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NEURORADIOLOGY

ORIGINAL ARTICLE

Intrathecal gadolinium-enhanced magnetic resonance cisternography with three-dimensional fluid-attenuated inversion recovery and T1-weighted imaging: new perspectives on arachnoid cysts

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PURPOSE

To assess the communication status of arachnoid cysts (ACs) and examine the findings of intrathecal gadolinium-enhanced magnetic resonance cisternography (IGMRC) using three-dimensional (3D) T1-weighted (T1W) and fluid-attenuated inversion recovery (FLAIR) sequences.

METHODS

A total of 44 cases of ACs that underwent IGMRC were included in the study. The degree of opacification was assessed on both early-phase (EP) and late-phase (LP) 3D T1W and 3D FLAIR images. Opacification levels on EP- and LP-FLAIR sequences were evaluated in cysts classified as complete, incomplete, or non-communicating (NC) based on 3D T1W imaging findings.

RESULTS

The opacification rate was 54.5% on EP-T1, 79.5% on EP-FLAIR, 79.5% on LP-T1, and 95.4% on LP-FLAIR. Significantly higher-grade opacification was observed on EP-FLAIR than on EP-T1 and on LP-FLAIR than on LP-T1. Completely communicating cysts exhibited higher-grade opacification on EP-T1 than on EP-FLAIR, whereas incompletely communicating cysts showed higher-grade opacification on both EP- and LP-FLAIR than on T1 images. Opacification was detected on LP-FLAIR in 77.8% of cysts initially categorized as NC according to 3D T1W imaging.

CONCLUSION

Combining both T1W and FLAIR sequences provides the most comprehensive evaluation and may reduce the need for LP imaging. Considering that most cysts that appear NC on T1W imaging demonstrate opacification on LP-FLAIR, it is suggested that the majority of ACs may be connected to the cerebrospinal fluid (CSF) spaces in some manner. However, due to factors such as cyst location and size and the dose of contrast agent used, they may not opacify sufficiently in cisternography studies.

CLINICAL SIGNIFICANCE

FLAIR sequences demonstrate higher sensitivity for detecting intrathecal contrast within ACs and may reveal communication with CSF spaces that cannot be identified using conventional T1W imaging alone.

KEYWORDS

Arachnoid cyst, magnetic resonance cisternography, T1, fluid-attenuated inversion recovery

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An arachnoid cyst (AC) is a pathological condition characterized by the accumulation of cerebrospinal fluid (CSF) between the arachnoid membranes.[1] It is among the most frequently encountered intracranial cystic lesions.[2] Asymptomatic ACs are typically monitored clinically and radiologically, whereas surgical intervention may become necessary, particularly in cases in which ACs cause persistent and progressive symptoms.[1]

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The initial stage of treatment often involves cyst fenestration into the nearest cortical sulcus, basal cistern, or ventricular system.[3] Various imaging modalities are used to assess communication between the cystic lesion and the physiological subarachnoid spaces, including cisternography examinations and various magnetic resonance (MR) techniques.[4-6] Cisternography methods typically involve imaging after intrathecal administration of contrast material, with computed tomography (CT) cisternography being a commonly preferred approach.[6] Nevertheless, these methods are limited by their relatively low contrast resolution and radiation exposure.

Intrathecal gadolinium-enhanced MR cisternography (IGMRC) is an investigative method that involves the intrathecal administration of gadolinium.[7] After intrathecal injection, imaging is performed during both the early phase (EP) (within the first 2 hours) and the late phase (LP) (between 6 and 24 hours). Numerous studies have demonstrated that this procedure does not adversely affect patient health when conducted using standard techniques.[8,9] Given its superior contrast resolution compared with CT cisternography, IGMRC provides more sensitive results regarding the communication status of ACs. In previous investigations, the three-dimensional (3D) fat-suppressed T1-weighted (T1W) imaging technique was commonly used.[7,10] Based on findings from this sequence, cysts are categorized as completely communicating (CC), incompletely communicating (IC), or non-communicating (NC) ACs.[11]

Recent studies have demonstrated that the 3D fluid-attenuated inversion recovery (FLAIR) sequence, when combined with intravenous gadolinium, exhibits greater sensitivity for detecting contrast enhancement in cortical sulci and basal cisterns than the 3D T1W sequence.[12] The higher sensitivity of FLAIR imaging to intrathecal contrast is related to the combined T1- and T2-shortening effects of gadolinium, together with suppression of the CSF signal, which allows subtle contrast-related signal changes to become more conspicuous. The use of the 3D FLAIR sequence in IGMRC may enable more precise visualization of even small amounts of gadolinium within the cyst that might not be discernible on 3D T1W images. Consequently, it may provide a more objective assessment of cyst communication status. Furthermore, the use of 3D FLAIR during the EP may reduce the need for LP imaging.

Main points

- Three-dimensional (3D) fluid-attenuated inversion recovery (FLAIR) sequences demonstrate higher sensitivity than 3D T1-weighted (T1W) sequences for detecting intrathecal gadolinium opacification in arachnoid cysts.
- Late-phase FLAIR imaging reveals opacification in many cysts initially classified as non-communicating on T1W images.
- Combining 3D T1W and 3D FLAIR sequences improves the evaluation of cyst communication and may reduce the need for late-phase imaging.

This study aims to assess the communication status of ACs in IGMRC examinations incorporating both 3D T1W and 3D FLAIR sequences and to compare the findings obtained from these sequences.

Methods

Our study received ethics committee approval Bursa Uludağ University Faculty of Medicine Clinical Research Ethics Committee (decision number: 2023-17/16, date: 13.10.2023). Written informed consent was obtained from all patients.

Patients

Fifty-one patients with planned surgery for AC who underwent IGMRC during the preoperative period between May 2019 and September 2022 were evaluated. All patients were assessed for surgical treatment because of symptomatic ACs and/or radiological findings suggestive of progression or mass effect. Clinical symptoms included headache, dizziness, and other neurological complaints. The decision to perform surgical intervention and the choice of technique, such as fenestration or shunting, were made by the neurosurgical team based on clinical and imaging findings. The inclusion criteria were as follows: age ≥ 18 years; presence of a pure AC without hemorrhage or infection; availability of non-contrast IGMRC images and EP and LP contrast-enhanced IGMRC images; and adequate technical quality of 3D FLAIR and 3D T1W sequences in all phases. Seven patients were excluded because of age < 18 years or incomplete or technically inadequate imaging. A total of 44 patients were included in the study. The patient selection process is summarized in Figure 1.

Imaging

All IGMRC sequences were acquired using a 1.5-T MR imaging (MRI) device (Aera®, Siemens, Erlangen, Germany). First, non-contrast 3D T1W sampling perfection with application-optimized contrasts using different flip-angle evolutions (SPACE) (echo type: spin echo; repetition time: 600 ms; echo time:

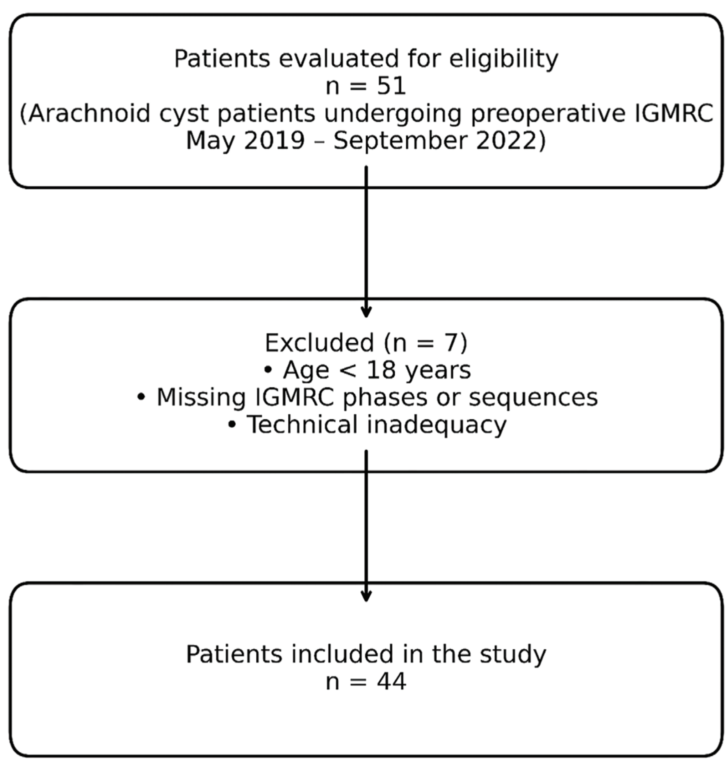

Figure 1. Flow diagram showing the patient selection and inclusion process for the intrathecal gadolinium-enhanced magnetic resonance cisternography (IGMRC) study.

7.2 ms; voxel size: 1 × 1 × 1 mm; fat suppression method: spectral fat saturation) and 3D FLAIR SPACE (echo type: spin echo; repetition time: 5,000 ms; echo time: 337 ms; inversion time: 1,800 ms; voxel size: 1 × 1 × 1 mm; fat suppression method: spectral fat saturation) sequences were obtained. Subsequently, the patients were referred to the interventional radiology unit for intrathecal injection of contrast material. All intrathecal injections were performed under fluoroscopic guidance (Axiom Artis Zee Floor, Siemens, Erlangen, Germany). After sterilization, puncture was performed at the L3–4 level with a 22-gauge spinal needle in the left lateral decubitus position. The needle was placed in the middle of the spinal canal under fluoroscopic guidance. When CSF reached the needle hub, 2 mL of meglumine gadoterate (Dotarem® Guerbet, Villepinte, France) was administered intrathecally. During administration, appropriate distribution of the contrast material into the subarachnoid space was observed in real time using fluoroscopy. Early and LP IGMRC images were obtained 2 and 8 hours after injection, respectively. The EP and LP imaging time points were selected to capture both early contrast distribution and delayed diffusion within the cyst. Delayed imaging time points reported in the literature vary widely, ranging from 6 to 24 hours.[7,10,11] In this study, the LP timing was selected within this range to allow adequate assessment of delayed opacification while maintaining practical in-hospital observation conditions.

Interpretation

All evaluations were performed retrospectively by two observers with 22 and 6 years of experience in neuroradiology who were blinded to the study results. First, the level of AC opacification was evaluated separately on each EP and LP 3D T1W and FLAIR image set. Opacification was graded using a semiquantitative visual system based on signal intensity changes within the cyst compared with precontrast images and the extent of involvement. Grade 0 was defined as no visible signal change. Grade 1 was defined as a faint focal or curvilinear signal increase. Grade 2 was defined as a mild gray-level signal increase involving part of the cyst. Grade 3 was defined as a moderate gray-to-bright signal increase involving most of the cyst. Grade 4 was defined as a marked bright signal increase with near-complete or complete opacification. This approach avoids reliance on external reference tissues and focuses on relative signal change and spatial extent. In addition, according to the findings on the 3D T1W sequence, cysts were categorized as CC-AC, IC-AC, or NC-AC. Lesions showing grade 0 opacification on both EP-T1 and LP-T1 images were classified as NC-AC. Lesions that became isointense with the basal cisterns on EP-T1 and showed grade 4 opacification were classified as CC-AC. Lesions that did not meet either of these definitions were classified as IC-AC. In all evaluations, both observers made their assessments independently for interobserver agreement analysis. Subsequently, cases with discrepant findings were reevaluated jointly, and a consensus decision was reached. All subsequent analyses were performed using the consensus dataset.

Data collection

The age and sex of the patients, the localization of ACs, the opacification grades on EP-T1, EP-FLAIR, LP-T1, and LP-FLAIR images, and the communication category of the cysts were recorded.

Statistical analysis

The conformity of continuous variables to a normal distribution was assessed using the Kolmogorov–Smirnov test, which demonstrated a non-normal distribution. Descriptive statistics and frequency analyses were performed for demographic data and AC localization. Interobserver agreement was assessed using Cohen's kappa statistics based on the initial independent evaluations of the two observers. Weighted kappa with quadratic weighting was used for ordinal variables (opacification grading), whereas unweighted kappa was used for categorical variables (cyst classification). Agreement was interpreted as poor (< 0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), or excellent (0.81–1.00). Following the interobserver agreement analysis, discrepant cases were resolved by consensus, and all subsequent statistical analyses were performed using the consensus dataset. Descriptive statistics and frequency distributions were calculated for opacification levels in each sequence. Differences in opacification levels between EP-T1 and EP-FLAIR and between LP-T1 and LP-FLAIR were analyzed using the Wilcoxon signed-rank test for both the entire cohort and subgroups within the same communication category. Comparisons of EP-FLAIR and LP-FLAIR opacification levels among the CC-AC, IC-AC, and NC-AC groups were performed using the chi-square test. All statistical analyses were conducted using SPSS version 28.0 (IBM Corp., Armonk, NY, USA).

Results

Demographic data and distribution of cyst locations are presented in Table 1.

Interobserver agreement for opacification grading was excellent across all sequences. The weighted kappa values were as follows: EP-T1, 0.879; EP-FLAIR, 0.942; LP-T1, 0.931; and LP-FLAIR, 1.00, indicating excellent agreement. Interobserver agreement for communication classification was also excellent, with a kappa value of 1.00.

The opacification rate was 54.5% (24/44) on EP-T1, 79.5% (35/44) on EP-FLAIR, 79.5% (35/44) on LP-T1, and 95.4% (42/44) on LP-FLAIR. The mean opacification grade was 1.5 ± 1.6 on EP-T1, 2.1 ± 1.4 on EP-FLAIR, 2.3 ± 1.4 on LP-T1, and 3.3 ± 1.1 on LP-FLAIR. Significantly greater opacification was detected on EP-FLAIR than on EP-T1 and on LP-FLAIR than on LP-T1 (P = 0.025 and P < 0.001, respectively) (Figure 2). In the EP, higher-grade opacification was detected on EP-FLAIR in 56.8% (25/44) of cases and on EP-T1 in 22.7% (10/44) of cases (Figure 2). In the LP, higher-grade opacification was observed on LP-FLAIR in 77.3% (34/44) of cases and on LP-T1 in 11.4% (5/44) of cases (Figure 2). The frequency distribution of opacification grades in each sequence is presented in Table 2.

Table 1. Demographic data and cyst localizations

	Patient count (n = 44), n %
Sex	
Woman	24 (54.5)
Man	20 (45.5)
Localization	
Middle cranial Fossa	13 (29.5)
Pericerebellar	13 (29.5)
Cranial convexity	5 (11.4)
Intraventricular	4 (9.1)
Cerebellopontine angle cistern	4 (9.1)
Quadrigeminal cistern	3 (6.8)
Suprasellar	1 (2.3)
Interhemispheric	1 (2.3)
Age	39.7 ± 14.1 (19–72)

According to the 3D T1W sequences, 22.7% (10/44) of the cysts were classified as CC-AC, 56.8% (25/44) as IC-AC, and 20.5% (9/44) as NC-AC. There was a significant difference in EP-FLAIR and LP-FLAIR opacification grades among all three categories ($P < 0.001$). Among the cases classified as NC-AC according to 3D T1W imaging, opacification was detected on EP-FLAIR in 11.1% (1/9) and on LP-FLAIR in 77.8% (7/9) (Table 3). In all CC-ACs, the EP-FLAIR opacification grade ranged from 1 to 3, and significantly higher-grade opacification was observed on EP-T1 than on EP-FLAIR ($P = 0.004$) (Figure 2). The opacification grade was significantly higher on EP-FLAIR than on EP-T1 in 96% (24/25) of IC-ACs, on LP-FLAIR than on LP-T1 in 92% (23/25) of IC-ACs, and on LP-FLAIR than on LP-T1 in 77.8% (7/9) of NC-ACs ($P < 0.001$, $P < 0.001$, and $P = 0.014$, respectively) (Figure 2).

Case examples are presented in Figures 3–6.

Discussion

Intrathecal gadolinium-enhanced MR cisternography is one of the examination methods used to assess the communication status of ACs with the subarachnoid space. Previous IGMRC studies primarily used 3D T1W sequences, whereas our study incorporated both EP and LP 3D FLAIR sequences in addition to conventional 3D T1W sequences.[7-11,13] Both EP-FLAIR and LP-FLAIR demonstrated higher sensitivity for detecting opacification than the 3D T1W sequences. Furthermore, among cysts initially classified as NC-AC based on 3D T1W images, opacification was detected in only one case on EP-FLAIR, whereas LP-FLAIR demonstrated opacification in the majority of these cysts (7/9, 77.8%). This finding suggests that LP-FLAIR may be particularly useful for detecting subtle or delayed communication that is not apparent on conventional T1W imaging. Nevertheless, in CC-ACs, EP-FLAIR demonstrated lower opacification grades than EP-T1. In IC-ACs, both EP-FLAIR and LP-FLAIR demonstrated higher opacification grades than the 3D T1W sequences.

Although many ACs are managed conservatively, evaluation of cyst communication may be clinically relevant in selected symptomatic patients with planned surgical intervention because it may influence the choice of surgical technique. In this study, IGMRC was performed only in such selected cases and was not intended for routine use. Compared with CT cisternography, IGMRC provides higher contrast resolution and may enable more sensitive detection of subtle communication.[8] However, as an invasive off-label technique, its use should be limited to carefully selected patients in whom the results are expected to affect clinical decision-making. Although previous studies have reported its relative safety when performed using appropriate protocols, potential risks, including neurotoxicity and adverse reactions, should be considered.[8-10]

In a previous IGMRC study using only fat-suppressed T1W sequences, opacification consistent with communication was detected in 77.2% of AC cases.[7] However, in a study conducted in patients with intraventricular ACs, communication was reported in only 38% of cases.[13] In contrast, CT cisternography studies have reported lower rates of communicating ACs, ranging from 18.1% to 65.3%.[4,14-17] In our study, using the conventional EP-T1 and LP-T1 methods, communication was identified in 79.5% of cases. In contrast, FLAIR sequences demonstrated opacification in 95.4% of cases. Among cysts initially categorized as NC based on T1W sequences, 77.8% exhibited opacification on LP-FLAIR. We propose that the term "minimally communicating AC" may be appropriate for these cysts. Based on these findings, we conclude that IGMRC performed solely with EP-T1 and LP-T1 imaging may provide insufficient information regarding communication status and that the addition of FLAIR sequences may offer a more sensitive method for detecting communication.

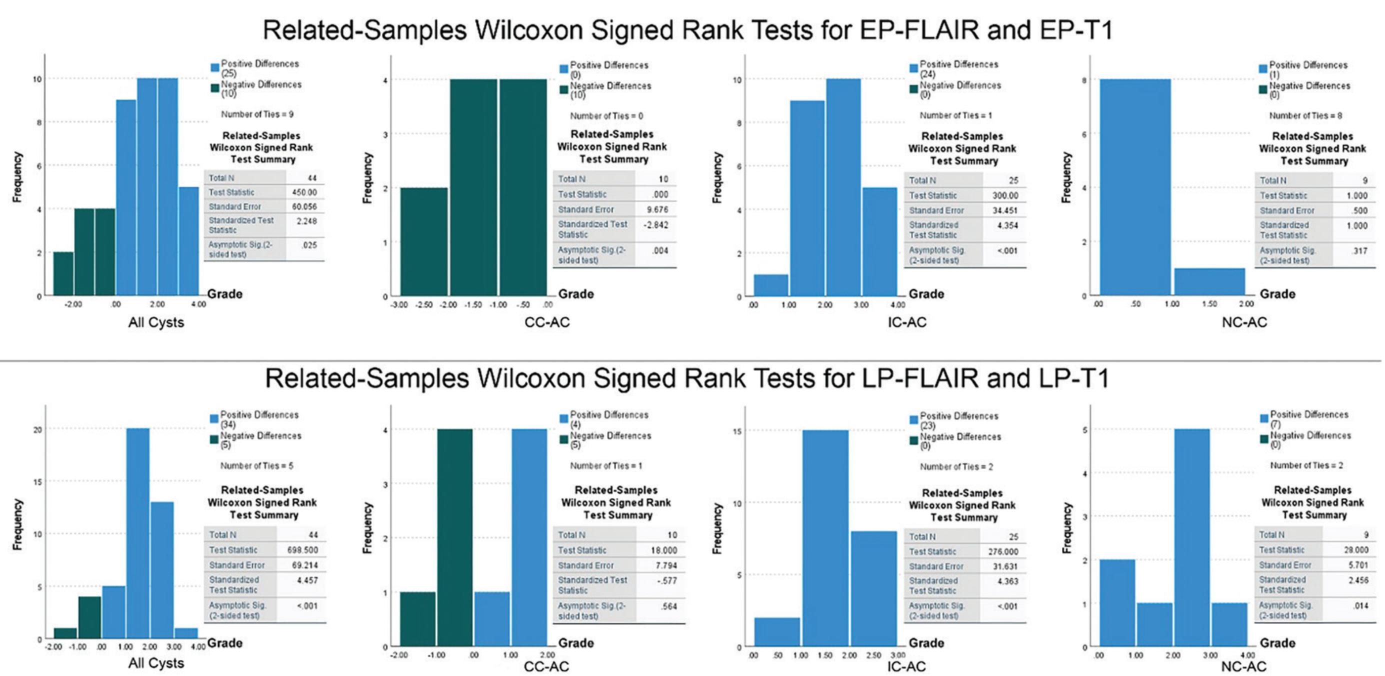

Figure 2. Wilcoxon signed-rank test results for overall ACs, CC-ACs, IC-ACs, and NC-ACs. Blue bars represent higher opacification grades on FLAIR, and green bars represent higher opacification grades on T1W images. CC, completely communicating; AC, arachnoid cyst; IC, incompletely communicating; NC, non-communicating; FLAIR, fluid-attenuated inversion recovery; T1W, T1-weighted.

Table 2. Opacification levels on each sequence

	EP-T1, n (%)	EP-FLAIR, n (%)	LP-T1, n (%)	LP-FLAIR, n (%)
Grade 0	20 (45.5)	9 (20.5)	9 (20.5)	2 (4.6)
Grade 1	4 (9.1)	7 (15.9)	1 (2.3)	1 (2.3)
Grade 2	10 (22.7)	7 (15.9)	9 (20.5)	7 (15.9)
Grade 3	0 (0)	14 (31.8)	17 (38.6)	6 (13.6)
Grade 4	10 (22.7)	7 (15.9)	8 (18.1)	28 (63.6)

EP, early phase; FLAIR, fluid-attenuated inversion recovery; LP, late phase.

Table 3. EP-FLAIR and LP-FLAIR opacification levels in different communication categories

	CC-AC, n (%)	IC-AC, n (%)	NC-AC, n (%)
EP-FLAIR			
Grade 0	0 (0)	1 (4)	8 (88.9)
Grade 1	2 (20)	4 (16)	1 (11.1)
Grade 2	4 (40)	3 (12)	0 (0)
Grade 3	4 (40)	10 (40)	0 (0)
Grade 4	0 (0)	7 (28)	0 (0)
LP-FLAIR			
Grade 0	0 (0)	0 (0)	2 (22.2)
Grade 1	0 (0)	0 (0)	1 (11.1)
Grade 2	1 (10)	1 (4)	5 (55.6)
Grade 3	4 (40)	1 (4)	1 (11.1)
Grade 4	5 (50)	23 (92)	0 (0)

EP, early phase; FLAIR, fluid-attenuated inversion recovery; LP, late phase; CC, completely communicating; AC, arachnoid cyst; IC, incompletely communicating; NC, non-communicating.

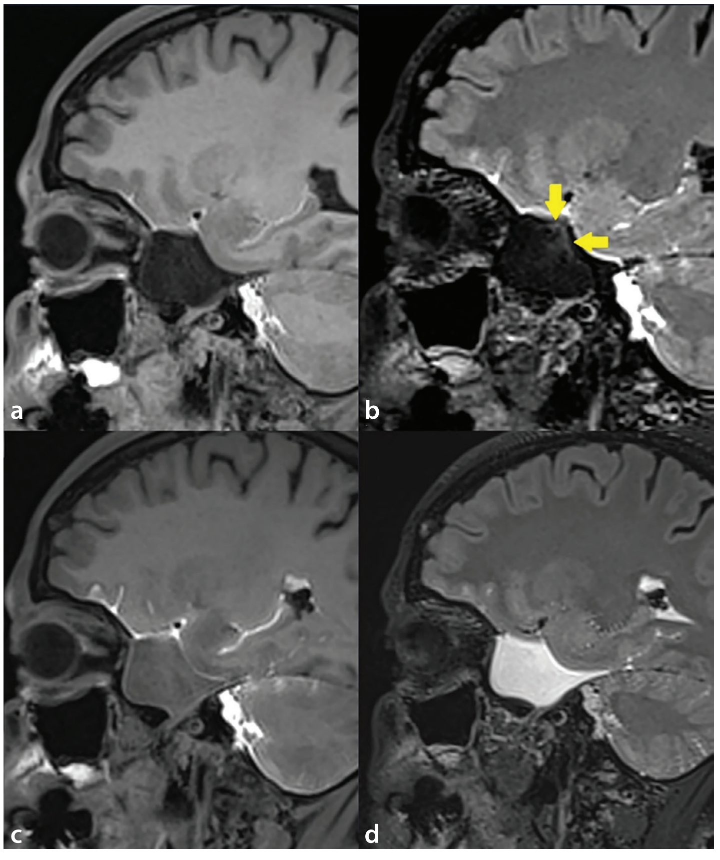

Figure 3. Example of a middle cranial fossa IC-AC. The EP-T1 image **(a)** shows no visible opacification. The EP-FLAIR image (**b**) demonstrates a faint focal signal increase in the posterosuperior peripheral portion of the cyst (yellow arrows), consistent with grade 1 opacification. The LP-T1 image **(c)** shows mild opacification involving part of the cyst (grade 2). The LP-FLAIR image **(d)** demonstrates marked signal increase with near-complete opacification (grade 4). AC, arachnoid cyst; IC, incompletely communicating; EP, early phase; EP, early phase; FLAIR, fluid-attenuated inversion recovery; LP, late phase.

Numerous studies in the literature have focused on intravenous contrast-enhanced FLAIR imaging.[12,18,19] Most of these studies compared the level of enhancement with that on T1W sequences. In particular, FLAIR has been reported to be more sensitive than T1W imaging for demonstrating leptomeningeal enhancement involving the basal cisterns and cortical sulci.[20] Phantom studies have shown that the T1-shortening effect in FLAIR sequences is more pronounced with low-dose gadolinium administration, leading to greater opacification than that observed on T1W sequences.[20,21] However, as gadolinium concentration increases, the dominant T2-shortening effect in FLAIR sequences reduces signal intensity, resulting in decreased brightness on FLAIR and increased brightness on T1W imaging. In our study, in CC-ACs showing opacification comparable with that of the basal cisterns on EP-T1 images, the opacification grade on EP-T1 was higher than that on EP-FLAIR. Conversely, in IC-ACs, higher opacification grades were observed on EP-FLAIR and LP-FLAIR images than on T1W images. These findings may be related to the high gadolinium concentration present during the EP in CC-ACs and the lower gadolinium concentration in IC-ACs.

According to the literature, the 95.4% opacification rate observed on LP-FLAIR in our study is notably high.[4,7,13-17] In our study, only two cysts showed no enhancement on any sequence. The relationship between gadolinium concentration and signal changes on MRI is complex. Factors such as the administered contrast agent dose, echo type, timing of image acquisition, and delivery of the contrast agent to the relevant region affect signal intensity on MRI.[22-25] Furthermore, the size and location of ACs may also influence the degree of opacification. The same amount of gadolinium may be highly diluted in larger cysts and less diluted in smaller cysts. Larger cysts may, therefore, require more gadolinium than smaller cysts to achieve sufficient opacification. Additionally, intrathecal contrast material is predominantly observed in the basal cisterns during the EP, whereas it may reach the ventricular system or cortical sulci only during the LP.[26] Cysts located near the basal cisterns, such as those in the middle cranial fossa or pericerebellar/cerebellopontine angle region, may demonstrate early contrast enhancement because of exposure to higher gadolinium concentrations. In contrast, intraventricular or convexity-located cysts may be exposed to lower amounts of gadolinium and may not opacify sufficiently. Patient weight and cyst size may

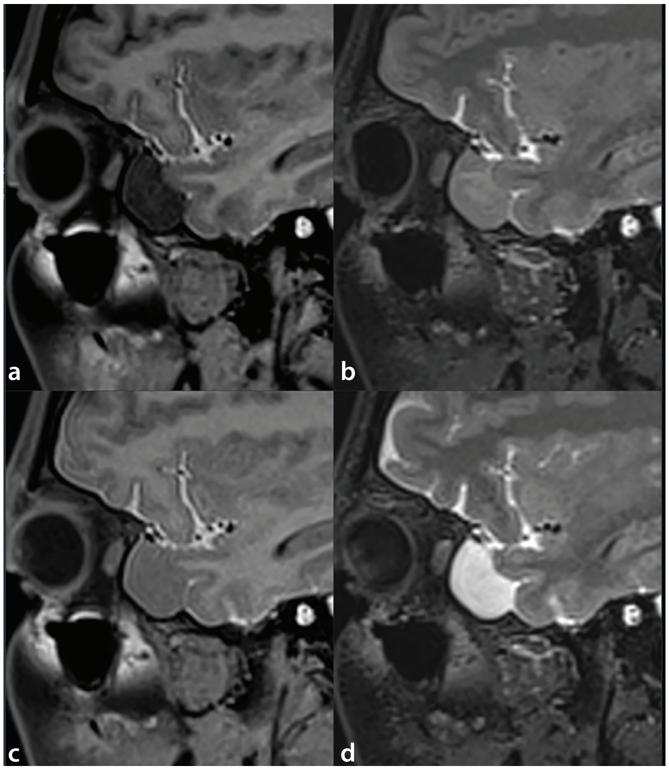

Figure 4. Example of a middle cranial fossa IC-AC. The EP-T1 image **(a)** shows a faint focal signal increase (grade 1). The EP-FLAIR image **(b)** shows moderate opacification involving most of the cyst (grade 3). The LP-T1 image **(c)** shows mild partial opacification (grade 2). The LP-FLAIR image **(d)** shows near-complete opacification (grade 4). AC, arachnoid cyst; IC, incompletely communicating; EP, early phase; EP, early phase; FLAIR, fluid-attenuated inversion recovery; LP, late phase.

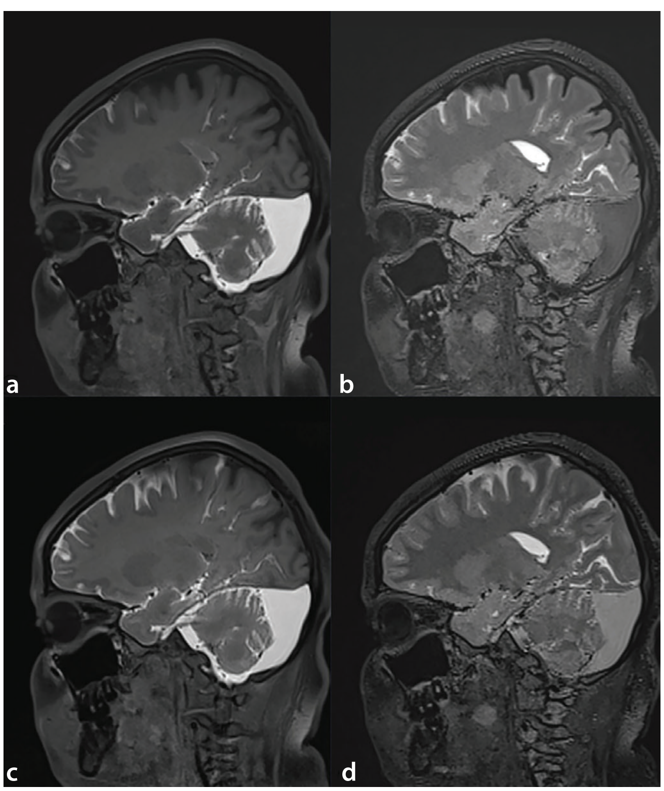

Figure 5. Example of a retrocerebellar CC-AC. The EP-T1 image **(a)** shows near-complete opacification (grade 4). The EP-FLAIR image **(b)** shows mild partial opacification (grade 2). The LP-T1 image **(c)** shows near-complete opacification (grade 4). The LP-FLAIR image **(d)** shows moderate opacification involving most of the cyst (grade 3). AC, arachnoid cyst; CC, completely communicating; EP, early phase; EP, early phase; FLAIR, fluid-attenuated inversion recovery; LP, late phase.

also affect opacification levels. The variation in opacification rates reported in previous studies of intraventricular cysts versus middle cranial fossa or retrocerebellar cysts may be attributable to these factors.[4,7,13,14,17] Based on the LP-FLAIR opacification observed in nearly all ACs in our study, we hypothesize that most ACs may, in fact, have some degree of communication with the CSF spaces and that opacification status may vary depending on the factors discussed above. However, the current study was not designed to perform subgroup analyses based on these variables because of sample size limitations. Future studies with larger cohorts could evaluate the effects of factors such as cyst location, contrast agent dose, patient weight, and cyst size on AC opacification levels.

Another advantage of EP-FLAIR is its ability to demonstrate a significantly higher opacification rate than EP-T1. The greater opacification observed on EP-FLAIR suggests that it may have the potential to reduce the need for LP imaging when only the presence of communication is of interest; however, this observation should be interpreted cautiously and requires validation in prospective studies. In cases in which opacification is not detected on either EP-FLAIR or EP-T1, LP imaging can still be performed.

This study has several limitations. First, the opacification grading system is semi-quantitative and based on visual assessment, which may introduce a degree of subjectivity despite the high interobserver agreement. Although the proposed grading system provides a detailed framework for research purposes, simpler classification approaches with greater clinical practicality may be preferred in routine practice. Second, the retrospective design and relatively small sample size may limit the generalizability of the findings. Third, intrathecal gadolinium administration is an off-label and invasive procedure, which limits the routine applicability of this technique. Finally, the lack of subgroup analyses according to cyst size and location represents an additional limitation. Further studies with larger patient populations are needed to validate these findings.

In conclusion, combining both T1W and FLAIR sequences provides the most comprehensive evaluation of ACs and may reduce the need for LP imaging. The findings suggest that the majority of ACs may demonstrate some degree of communication with the CSF, particularly when evaluated using sensitive imaging techniques such as 3D FLAIR. Considering that most cysts that ap-

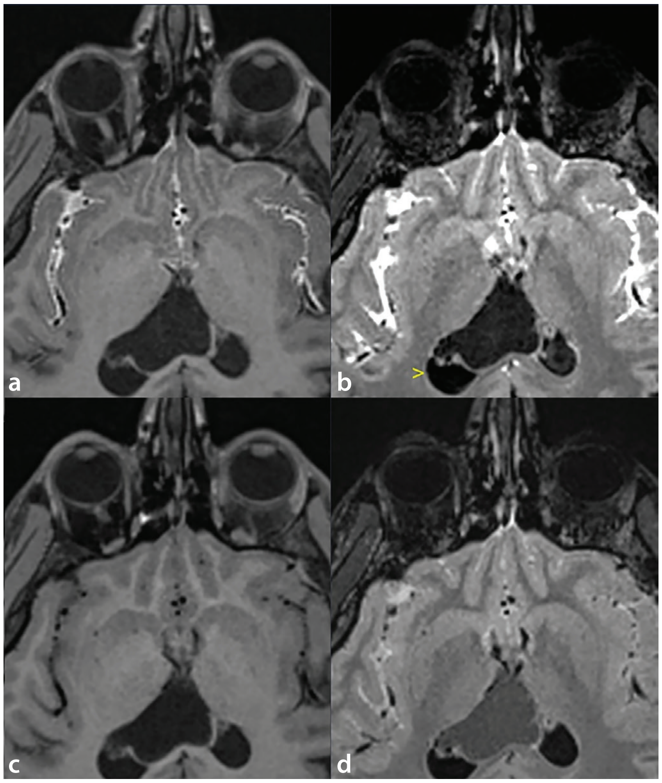

Figure 6. Example of an intraventricular NC-AC based on 3D T1W images. The EP-T1 **(a)** and LP-T1 **(c)** images show no opacification (grade 0). The EP-FLAIR image **(b)** shows no opacification in the occipital horn of the right lateral ventricle (arrowhead) and a faint focal signal increase within the cyst (grade 1). The LP-FLAIR image **(d)** shows mild partial opacification within the cyst (grade 2). AC, arachnoid cyst; NC, non-communicating; EP, early phase; EP, early phase; FLAIR, fluid-attenuated inversion recovery; LP, late phase.

pear NC on T1W imaging demonstrate opacification on LP-FLAIR, it is suggested that most ACs may be connected to the CSF spaces in some manner. However, due to factors such as cyst location and size and the dose of contrast agent used, they may not opacify sufficiently in cisternography studies.

Footnotes

Conflict of interest disclosure

The authors declared no conflicts of interest.

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