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Analysis of Changes in Signal Intensity of Choroidal Plexus in MRI Using FLAIR-DW-EPI Pulse Sequence

[1,]Jingyu Kim, [2]Sang-Jin Im*

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Abstract In this study, the signal intensity of choroid plexus, which is producing cerebrospinal fluid, is analyzed according to the FLAIR diffusion-weighted imaging technique. In the T2*-DW-EPI diffusion-weighted image, the FLAIR-DW-EPI technique, which suppressed the water signal, was additionally examined for subjects with high choroid plexus signals and compared and analyzed the signal intensity. As a result of the experiment, it was confirmed that the FLAIR-DW-EPI technique showed a signal strength equal to or lower than that of the brain parenchyma, and there was a difference in signal strength between the two techniques. As a result of this study, if the choroidal plexus signal is high in the T2 * -DW-EPI diffusion-weighted image, additional examination of the FLAIR-DW-EPI technique is thought to be useful in distinguishing functional problems of the choroid plexus. In conclusion, if the choroidal plexus signal is high on the T2*-DW-EPI diffuse weighted image, it is thought that further examination of the FLAIR-DW-EPI technique will be useful in distinguishing functional problems of the choroidal plexus.

Key-word : Choroid plexuses, Diffusion weighted image, FLAIR, Signal intensity

[1,]Jingyu Kim* (✉) ***corresponding author***
Dept. of Radiological & Madico-Oncological Science, University of Science & Technology
(34113) 217, Gajeong-ro, Yuseong-gu, Daejeon, Korea

[2]Sang-Jin Im
M.Sc. Biomedical Science Lee Gil Ya Cancer and Diabetes Institute, Gachon University
(21999) 155, Gaetbeol-ro, Yeonsu-ku, Incheon, Korea

I. Introduction

The diffusion-weighted image is an image of the degree of diffusion of water molecules in a tissue using an MR device[1]. The diffusion-weighted image is an image of the degree of diffusion of water molecules in a tissue using an MR device. In MRI, the diffusion of water molecules decreases the signal, so if the diffusion is good, the signal is weak, and if the diffusion is not good, the signal is strong. The clinical application of diffusion-weighted imaging is used for early diagnosis of acute cerebral infarction, differentiation between brain tumors and abscesses, and diagnosis of CJD (Creutzfeldt-Jakob Disease)[2]. Brain tissue is an aggregate of over 100 billion nerve cells, and the movement of water molecules is not completely free and is limited by the characteristics of the tissue. Isotropic diffusion refers to a case where water molecules can move in any direction, and anisotropic diffusion refers to a case where water molecules move in a specific direction only by surrounding structures[3]. Water molecules in the human brain tissue are not completely free, and in addition to the diffusion movement of fine water molecules, the movement of the brain tissue itself, cardiac movement, blood flow in the micro-vessel,

and movement of the patient are affected. The diffusion coefficient measured during actual MRI includes the effects of these various factors and is called the apparent diffusion coefficient (ADC)[4]. The degree of diffusion can be qualitatively predicted according to the signal intensity, and the diffusion coefficient can be calculated and analyzed quantitatively[5]. The choroid plexus or plica choroidea, is a plexus of cells that arises from the tela choroidea in each of the ventricles of the brain. The choroid plexus consists of modified ependymal cells surrounding a core of capillaries and loose connective tissue. There are many capillaries in the choroid layer, and consists of a window-shaped capillary and one layer of polar epithelial cells surrounding it, and is directly involved in the production of cerebrospinal fluid. The choroid plexus produces most of the cerebrospinal fluid (CSF) of the central nervous system. When the water permeability due to the difference in osmotic pressure of the choroidal plexus is significantly reduced, the production of cerebrospinal fluid is significantly reduced. MRI brain diffusion imaging has been helpful in the diagnosis and treatment of super-acute cerebral infarction in clinical practice[6]. In addition, it has been usefully used to differentiate between an arachnoid cyst and epidermoid cyst, and to diagnose brain abscess[7]. However, research on the fact that the signal intensity varies depending on the degree of diffusion according to the inspection technique of the diffusion-weighted image is not active[7]. In this study, the signal intensity of choroid plexus, which is producing cerebrospinal fluid, is analyzed according to the FLAIR diffusion-weighted imaging technique.

II. Materials and methods

1. T1 and T2 weighted image

When performing an actual MRI, 90-degree high-frequency pulses usually have to be repeatedly applied hundreds of times, so the time interval between pulses (repetition time, TR) has a great influence on the MRI signal. That is, if the TR is long, both tissues with a long T1 relaxation time or short tissues are subjected to the next 90-degree pulse while sufficiently recovering the longitudinal magnetization, and a strong signal can be generated every 90-degree pulse[8]. However, if the TR is short, the fat tissue with a short T1 relaxation time can sufficiently recover the longitudinal magnetization, but other tissues fail to recover sufficiently, and the next 90-degree pulse is applied. As a result, the MRI signal is reduced. Therefore, if the TR is shortened, an image that reflects the difference in T1 relaxation time between tissues as contrast can be created, and this is a T1 weighted image[8]. In other words, the T1 weighted image uses a short TR and a short TE, and a short TR enhances T1 contrast between tissues, and a short TE suppresses T2 contrast[8].

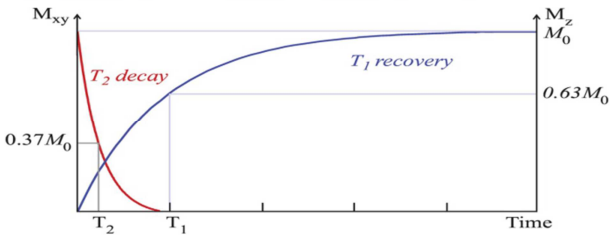


Figure 1. T1 relaxation and T2 decay[9]

The transverse magnetization created by the 90-degree high-frequency pulse decays with time. If a high-frequency pulse of 180 degrees is applied at an appropriate time, the vector of the transverse magnetization that is decaying is changed 180 degrees in the opposite direction, so that the transverse magnetization can be refocused. The time interval between the 90-degree pulse and the signal generation is called the echo time (TE), and by adjusting this, an

image reflecting the difference in T2 relaxation time between tissues as a contrast, that is, a T2 weighted image can be obtained. When TE is shortened and the transverse magnetization decay of the tissue does not occur, a 180-degree pulse is applied to obtain an image with low T2 contrast between tissues. On the other hand, when TE is lengthened and a 180-degree pulse is applied at a time when the T2 between tissues is sufficiently different, a T2 weighted image with high T2 contrast is obtained[10].

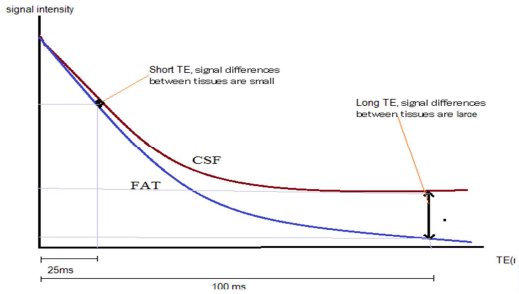


Figure 2. Signal difference between fat and water according to TE time[10]

2. FLAIR (fluid attenuated inversion recovery)

The FLAIR technique is a technique that suppresses the signals of the cerebrospinal fluid as a kind of inversion recovery technique[11]. The white matter-gray matter contrast is similar to that of the T2-weighted image, except that the signal of the cerebrospinal fluid is suppressed black because the long TR and the long TE are used. The sequence of pulses in the spin-echo image starts with a 90-degree pulse, but the inversion recovery technique applies a 180-degree inversion pulse before the 90-degree pulse. Immediately after the 180-degree reversal pulse, the net magnetization of the tissue is completely inverted toward the (-) side of the longitudinal axis, and then T1 relaxation occurs according to the characteristics of each tissue, and magnetization in the (+) longitudinal direction begins to occur[11]. In this process, there is a point in time when the net magnetization of the vertical axis becomes zero, and the time from the 180-degree pulse to this point is called the inversion time (TI). Fat has a reversal time of 150 ms, white matter 300-400 ms, gray matter 600-700 ms, and cerebrospinal fluid 2000-2500 ms. Therefore, the 90-degree pulse is applied after waiting for the inversion time of the tissue to suppress the signal after the 180-degree inversion pulse[12]. That is, applying a 90-degree pulse after 150 ms becomes a STIR (short TI inversion recovery) technique that suppresses the fat signal, and applying a 90-degree pulse after 2000 to 2500 ms results in a FLAIR image that suppresses the cerebrospinal fluid signal. It can be seen that the signal of the desired tissue can be suppressed by adjusting the inversion time using 180-degree pulses of various inversion times while the TR and TE are fixed. FLAIR images can easily detect small lesions adjacent to the CSF space, and lesions with slightly increased T2 signals[13].

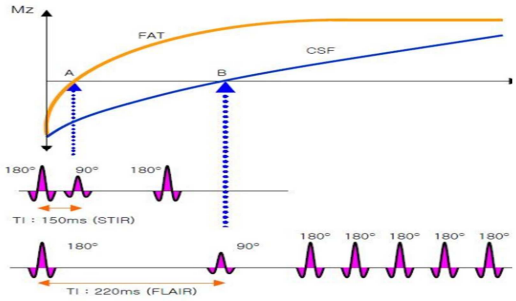
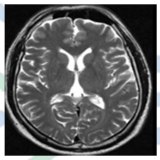
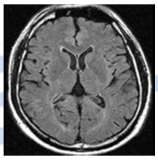
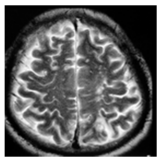
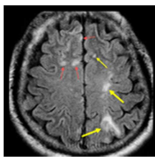
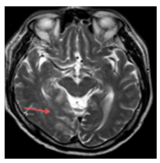
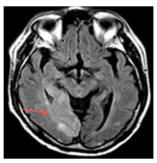


Figure 3. STIR and FLAIR according to TI[14]

Table 1. Comparison of T2 weighted images and FLAIR images[15]

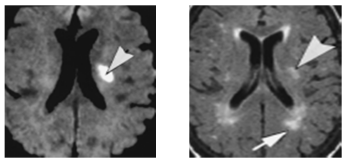
	T2WI	FLAIR
Normal image		
Embolic infractions		
Acute infraction		

III. Experimental

1.5 Tesla superconducting magnetic resonance imaging device and Head & Neck coil were used. We studied 17 patients (8 males and 9 females) with the high signal intensity of choroid plexus in diffuse-weighted imaging (T2*-DW-EPI technique). An image of a subject with high signal strength with choroid plexus was additionally obtained by applying the FLAIR-DW-EPI technique. The signal intensity and diffusion coefficient of choroid plexus were obtained and compared with the diffusion-weighted images obtained by the two techniques. The parameters for obtaining diffuse-weighted images were T2*-DW-EPI and FLAIR-DW-EPI. Images were obtained using the same section of the same patient with a field of view of 28 cm, a section thickness of 6 mm, and a spacing of 1 mm. The T2*-DW-EPI technique was set to repetition time (TR) 12,000 ms, echo time (TE) 160.0 ms, and inspection time 30 sec. The FLAIR-DW-EPI technique used repetition time (TR) 12,000 ms, echo time (TE) 140.0 ms, inversion time (TI) 2,400 ms, and test time 80 sec. In order to reduce magnetic susceptibility artifacts, the lateral ventricle posterior choroid plexus was observed from the skull base to the vertex in parallel to the glabellomeatal line. For image analysis, the image data was transmitted to the Workstation, and a region of interest (ROI) at the center of the choroid plexus was designated as 28 ㎟ to obtain signal intensity and diffusion coefficient. To compare the difference between the two techniques, the signal intensity and diffusion coefficient of acute cerebral infarction and intraventricular hemorrhage were calculated.

IV. Result and Discussion

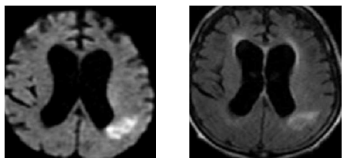
In the T2*-DW-EPI technique, 19 patients showed the high signal intensity of the choroidal plexus. Of these, 10 were male and 9 were female. The average age of all of them was 61.3 years (33~89), the average age of men was 61.5 years, and the average age of women was 59.8 years. When comparing the images examined by applying the FLAIR-DW-EPI technique to those of the T2*-DW-EPI technique, it was found that there is a significant difference in signal intensity.



T2*-DW-EPI FLAIR-DW-EPI

Figure 4. Choroid plexus

Quantitatively, in the T2*-DW-EPI technique, the signal intensity of the choroid plexus was 251.6 ㎟/s and the apparent diffusion coefficient (ADC) was 1.86×103 ㎟/s. The FLAIR-DW-EPI technique was 61.3 ㎟/s and the ADC was 1.84×103 ㎟/s, which was similar to the brain cortex. The difference in signal intensity between the two techniques was 191 ㎟, which was highly observed in the T2*-DW-EPI technique, and there was little difference in the overt diffusion coefficient. In the case of acute cerebral infarction, both techniques showed high signal intensity and were 251.5 ㎟/s and 212.8 ㎟/s, respectively, and ADCs were 0.81×103 ㎟/s and 0.80×103 ㎟/s, respectively.



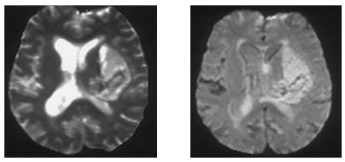
T2*-DW-EPI FLAIR-DW-EPI

Figure 5. Acute cerebral infarction

Table 2. Signal intensity analysis

Label	DW-EPI	Signal intensity	ADC(X10^3)
Brain	T2*	116.1	1.08
	FLAIR	113.1	1.23
Choroid plexus	T2*	250.8	1.87
	FLAIR	60.8	1.85
Acute infraction	T2*	250.5	0.82
	FLAIR	212.6	0.80
Acute hemorrhage	T2*	389.4	0.84
	FLAIR	337.6	0.76

In the case of a lateral ventricular cerebral hemorrhage, both techniques showed high signal intensity, 389.6 ㎟/s, and 337.8 ㎟/s, respectively, and ADCs were 0.83×103 ㎟/s and 0.77×103 ㎟/s, respectively.



T2*-DW-EPI FLAIR-DW-EPI

Figure 6. Lateral ventricular cerebral hemorrhage

The degree of signal attenuation by diffusion is proportional to the moving size of the molecule and the intensity of the diffusion-enhanced gradient magnetic field. The intensity of the diffusion-enhanced gradient magnetic field is called b-value (s/㎟), which is related to the intensity of the gradient magnetic field, the time applied to the gradient magnetic field, and the time interval between the front and rear gradient magnetic fields. In general, diffuse-enhanced images can be sufficiently visualized by applying a b value of about 1,000. In the diffusion-weighted image, the signal intensity is determined by the combination of the overt diffusion coefficient and the T2 component, which indicates the degree of diffusion of water molecules in the tissue. If the b value is 0s / ㎟, the T2 weighted image is displayed, and you can increase the B value to reduce the T2 effect or suppress the water signal[15].

In this study, the diffusion gradient magnetic field was applied in the selection direction of the section, the frequency

coding direction, and the phase coding direction. T2*-DW-EPI technique with b-value (s/㎟) of 1,000 and the resonant frequency is applied by setting the null point as the inversion time when the water molecule signal reaches the x, y plane A FLAIR-DW-EPI technique was used to obtain the results of the spread and signal intensity of choroid plexus. Most of choroid plexus did not show high signal intensity in T2*-DW-EPI testers, but showed the same or low signal intensity as the brain parenchyma. The subjects of this study were tested with subjects with high signal strength. As a result of comparing the signal and diffusion degree of choroid plexus between the two techniques, the T2*-DW-EPI technique showed high signal strength. On the other hand, the FLAIR-DW-EPI technique, which suppressed the water signal, showed the same or low signal intensity as that of the brain parenchyma and was compared. However, there was no difference in the overt diffusion coefficient. Choroid plexus is considered to exhibit high signal strength as the T2 effect remains in the T2*-DW-EPI technique. Due to the structure of the choroid plexus, the process of generating cerebrospinal fluid in countless capillaries was partially transformed into a sponge-type cystic structure, and it is believed that the diffusion of water molecules was slower than that of stagnant or normal people, resulting in high signal intensity[16]. In the results of the FLAIR-DW-EPI test, which suppressed the water signal, the sponge-type cystic structure showed a signal similar to or lower than that of the brain parenchyma as the water signal was suppressed. On the other hand, in the case of acute cerebral infarction and acute cerebral hemorrhage, both techniques showed high signal intensity.

V. Conclusion

In this study, the signal intensity of the choroid plexus generating cerebrospinal fluid was analyzed by acquiring signals using the T2*-DW-EPI technique and the FLAIR-DW-EPI technique. Acute cerebral infarction and acute cerebral hemorrhage on diffuse-weighted images were observed with higher signal intensity compared to normal brain in diffuse images, and the overt diffusivity (ADC) was observed to be low, confirming that it is an excellent technique for diagnosing acute cerebral infarction. In the T2*-DW-EPI diffusion-weighted image, the FLAIR-DW-EPI technique, which suppressed the water signal, was additionally examined for subjects with high choroid plexus signals and compared and analyzed the signal intensity. As a result, it was confirmed that the FLAIR-DW-EPI technique showed a signal intensity equal to or lower than that of the brain parenchyma, and there was a difference in signal intensity between the two techniques. The results of this study are that in patients with high choroid plexus signals on T2*-DW-EPI diffusion-weighted images, the FLAIR-DW-EPI technique was additionally examined. It is thought to be useful for the discrimination of cystic structures.

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