Visualization of Endolymphatic Hydrops with 1.5T MRI in Ménière's Disease: A Preliminary Study

Frédérique Chapon[1]; Mélanie Sanjuan[2]; Olivier Monnet[1]; Arnaud Devèze[3]; Maya Elziere[3]; Christine Fatou-Balansard[4]; Gilles Plasse-Fauque[2]; Michèle Rakedjian[2]; Catherine Cannoni[2]; Philippe Derome[2]; Rym Djouri[5]

[1] Department of Radiology, Saint Joseph Hospital, Marseille, France
[2] Department of Otolaryngology, Saint Joseph Hospital, Marseille, France
[3] Department of Otolaryngology, Clairval Hospital, Marseille, France
[4] Department of Otolaryngology, Aix en Provence Hospital, France
[5] Siemens Healthineers, MRI Application, France

Introduction

Ménière's disease is associated with endolymphatic hydrops (EH). This has been described in postmortem histological samples of patients with Meniere's disease [1]. There is no current data to determine whether this EH is the cause or consequence of another etiology (traumatic, autoimmune, electrolyte imbalance, viral) at the origin of the symptoms.

In its complete form, the pathology is characterized by episodes of vertigo, tinnitus, and hearing loss. Its evolution is erratic and many patients present incomplete forms. Since 2007 and the work of Nakashima et al. [2], MRI has been among the examinations that can help diagnose Ménière's disease by allowing an *in vivo* visualization of EH.

Numerous recent studies have shown that 3T MRI can visualize EH by using different routes for contrast agent administration (intratympanic versus intravenous), by varying the contrast dose (single, double, triple dose), and by modifying the technical parameters of the acquisition (coils and number of channels) and sequences (3D FLAIR and 3D-real IR). Our study aims to validate EH detection with 1.5T MRI after intravenous contrast injection.

Material and methods

From September 2016 to September 2017, 53 patients with clinical signs of Ménière's disease (35 women and 18 men ranging from 14 to 80 years of age) underwent 1.5T MRI of the temporal bone to demonstrate EH (3D Fluid Attenuation Inversion Recovery with variable Flip Angle Turbo Spin Echo – 3D SPACE FLAIR – sequence).

The examination was performed on a MAGNETOM Avanto^{fit} system with a 20-channel Head coil. The main parameters of the sequence were: FOV 200 x 190 mm; Slice thickness 0.85 mm; TR 7000 ms; TE 536 ms; number of excitations 4; TI 2200 ms; matrix 256 x 256; bandwidth 448 Hz/px; scan time 10 minutes. The intravenous double-dose contrast agent injection (Gadovist 1.0 mmol/mL, Bayer Healthcare, Germany) was administered 4 hours prior to image acquisition.

Before the study, all patients underwent 1.5T MRI to rule out other causes of their symptoms. Examinations of eight patients were excluded from the study because of motion artifacts. A retrospective collection of clinical data was carried out. For statistical analysis, we selected 21 patients with clinically definite disease (definite Ménière's disease according to the revised AAO-HNS criteria [3, 4]) in order to be certain of the presence of EH.

The MRI data of these 21 patients were retrospectively and qualitatively analyzed by two experienced neuroradiologists who were blinded to the side of the symptoms (unilateral or bilateral) and to the clinical score of Ménière's disease.

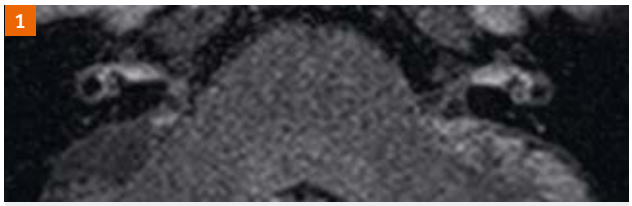

Figure 1: Normal bilateral vestibule.

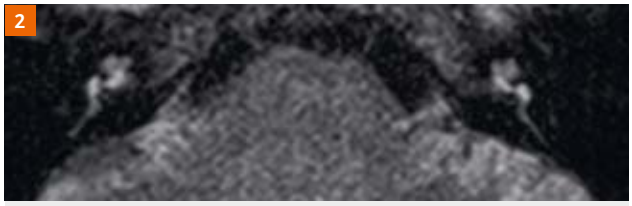

Figure 2: Normal bilateral cochlea.

Hydrops of the cochlea and vestibule were separately assessed by visual comparison of the relative areas of the unenhanced endolymphatic space versus the contrast-enhanced perilymphatic space.

MR imaging findings

In the normal vestibule on the delayed 3D FLAIR sequence, the added surface areas of the saccule and utricle are less than half of the area of the vestibule at horizontal semicircular canal level. Vestibular EH is defined as distension of the endolymphatic space (saccule, utricle, or both) to > 50% of the vestibule.

In the cochlea, absence of hydrops is defined as the absence of displacement of Reissner's membrane. Cochlear EH is defined as distension of the cochlear duct in the scala vestibuli.

Statistical analysis for interobserver agreement in detecting cochlear and vestibular EH was performed with the adjusted kappa test and Bowker's test. The agreement between the radiologists' response and the laterality of the clinical impairment was performed by Cohen's kappa test.

Results

MRI EH detection

Vestibular EH was detected in 19 out of 21 cases. Both radiologists agreed on the absence of hydrops in the two remaining cases. The kappa test for interobserver agreement was 0.74 with a match rate of 90%. Cochlear EH was seen in 14 out of 21 cases. Both radiologists agreed on the absence of hydrops in the remaining 7 cases. The kappa test for interobserver agreement was 0.95 with a match rate of 95%.

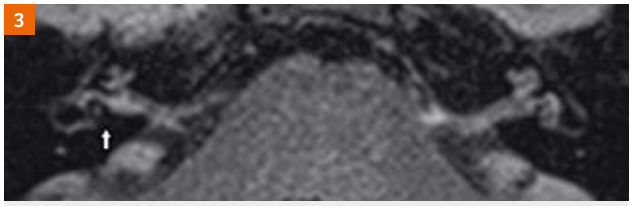

Figure 3: Hydrops in right vestibule (white arrow).

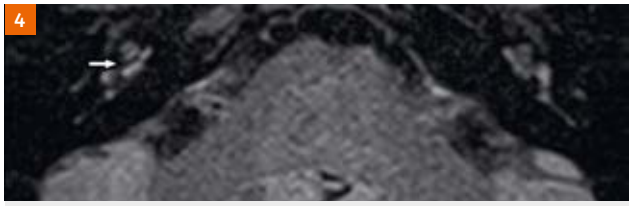

Figure 4: Hydrops in right cochlea (white arrow).

Table 1: Inter-radiologist agreement: Vestibule.

		Radiologist 2			
		0	R > L	L > R	Total
Radiologist 1	0	2	0	0	2
	R > L	0	10	0	10
	L > R	2	0	7	9
	Total	4	10	7	21

Match rate: 19/21 (90%)
Weighted kappa[1]**:** 0.74 [IC95 0.42–1.00]; Strong agreement between radiologists
Bowker's test of symmetry: p = 0.5724; Non symmetry hypotheses between radiologists rejected
R = right, L = left

Table 2: Inter-radiologist agreement: Cochlea.

		Radiologist 2				
		0	R	L	Bilateral	Total
Radiologist 1	0	7	0	0	0	7
	R	0	7	0	1	8
	L	0	0	6	0	6
	Total	7	7	6	1	21

Match rate: 20/21 (95%)
Weighted kappa[1]**:** 0.95 [IC95 0.84–1.00]; Almost total agreement
Bowker's test of symmetry: p = 0.8013; Non symmetry hypothesis between radiologist rejected

[1] Kappa Index: < 0 (disagreement); 0–0.20 (very week agreement); 0.21–0.40 (weak agreement); 0.41–0.60 (moderate agreement); 0.61–0.80 (strong agreement); 0.81–0.99 (almost perfect agreement); 1.00 (perfect agreement)

Correlation between imaging and clinical diagnosis

There was a high level of agreement between the radiologists and the clinical diagnosis for both cochlear and vestibular EH: 82% for cochlear (Cohen's Kappa test 0.64) and 92% for vestibular (Cohen's Kappa test 0.85).

Table 3: Agreement between radiologists and clinical data: Vestibular.

		Clinical Data		
		R	L	Total
Radiologists	R	8	2	10
	L	1	6	7
	Total	9	8	17
	Undetermined	1	1	2
	Disagreement	0	2	2

Match rate L/R: 14/17 (82%); Only in the upper part of the table (L/R)
Total agreement: 14/21 (67%); Taking into account the whole table
Kappa simple: 0.64 (0.28–1.00); Strong agreement
Symmetry test: p = 0.5637; Non symmetry hypothesis between radiologists and clinical data rejected

Table 4: Agreement between radiologists and clinical data: Cochlear.

		Clinical Data		
		R	L	Total
Radiologists	R	6	1	7
	L	0	6	6
	Total	6	7	13
	Undetermined	3	4	7
	Disagreement	1	0	1

Match rate D/G: 12/13 (92%); Only in the upper part of the table (L/R)
Total agreement: 12/21 (57%); Taking into account the whole table
Kappa simple: 0.85 (0.56–1.00); Almost full agreement
Symmetry test: p = 0.3173; Non symmetry hypothesis between radiologists and clinical data rejected

Discussion

Apart from major episodes of vertigo, hearing loss, and tinnitus, many patients suffer from incomplete forms of Ménière's disease and experience fluctuating hearing loss, recurring vertigo without hearing loss, or hearing loss preceding a few months or years of dizzy spells. The diagnosis is based on the recently revised AAO-HNS criteria [3, 4].

We chose to analyze the results of patients with definite Ménière's disease in order to be sure that EH was present.

The main aim of using MRI to visualize EH is to confirm the diagnosis at an early stage and thus begin treatment before possible hearing sequelae occur.

As mentioned above, since Nakashima et al. described the visualization of EH in 2007 [2], numerous studies have been carried out that confirm the possibility of visualizing EH with 3T MRI scanners (with 3D SPACE FLAIR or 3D-real IR [1]). To our knowledge, few studies have been published on MRI at 1.5T [12].

In our study, we used a 3D FLAIR sequence after administering contrast media intravenously (which is less restrictive, less painful, and avoids local complications).

Visualization of EH at 1.5T is possible and reproducible with a strong agreement between radiologists (adjusted kappa: 0.74; agreement: 90%). For the cochlear, the agreement between radiologists is very strong (adjusted kappa: 0.95; agreement: 95%).

The impossibility of distinguishing the saccule and utricle in our images (with the anatomical structures appearing 'fused') and the asymmetry of the dilation are strong indications of vestibular impairment.

In our study, cochlear involvement appears to be a very strong and reproducible criterion.

On correlation of radiological and clinical findings, there was a high agreement in both vestibular and cochlear involvement, with EH found in 19 out of 21 cases with clinically significant disease.

The radiologists agreed on the absence of vestibular and cochlear hydrops in two cases. These results match those published by Fraysse et al. [8] and Barath et al. [9]. The assumptions used for these patients were the short duration of the disease (< 6 months) and an examination carried out between episodes. Indeed, the reversibility of EH displayed in MRI is commonly accepted [6].

Based on asymmetry between the vestibules, two patients showed a more pronounced hydrops on the contralateral side to the clinical attack. Nonsymptomatic ear involvement is frequently reported in the literature [10, 11], with some papers suggesting a systemic origin for Ménière's disease.

In our study, the grading of the vestibular lesion as proposed by Nakashima [2] is not reproducible, which led to disagreement between radiologists. These results demonstrate the limitations of the sequence at this field level.

The duration of the sequence at 1.5T (10 minutes, vs. 7 minutes at 3T) is an important factor to take into account. It causes motion artifacts and required us to exclude 8 patients from the study. Simple immobilization of the head during patient preparation can significantly decrease artifacts.

Conclusion

Using MRI to visualize EH means that patients suffering from Ménière's disease can receive treatment at an early stage and before the appearance of auditory sequelae. Hydrops can be visualized with a 1.5T MRI system, and 3D FLAIR is a robust sequence for visualizing cochlear and vestibular hydrops.

The possibility of performing these routine examinations at 1.5T is a significant step forward in terms of treating these patients. It facilitates their access to imaging and can optimize the management of their condition.

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Contact

Frédérique Chapon
Hôpital Saint Joseph

26 boulevard de Louvain
13008 Marseille
France
frederiquechapon@icloud.com