The use of flair imaging in MRI for detecting meningeal lesions

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KeyWords:

T2-Flair, T2-Flair Post Gadolinium Injection, Brain Resonance.

Abstract

Magnetic Resonance Imaging (MRI) with Fluid-Attenuated Inversion Recovery (FLAIR) sequence post-contrast is a highly specialized imaging technique used to assess and identify lesions and inflammation in various tissues, particularly in the brain. This sequence is enhanced by the administration of a contrast agent, typically gadolinium, which improves the visibility of meningeal lesions by increasing the contrast between affected and normal tissues.
The FLAIR sequence is adept at suppressing the signal from free fluid, making it particularly useful for detecting subtle changes in tissue that may not be apparent in other imaging sequences. When combined with a contrast agent, FLAIR can reveal areas of breakdown in the blood-brain barrier indicative of inflammation, infection, or meningeal lesions. This is crucial for diagnosing conditions such as multiple sclerosis, encephalitis, and in general meningeal lesions.

INTRODUCTION

T2-FLAIR is a sequence from the Inversion Recovery family, where the inversion time (TI) following the 180° inversion pulse has a duration of approximately 2000 milliseconds in 1.5 T MRI systems. After this inversion time, the signal given by the cerebrospinal fluid is found to cross zero, therefore the subsequent excitation will not involve this tissue. Although FLAIR [1] images are heavily T2-weighted (T2W) images, the contrast enhancement in FLAIR imaging is the result of a slight T1 effect produced by the long TI; therefore, lesions that show enhancement on contrast-enhanced T1-weighted imaging (CE-T1WI) [2] also show enhancement on contrast-enhanced FLAIR images (CE-T2-FLAIR). In the post-contrast phase, areas of active inflammation absorb more contrast, appearing brighter on the FLAIR images. This characteristic enhancement allows for more precise localization and characterization of the meningeal lesions and inflammatory process, aiding in differential diagnosis and guiding treatment strategies. Moreover, the use of FLAIR post-contrast can monitor therapeutic responses in brain diseases, providing a non-invasive means to assess the efficacy of treatment regimens over time. The sensitivity of this technique makes it a valuable tool in the longitudinal study of chronic inflammatory conditions [2].
Overall, MRI FLAIR with contrast enhancement stands out as an essential imaging modality in the evaluation of meningeal lesions and inflammatory diseases, offering detailed insights that are critical for effective patient management.

MATERIALS AND METHODS

The paramagnetic contrast agent used in magnetic resonance imaging is Gadolinium. The latter reduces the T1 and T2 [3] relaxation times of the tissues in which it has accumulated. The increase in contrast intensity of the lesion is mainly caused by the T1 reduction effect.
Speaking of FLAIR, therefore of a specific sequence of the central nervous system, we briefly explain the process that leads to the increase in contrast in the latter; it is the result of a combination of 3 processes:

1. 1. For intra-axial brain lesions, the Blood Brain Barrier (BBB) must be disrupted for Gadolinium to enter the extracellular space;
2. For extra-axial lesions, improvement is observed in lesions with relatively high vascularity.
3. For the lepto meningeal regions, contrast leakage from the vessels into the liquid occurs.

Although T1-weighted sequences are generally considered the primary post-contrast injection sequence, at our diagnostic imaging service it is routine to include post-Gadolinium FLAIR T2W sequences in study protocols for the detection of various intracranial diseases, meningeal and parenchymal lesions.
We noted that the differences in enhancement characteristics between post-Gadolinium T1 and FLAIR images can be explained by a combination of a different T1 shortening effect at a given Gadolinium concentration and a different T2 effect depending on the vascularization of a defined lesion.
In conclusion, the FLAIR sequence is more sensitive to T1 shortening than the T1 sequence at lower Gd concentrations, whereas the FLAIR sequence

JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP

ESSAY

Citation:

L. Sirocchi
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JAHC Essay 2024

Received: 08/11/2023
Revised: 22/04/2024
Accepted: 23/04/2024
Published: 27/04/2024

was sensitive to the effects of T2 at high Gd concentrations.

This means that:
1. Weakly enhancing lesions on CE-T1WI are depicted on CE-T2 FLAIR images,
2. Marked lesions with high Gadolinium accumulation show no enhancement on T2-FLAIR images because the signal-reducing T2 effects obscure the signal-enhancing T1 effects.

In many MRI protocols, there is a tendency to perform T2-FLAIR after injection of contrast agent to lengthen the interval between the latter and the acquisition of the CE-T1w.

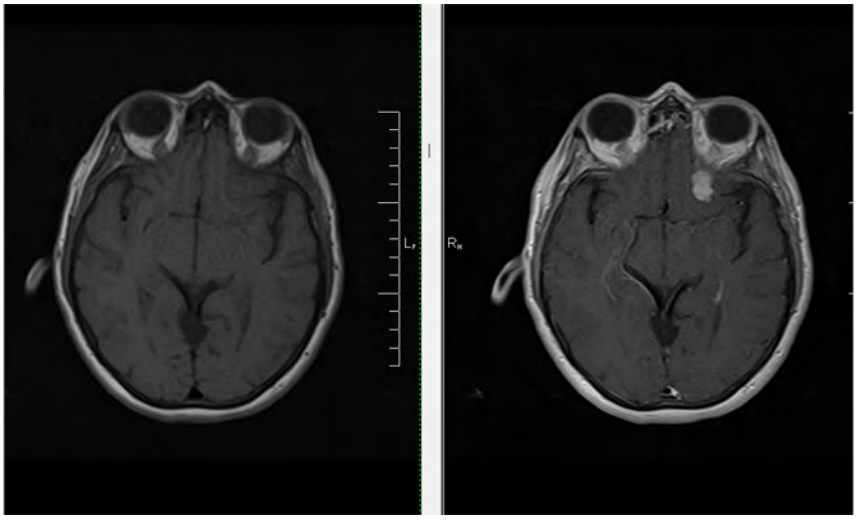
We report the article by Vågberg M. et al. 2017 that shows their protocol for the study of MS (Table A) involves the administration of the contrast, subsequently the acquisition of the 3D FLAIR sequence, and then lastly after a few minutes the post T1 [4].

Recommended MRI protocols	
Diagnostic protocol	**Follow-up protocol**
1. 3D T1 (Pre-contrast)	1. Administration of GBCA
2. Hemorrhage sensitive sequence (i.e., SWI, GRE, or FFE)	2. Axial T2
3. DWI	3. 3D T2-FLAIR
4. Administration of GBCA	4. 3D T1
5. Axial T2	
6. 3D T2-FLAIR	
7. 3D T1 (Post-contrast)	GBCA, gadolinium-based contrast agent; MRI, magnetic resonance imaging.

Table A

Finally, we report two articles that confirm how the T2 FLAIR sequence is influenced by Gadolinium injection and therefore how it is right to have a full understanding to avoid falling into misunderstandings and possible interpretative difficulties.
We report the article by R. Tortora et al. where it is reported that in the protocol the pre-contrast T1 and FLAIR sequences are performed first, then gadolinium is injected, and the study continues. [5]
We report the article by Ten Jin et al. that shows the correlation between brain metastasis enhancement levels on T2-fluid-attenuated inversion recovery (CE-T2 FLAIR) and vascular permeability parameters on dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) [6]

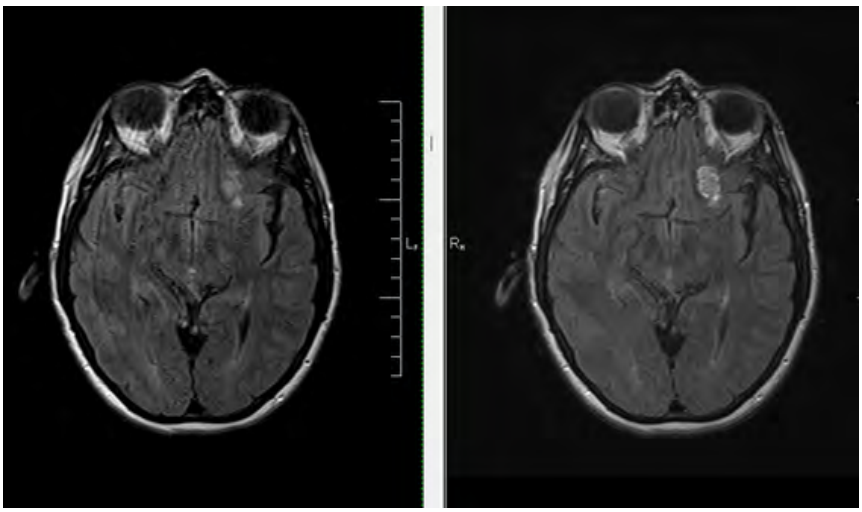
In our study, the contrast agent (Gadovist, gadobutrol- Bayer Healthcare) was administered at the standard dose of 0.1 mmol/kg body weight. Post-contrast images were obtained approximately 15 minutes after contrast administration. For the patient, MRI imaging was performed using a 1.5T scanner (TOSHIBA EXCELART VANTAGE). Axial CE-T2 FLAIR imaging in all patients was performed immediately after routine coronal and axial T1WI. The CE-T1WI axial and CE-T2 FLAIR axial imaging scans were started at 10 seconds and 15 minutes after contrast agent injection, respectively. As reported in the report, in the left insular area the presence of a hyperintense area is confirmed in the T2 W and T2W FLAIR sequences with post-contrast enhancement; the finding described is initially compatible with meningioma but requires specialist evaluation and clinical monitoring over time. Delayed postcontrast T2 and T1 FLAIR imaging demonstrated improved enhancement of meningeal and parenchymal lesions, identifying more lesions compared to postcontrast T1 MTC. The T2 FLAIR images, taken after the contrast was administered, offered enhanced visualization of extra-axial mass lesions, showing more pronounced enhancement and a clearer definition of the dural tail [7].



T1W T1W POST MDC

Fig. 1

On the left, you can see how in the pre-contrast T1W the meningioma is not visible, unlike the post-contrast T1W on the right, performed 10 minutes after the injection where it is visible.



FLAIR T2 W FLAIR T2W POST MDC

Fig.2
It can be seen that on the right the neoformation is more intense and defined. Since the scan was performed 10 minutes later, we began to see a loss of signal in the central area of the lesion due to the accumulation of gadolinium.

CONCLUSIONS

In this study, we described the behavior of the T2W FLAIR sequence and its reaction to the paramagnetic contrast agent.
We have described its post-contrast benefits where its intensity increases cases such as meningeal lesions and brain tumors, referring to the study protocol that we are carrying out in our hospital.
We agree that disclosure and a greater understanding of its properties are important to avoid its improper use and interpretation errors.

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