calculated, which shows that the FLAIR sequence has a higher arithmetic mean than the T_2 sequence (Table 3).

	Sequence	N	Mean	Std. Deviation	Std. Error Mean
Lesion 10 mm ≤≥ 20 mm	T2	50	2.70	2.558	.362
	FLAIR	50	5.70	4.414	.624

Table 3 Presented lesions larger than 10 mm and smaller than 20 mm

Based on the calculated arithmetic mean from the previous table and the T-test (Table 4), it is concluded that the difference is statistically significant in favor of the FLAIR sequence in observing lesions larger than 10 millimeters and smaller than 20 millimeters, i.e. the FLAIR sequence had statistically significantly better results compared to the T_2 sequence.

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Table 4 T – test of lesions larger than 10 mm and smaller than 20 mm

Lesion 10 mm ⩽ 20 mm				
Equal variances not assumed	Equal variances assumed			
	18.900	F		Levene's Test for Equality of Variances
	000	Sig.		
-4.159	-4.159	t		t-test for Equality of Means
78.572	98	DF		
000	000	Sig. (2-tailed)		
-3.000	-3.000	Mean Difference		
.721	.721	Std. Error Difference		
-4.436	-4.432	Lower	95% Confidence Interval of the Difference	
-1.564	-1.568	Upper		

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Presented lesions larger than 20 millimeters

In all 50 patients enrolled in the study, vascular lesions in the brain larger than 20 millimeters were measured and counted. Based on the provided data, the arithmetic mean was calculated, on the basis of which it is evident that the FLAIR sequence has a higher arithmetic mean than the T_2 sequence (Table 5).

	Sequence	N	Mean	Std. Deviation	Std. Error Mean
Lesion ≥ 20 mm	T2	50	5.16	3.930	.556
	FLAIR	50	7.82	4.503	.637

Table 5 Presented lesions larger than 20 millimeters

Based on the calculated arithmetic mean from the previous table and the T-test, it is concluded that the difference is statistically significant in favor of the FLAIR sequence in observing lesions larger than 20 millimeters, i.e. the FLAIR sequence had statistically significantly better results compared to the T_2 sequence (Table 6.)

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		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	DF	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Lesion ≥ 20 mm	Equal variances assumed	1.388	.242	-3.147	98	.002	-2.660	.845	-4.337	-.983
	Equal variances not assumed			-3.147	96.240	.002	-2.660	.845	-4.338	-.982

Table 6 T – test for lesions larger than 20 millimeters

Comparison of results for all three lesion groups

After statistical data processing, the FLAIR sequence was found to provide a better representation of vascular lesions in the brain compared to the T_2 sequence in all three different groups. After comparing the results obtained between these groups, it is evident that the flair sequence has a higher arithmetic mean than the T_2 sequence (Table 7).

	Sequence	N	Mean	Std. Deviation	Std. Error Mean
Lesion <10mm	T2	50	--3.96	2,755	.390
	FLAIR	50	8.06	3.899	.551
Lesion 10 mm ≤ 20 mm	T2	50	2.70	2.558	.362
	FLAIR	50	5.70	4.414	.624
Lesion ≥ 20 mm	T2	50	5.16	3.930	.556
	FLAIR	50	7.82	4.503	.637

Table 7 Group statistics for all three lesion sizes

Based on the T – test for all three sizes of observed lesions (Table 8) and on the basis of group statistics for all three sizes of lesions, it is concluded that the differences are statistically significant in favor of FLAIR sequence in all three observed sizes of lesions, i.e. the FLAIR sequence had statistically significantly better results compared to the T_2 sequence.

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		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	DF	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Lesion <10mm	Equal variances assumed	3.230	.075	-6.073	98	000	-4.100	.675	-5.440	-2.760
	Equal variances not assumed			-6.073	88.169	000	-4.100	.675	5.442	-2.758
Lesion 10 mm ≤ 20 mm	Equal variances assumed	18.900	000	-4.159	98	000	-3.000	.721	-4.432	-1.568
	Equal variances not assumed			-4.159	78.572	000	-3.000	.721	-4.436	-1.564
Lesion ≥ 20 mm	Equal variances assumed	1.388	.242	-3.147	98	.002	-2.660	.845	-4.337	-.983
	Equal variances not assumed			-3.147	96.240	.002	-2.660	.845	-4.338	-.982

Table 8 T – test for all three sizes of observed lesions

DISCUSSION

In order to evaluate the sensitivity of T_2 and FLAIR sequence in the diagnosis of vascular lesions in the brain, several studies have been conducted in which the superiority of the FLAIR sequence in the identification and better displaying the vascular lesions compared to the T_2sequence was determined.

Sahu ID et al have conducted a retrospective descriptive study in which they found that both sequences, $T_2$and FLAIR, provide useful diagnostic information in the study of vascular brain lesions. In some cases a T_2sequence may be preferable, but in most cases the FLAIR sequence is preferred. Although the noise level is higher on FLAIR scans, comparing them with T_2 scans, the FLAIR sequence is more useful than the T_2 sequence in the detection of vascular lesions.[8] The data of this study correlate with the results obtained as part of this study, where it was noted that vascular lesions are shown in higher numbers and at a higher resolution on the FLAIR sequence.

Lansberg MG. Et al have, as part of their study, established the signal intensity characteristics of acute and subacute ischemic lesions in assessing the age of lesions. They found that mean signal intensity gradually increased within the first seven days of cerebrovascular accident. In the period from 8 to 14 days, signal values showed moderately reduced values. However, after 14 days the signal intensity values have remained stable on the FLAIR sequence, while the signal intensity values on the T_2 sequence increased significantly.

Lansberg MG. Et al have, as part of their study, established the signal intensity characteristics of acute and subacute ischemic lesions in assessing the age of lesions. They found that mean signal intensity gradually increased within the first seven days of cerebrovascular accident. In the period from 8 to 14 days, signal values showed moderately reduced values. However, after 14 days, signal intensity values remained stable on the FLAIR sequence, while signal intensity values on the T_2 sequence increased significantly.[4]

Azizyan A. et al have concluded in their study that FLAIR vascular hyperintensity indicates the status of leptomeningeal collateral perfusion in vulnerable brain tissue, rather than a direct visualization of thrombus. This makes it clinically valuable as it can help clinicians decide when to attempt recanalization and whether tissue salvage can be expected. Furthermore, FLAIR vascular hyperintensities have high specificity and sensitivity to detect arterial occlusion and stenosis. FLAIR vascular hyperintensities are also very effective in detecting areas of collateral circulation and can serve as a substitute for PWI sequences when they are not available.[1]

The prognostic value of FLAIR vascular hyperintensity still needs to be investigated. The categorization of distal versus proximal FLAIR vascular hyperintensities has proven to be significant. Other authors state that FLAIR vascular hyperintensities give different diagnostic and prognostic values.[5,6,7,9] FLAIR vascular hyperintensities within the middle cerebral artery can give the clearest and most consistent prognostic information as opposed to FLAIR vascular hyperintensities in the posterior and vertebral-basilar circulation. Future studies will determine in which settings the presence of FLAIR vascular hyperintensity can be used as valuable information for the clinician. FLAIR vascular hyperintensities indicate a risk of persistent vascular stenosis or occlusion, associated with an increased risk of future stroke. They also help identify patients with favorable collateral blood flow, who could benefit from aggressive revascularization therapy.

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CONCLUSION

In a retrospective descriptive study, both sequences, T_2 and FLAIR, were found to provide useful diagnostic information in the assessment of vascular lesions. Statistically, a difference was found in the better presentation of vascular lesions on the FLAIR sequence compared to the T_2 sequence. In some cases, a T_2 sequence may be sufficient but in most cases a FLAIR sequence is preferable. Although the noise level is higher on the FLAIR sequence, comparing it with the T_2 sequence, the flair sequence is more useful in detecting vascular lesions.

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