CASE SERIES

Arachnoid cysts: the role of the BLADE technique

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Abstract

Background: This study aims at demonstrating the ability of BLADE sequences to reduce or even eliminate all the image artifacts as well as verifying the significance of using this technique in certain pathological conditions.

Material and Methods: This study involved fourteen consecutive patients (5 females, 9 males), who routinely underwent magnetic resonance imaging (MRI) brain examination, between 2010-2014. The applied routine protocol for brain MRI examination included the following sequences: i) T2-weighted (W) fluid-attenuated inversion recovery (FLAIR) axial; ii) T2-W turbo spin echo (TSE) axial; iii) T2*-W axial, iv) T1-W TSE sagittal; v) Diffusion-weighted (DWI) axial; vi) T1-W TSE axial; vii) T1-W TSE axial+contrast. Additionally, the T2-W FLAIR BLADE sequence was added to the protocol in cases of cystic tumors. Two radiologists independently evaluated all the images at two separate settings, which were performed 3 weeks apart. The presence of image artifacts such as motion, flow, chemical shift and Gibbs ringing artifacts, were also evaluated by the radiologists. In the measurements of the cysts, the extent of the divergence by the two MRI techniques (conventional and BLADE) was used by the two radiologists to evaluate the accuracy of the two techniques to determine the size of the cysts.

Results: BLADE sequences were found to be more reliable than the conventional ones regarding the estimation of the cyst size. The qualitative analysis showed that the T2 FLAIR BLADE sequences were superior to the conventional T2 FLAIR with statistical significance ($p < 0.001$) in the following fields: i) overall image quality, ii) cerebrospinal fluid (CSF) nulling; iii) contrast between pathology and its surrounding; iv) borders of the pathology; v) motion artifacts; vi) flow artifacts; vii) chemical shift artifacts and viii) Gibbs ringing artifacts.

Conclusions: BLADE sequence was found to decrease both flow artifacts in the temporal lobes and motion artifacts from the orbits. Additionally, it was shown to improve flow artifacts and image quality in cystic pathologies such as arachnoid cysts. Hippokratia 2016, 20(3): 244-248

Key words: Arachnoid cysts, magnetic resonance imaging, BLADE sequence, flow artifacts, motion artifacts

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Introduction

With the increasing use of magnetic resonance imaging (MRI) and computed tomography (CT) in brain examinations, a corresponding increase has been reported in the number of arachnoid cysts that are incidentally diagnosed[1-5]. Arachnoid cysts are benign, congenital, intra-arachnoidal space-occupying lesions that are filled with clear cerebrospinal fluid (CSF) not communicating with the ventricular system[6,7]. The typical arachnoid cyst has no identifiable internal architecture and does not enhance. The cyst has the same signal intensity as CSF at all sequences including the fluid-attenuated inversion recovery (FLAIR). This characteristic is in contrast to other lesions which may give a variety of signals[8]. Occasionally, however, hemorrhage, high protein content, or lack of flow within the cyst may complicate the MR appearance[6,9-10].

An epidermoid cyst is the most difficult lesion to distinguish from the arachnoid cyst. On MR images, epidermoid cysts appear isointense to CSF. Arachnoid cysts displace adjacent arteries and cranial nerves rather than engulf them, as epidermoid cysts often do. Also, chronic subdural hematoma and a porencephalic cyst can be confused with an arachnoid cyst[11]. While these lesions are often clinically “silent”, a variety of symptoms may develop, depending on the location and size of the cyst.

Although asymptomatic patients whose arachnoid cyst is an incidental finding, are not considered to be candidates for surgery, according to some groups, it is advisable to surgically treat them similarly to symptomatic arachnoid cysts, which warrant surgical treatment[12-18]. It is therefore very important to be able to see the exact structures and signals within the cyst without artifacts.
The purpose of this study was firstly to determine the extent by which BLADE sequences can reduce the previously mentioned image artifacts and secondly to examine the impact of this technique in certain pathological conditions.

Material and Methods

Patients

In this retrospective study, we included fourteen consecutive patients (5 females, 9 males) with mean age 32 years (range: 8 months - 45 years). These patients routinely underwent MRI brain examinations from February 2010 to February 2014. Written informed consent was obtained from all the subjects participating in the study protocol. Since this was a retrospective study where the patients received standard care as per institutional guidelines, with all the data being anonymized, an ethical committee approval was deemed unnecessary.

MR imaging techniques

A brain examination was performed on all the patients using a 1.5-T scanner (Magnetom Avanto, Siemens Medical Systems, Erlangen, Germany) with the Siemens 12-channel head matrix coil. The parameters of the different sequences are presented in Table 1.

The routine protocol of brain MR examination included the following sequences: i) T2-weighted (W) FLAIR axial; ii) T2-W turbo spin echo (TSE) axial; iii) T2*-W axial; iv) T1-W TSE sagittal; v) Diffusion-weighted (DWI) axial; vi) T1-W TSE axial; and vii) T1-W TSE axial+contrast. The T2-W FLAIR BLADE sequence was added to the protocol in cases of cystic tumors. In few cases, the T1-W FLAIR BLADE sequence was also applied.

The average time to acquire a T2-W FLAIR sequence was 2.25 min, whereas for the T2-W FLAIR BLADE it was 5.08 min. The decision for the additional imaging was made by the physician and it had been incorporated into the routine imaging protocol.

The term BLADE is the product name (used by Siemens Medical System, Erlagen, Germany) for a TSE sequence that uses the ‘Periodically Rotated Overlapping Parallel Lines with Enhanced Reconstruction’ (PROPELLER) k-space trajectory. The BLADE method acquires a number of blades that are rotated around the center of the k-space. Each blade consists of a number of lowest phase encoding lines of a conventional rectilinear k-space trajectory that are acquired after a single radiofrequency excitation. This technique can potentially eliminate pulsation in MR images when that pulsation is caused by the unwanted modulation of k-space data.

Qualitative analysis

All the acquired images were evaluated independently at two separate sittings with three weeks interval by two radiologists, who did not have access to any other image information when they made their assessments.

The radiologists graded the images on a 5-point scale (0: non-visualization, 1: poor, 2: average, 3: good, 4: excellent) for each of the following image characteristics: i) overall image quality, ii) CSF nulling, iii) contrast at the pathology and its surrounding, iv) size of pathology, and vi) limits of pathology.

Also, the presence of image artifacts (motion, flow, chemical shift, Gibbs ringing) was evaluated by the two radiologists, using a separate scoring scale (4: minimum, 3: slight, 2: moderate, 1: severe, 0: maximum). The statistical significance of the qualitative data was determined by the Kruskal-Wallis nonparametric test.

Quantitative analysis

The radiologists compared the techniques used (conventional and BLADE) in order to evaluate the size of the cyst, by assessing the extent by which the measurements of the cysts diverge. The T2-W TSE axial sequence was used as a reference because it is not prone to flow artifacts and arachnoid cysts are depicted with enhanced signal-to-noise ratio (SNR) resulting in better contrast from their surroundings. The quantitative evaluation was performed by means of the Kolmogorov-Smirnov nonparametric test.

Table 1: Summary of the sequences that were applied in brain MR examination in the current case series.

Sequences	T2 FLAIR	T2 FLAIR BLADE	T2 TSE
TR (ms)	9000	9000	4800
TE (ms)	92	106	93
Matrix (mm/mm)	256/256	320/320	448/380
BW (Hz/pixel)	190	362	192
A.T. (s)	2:25	5:08	3:18
Thickness (mm)	5	5	5
Space (%)	30	30	30
FOV (mm)	230/85.7%	230	230/80%

FLAIR: fluid attenuated inversion recovery, TSE: turbo spin echo, TR: repetition time, TE: time of echo, BW: bandwidth, FOV: field of view.

Results

The findings of the analysis indicate that the BLADE sequences were superior to the conventional ones regarding the overall image quality, CSF nulling, contrast of the pathology and its surrounding, size of pathology, borders of the pathology, motion artifacts, flow artifacts, chemical shift artifacts, and Gibbs ringing artifacts.

The qualitative measurements show that T2 FLAIR BLADE sequences are significantly superior to the conventional T2 FLAIR with statistically significantly differences in terms of: i) overall image quality (p =0.003) (Figure 1), ii) CSF nulling (p <0.001) (Figures 2 and 3), iii) contrast of the pathology and its surrounding (p <0.001) (Figure 3), iv) borders of the pathology (p <0.001) (Figure 3), v) motion artifacts (p <0.001) (Figure 4), vi) flow artifacts (p <0.001) (Figure 1, Figure 2, Figure 4), vii) other artifacts (p <0.001) [chemical shift artifacts (Figure 3) and Gibbs ringing artifacts].

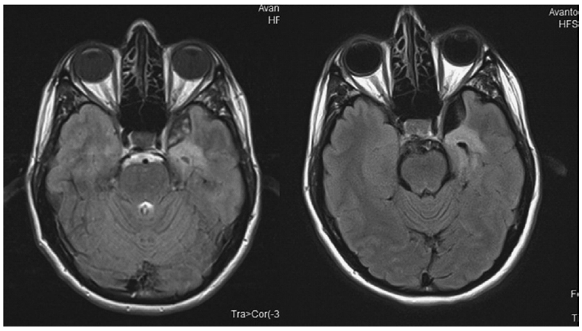

Figure 1: Axial T2 fluid attenuated inversion recovery (FLAIR) (left), Axial T2 FLAIR BLADE (right) images of the brain. The signal within the arachnoid cyst in the conventional image cannot be assessed accurately due to the image flow artifacts. In T2 FLAIR BLADE, these artifacts are reduced resulting in very good depiction of the pathology, which provides the possibility for more accurate measurements so that a potential pressure on the medial rectus muscle or internal carotid can be estimated.

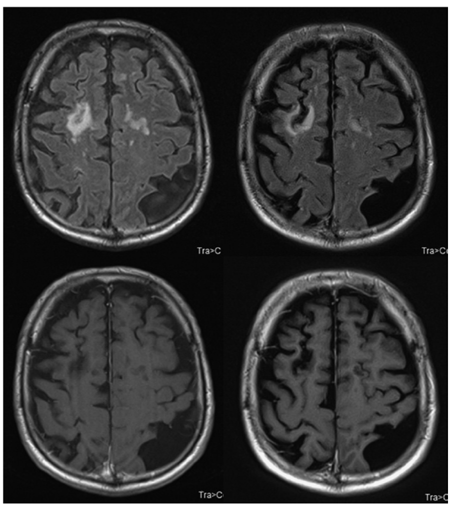

Figure 2: Axial T2 fluid attenuated inversion recovery (FLAIR) (upper left), Axial T2 FLAIR BLADE (upper right), Axial T1 turbo spin echo (TSE) (lower left), Axial T1 FLAIR BLADE (lower right) images of the brain. It is shown that in the T2 FLAIR image more flow artifacts are depicted and worse CSF nulling is achieved compared to the conventional T1 TSE image. In both corresponding BLADE images all the artifacts are reduced and excellent cerebrospinal fluid (CSF) nulling is achieved resulting in correct delineation of the arachnoid cyst and more accurate depiction of the ischemic lesion in the temporal lobes.

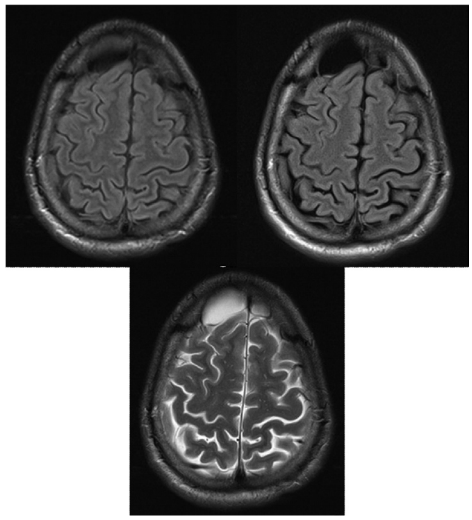

Figure 3: Axial T2 fluid attenuated inversion recovery (FLAIR) (upper left), Axial T2 FLAIR BLADE (upper right) and T2 turbo spin echo (TSE) (lower) images of the brain. It is very important to depict the exact limits of an arachnoid cyst in order to be able to determine any possible enlargement of the cyst. Here, it is shown that chemical shift artifacts are reduced in T2 FLAIR BLADE image and better cerebrospinal fluid (CSF) nulling is achieved, which results in a more accurate depiction of the pathology. BLADE images provide the possibility for performing more precise measurements compared to those obtained from T2 TSE images.

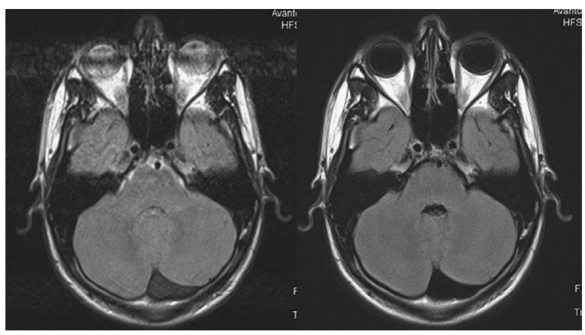

Figure 4: Axial T2 fluid attenuated inversion recovery (FLAIR) (left), Axial T2 FLAIR BLADE (right) images of the brain. In the conventional image a lot of motion and flow artifacts are depicted. Furthermore, the arachnoid cyst in the T2 FLAIR image contains various signals due to the poor cerebrospinal fluid (CSF) nulling, which results in degradation of the diagnostic value of the image. These issues are resolved in T2 FLAIR BLADE and additionally better depiction of the orbits and the temporal lobes is achieved.

Similarly, the quantitative results about the extent of the cyst size indicate that the BLADE measurements were found to be much more reliable than the conventional ones with the differences being statistically significant ($p < 0.001$).

Discussion

The number of incidentally diagnosed arachnoid cysts has increased with the technological progress of diagnostic brain imaging. The optimum diagnostic case scenario is a sharply demarcated extra-axial cyst that can displace or deform adjacent brain tissue. Also, an often seen sign is the scalloping of the adjacent calvarium. The size of arachnoid cysts varies, from small and incidental to large space-occupying lesions[12]. Arachnoid cysts are generally stable over time, although cases of sudden or progressive enlargement, as well as spontaneous resolution, have been reported.

Practice has proven that image artifacts like motion artifacts, flow artifacts and other, are very often seen in MR images and their presence complicates diagnosis. Many studies have been conducted showing that BLADE sequences significantly reduce those artifacts[19-21]. That is of particular significance not only for the surgical operations but also for better patient management, which requires the depiction of arachnoid cysts with a clear signal, high contrast, and clearly demarcated borders. While these lesions are often clinically silent, a variety of symptoms may develop, depending on the location and size of the cyst. Although they generally have a congenital origin, they may appear after head trauma or infection. Some of them appear to be due to a ball-valve communication with the subarachnoid space, and may progressively enlarge and become symptomatic, and then they require surgery[22]. Since the initial diagnosis of an arachnoid cyst, the follow-up evaluation of its size has become essential, especially in the cases where the cyst displaces the adjacent arteries and cranial nerves. This may trigger several symptoms depending on the exact location and size of the cyst. Unfortunately, due to image artifacts (motion, flow chemical shift), it is difficult to evaluate the borders and therefore the exact size of the cyst. Most authors agree that symptomatic arachnoid cysts warrant surgical treatment[12,23,24].

The basic protocols for the study of the brain include T1-W TSE, T2-W TSE, and T2-W FLAIR sequences. Normal CSF has long T1 and long T2 times that manifest themselves as a dark signal on T1-weighted images and a bright signal on T2-weighted images. FLAIR imaging results in nulling and dark CSF signal[25]. According to some authors, operative strategies can be more easily worked out on the FLAIR images. Furthermore, the differences between the arachnoid and epidermoid cysts may be depicted on T2 FLAIR images[11]. It has been observed that on FLAIR images, flow artifacts are more prominent and severe[25-28]. However, recent studies have shown that FLAIR images produce better results when combined with the BLADE technique[25,28,29] since they improve CSF nulling and further reduce flow-related artifacts. Thus, with BLADE sequences, the extent of the cyst size was calculated more accurately (see Figure 3). Chemical shift artifacts are reduced in T2 FLAIR BLADE image, and better CSF nulling is achieved. The measurements of the size of the cyst were compared with those obtained from T2-W TSE images.

Von Kalle T et al[30], who studied pediatric patients, found pulsation artifacts to be more prominent than movement artifacts, and significantly less often in BLADE images. Pulsation artifacts were more frequent and severe in conventional FLAIR images, but sometimes these artifacts were also observed in FLAIR BLADE images. Nyberg E et al[19], found that T2 FLAIR BLADE was superior to conventional T2 FLAIR in reducing motion related artifacts. Notwithstanding, his research focused on the reduction of motion artifacts and the two techniques were not compared for other artifacts.

The present study indicates that image artifacts and especially the flow artifacts are more prominent in cystic lesions; thereby the use of BLADE was even more effective in decreasing them and improving the contrast of the pathology compared to the conventional sequences. In Figure 1, the flow artifacts are so severe that we cannot estimate the type of signal within the arachnoid cyst or where are the exact limits of the cyst. BLADE sequence decreases both flow artifacts in the temporal lobes and motion artifacts in the orbits (Figure 2). It is shown that in the conventional T2 FLAIR image more flow artifacts are depicted in comparison to the conventional T1 TSE, and worse CSF nulling is achieved. As it can be seen, the corresponding BLADE sequences reduced the flow artifacts, and excellent CSF nulling was achieved resulting in correct delineation of the arachnoid cyst. The ischemic lesions in the temporal lobes are shown better in the T2 FLAIR BLADE than in the T2 FLAIR image. Moreover, a brain with cystic lesions tend to produce more pulsation related artifacts (ghosts) than a normal brain and that makes the effects of the BLADE technique even more important.

In Figure 4, as it can be seen, the flow artifacts that are present in the arachnoid cyst in the conventional T2 FLAIR were reduced in the T2 FLAIR BLADE and better CSF nulling was achieved, which leads to a more accurate estimation of the content of the arachnoid cyst. An equally important benefit of BLADE is that the better CSF nulling that it achieved led to better contrast between the pathology and its surrounding and better delineation of the limits of the pathology (Figure 3). BLADE images were found superior to the conventional ones in all the examined cases. It is therefore very important to perform more studies, like the present one, in order to evaluate whether the use of BLADE is indispensable for the depiction of specific pathologies.

Conflict of interest

Authors declare no conflict of interest.

Acknowledgment

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