Aims and objectives

Menière's disease is a highly stressful and personally restricting disorder of the inner ear. Diagnosis is made by clinical characteristics and clinical/physiological testings, but in many cases a definite diagnosis of Menière's disease - according to the diagnostic criteria of the AAO-HNS - is not possible.

The recently established Endolymphatic Hydrops MRI (EH-MRI) by use of i.v.-application of Gadolinium-based contrast agents allows the in-vivo diagnosis of Menière's disease (Naganawa et al. 2012).

The existing semi-quantitative, objective grading systems may be inaccurate concerning therapy monitoring and have recently shown deficits under special anatomical/pathological circumstances (e.g. intralabyrinthine tumor manifestation).

Objective of this study was to demonstrate the quantitative evaluation of endolymphatic hydrops in Menière's disease patients, compared to semi-quantitative image evaluation.

Moreover, the legitimate question is raised, why EH-MRI is actually only performed rarely in Europe. Especially under consideration that special therapy options depend on the definite diagnosis of Menière's disease, second objective of this study was to evaluate the patient acceptance and personal benefit for the patient collective.

Methods and materials

This prospective clinical study was conducted at the University Hospital Münster, including n = 10 patients with definite and n = 1 patient with possible diagnosis of Menière's disease. As negative control an asymptomatic subject was examined the same way.

The patient's mean age was 32 to 72 years (54.91 ± 14.2 years), 7 patients were female and 4 male.

4 hours before MR measurements intravenous application of a single dose Gadovist® Gd-DO3A-butrol (0.2 ml/kg or 0.1 mmol/kg body weight) was performed.

The imaging was performed on a 3-tesla MR imaging unit (Philips Achieva, Philips Medical Systems, Best, NL) using a 16-channel array head and neck coil. The evaluation of endolymphatic hydrops started with a T2DRIVE 3D MR cisternography for anatomical reference of total lymph fluid. Parameters are: TR 2000 ms; TE 200 ms; flip angle 90°, refocusing angle 120°. 1.0-thick axial slices covering the labyrinth were gained, FOV 100 x 100 x 37.5 mm. The matrix size was 240 x 161.
Afterwards, special sequences for differentiation of endolymphatic and perilymphatic fluid were adapted to our scanner unit. Parameters for positive endolymphatic image (PEI; VISTA-IR-2050) were: VISTA sequence (TR 9000 ms; TE 540 ms; inversion time 2050 ms; SPAIR fat suppression pulse with an inversion delay of 220 ms, refocusing angle 160°, matrix size 126 x 163, FOV 150 x 179.2 x 57.6 mm.

Parameters for positive perilymphatic image (PPI; VISTA-IR 2350) were: VISTA sequence (TR 9000 ms; TE 540 ms; inversion time 2350 ms; SPAIR fat suppression pulse with an inversion delay of 220 ms, refocusing angle 160°; matrix size 126 x 163, FOV 150 x 179.2 x 57.6 mm, the scan time was 9.5 minutes.

As well as for PEI as for PPI 1.0-thick axial slices were gained. After acquisition of the images, we gained HYDROPS images after motion correction by subtracting PEI from PPI as proposed by Naganawa et al. (2012).

Endolymphatic hydrops was graded by two different radiologists in consensus-procedure according to the criteria of Nakashima, Naganawa et al. (2009).

Quantitative evaluation was performed by slice-by-slice-segmentation of the outer margins of the labyrinth in MR-cisternography and endolymphatic space in PEI. The proportion of the endolymphatic space relative to the total labyrinth space was expressed in percent and compared to the qualitative analysis (Fig. 1).

After the examination, a survey consisting of 7 questions was conducted for evaluation of patient acceptance and satisfaction.

Institutional review board approval was obtained for this study.

Images for this section:
Fig. 1: Volumetric assessment of labyrinth and endolymphatic space: Positive Endolymphatic Image (PEI) and T2DRIVE-Cisternography were segmented slice-by-slice. Afterwards, the gained volumes were compared to each other to perform quantitative Endolymphatic Hydrops Grading.
Results

Quantitative vs. semi-quantitative analysis:

MRI was carried out on average 4.2 ± 0.4 h after i.v.-injection of a standard-dose Gadovist®/Gd-DO3A-butrol (0.2 ml/kg or 0.1 mmol/kg body weight).

The quantitative measurements of the inner ear liquid compartments showed a mean volume of the cochlear labyrinth of 102 ± 21.21 µl and a mean volume of the vestibular labyrinth of 162.73 ± 26.89 µl. The total labyrinth volume was 264.73 ± 39.46 µl. Coefficient of variance was 14.91 %. Regarding the sickness duration, the mean labyrinthine volume of patients with sickness duration < 30 months was 239.25 ± 30.49 µl and those with > 30 months had a mean labyrinthine volume of 279.29 ± 36.51 µl. The difference was statistically significant (p = 0.025; Wilxoxon-Mann-Whitney-U-Test, Fig. 2). Affected inner ears showed this significant volume increase as well as the side without endolymphatic hydrops.

Symptoms occurred on the left ear in 5 cases (right ear 4 cases) and in one case both ears were affected.

Semi-quantitatively for the total of n = 22 cochlear structures in 12 inner ears no cochlear hydrops was detected, n = 4 inner ears presented with a mild cochlear hydrops (I°) and n = 6 inner ears were effected significantly (II°) by cochlear endolymphatic hydrops. The quantitative analysis of the endolymphatic space delivered 3 inner ears with mild cochlear hydrops (I°), n = 6 with significant cochlear hydrops and 13 patients had no relevantly dilated endolymph. The correlation coefficient r between both methods was r = 1 for the right ear and r = 0.95 for the left ear.

The semi-quantitative analysis of the vestibule showed the following results: n = 7 inner ears showed a mild vestibular endolymphatic hydrops (I°), n = 7 a significant vestibular EH (II°) and 8 inner ears showed no relevant EH (0°). Correlation coefficients between semi-quantitative and quantitative analysis were r = 1 for the right and r = 0.73 for the left vestibular structures (Fig. 3).

We detected no statistical significant difference between both methods.

One case showed the rare entity of an intravestibular Schwannoma, which was localised on level of the lateral semicircular canal (Fig. 4), so the standard-approach for semi-quantitative evaluation was affected and the endolymphatic volume could only be determined approximately. After quantitative slice-by-slice measurements excluding the intralabyrinthine mass, the approximated volume could be verified.

The asymptomatic subject showed no significantly dilated endolymphatic space with both methods.
Patient acceptance testing:

9 from 11 patients participated in the survey. Concerning the experienced stress of the examination a mean value of 3.2 ± 2.8 (on a scale of 1 to 10 with 1 = non-stressful and 10 = very stressful) was reached, no patient had any problems with the i.v.-application of the contrast agent. The personal benefit for the patients was high; only one patient (11.1 %) stated out that he/she felt no personal benefit. Under consideration that every patient in the study considered the amount of effort as reasonable, the personal reasons for the high acceptance were the personal certainty of the diagnosis after the examination (75 %), the felt certainty of the therapeutic efficacy (12.5 %) and last but not least the subjective feeling of certainty of non-severity of the disease (12.5 %). All patients felt confident that the results of the examination have an impact on therapy and course of the disease. Moreover, all of the included subjects would recommend Endolymphatic Hydrops MRI to other patients.

Images for this section:
**Fig. 2:** Total labyrinth size (y-axis) in dependence of the duration of the disease (x-axis). The difference between both groups was considered significant ($p = 0.025$).
**Fig. 3:** Comparison of semi-quantitative and quantitative/volumetric assessment of endolymphatic size.

**Fig. 4:** 3D-Model of the inner ear gained by slice-by-slice segmentation of the different compartments. Hydropic endolymphatic structures are illustrated as black structures, and the intralabyrinthine tumor in the vestibule is colored red. Single voxels are not represented in this graphic.
Conclusion

Endolymphatic Hydrops MRI is a highly recommendable diagnostic tool to evaluate endolymphatic hydrops in Menière’s disease. Our study shows that the existing semi-quantitative grading systems are highly accurate, but special anatomical conditions (e.g. intralabyrinthine tumors) should be additionally evaluated by quantitative post-processing methods.

Compared to other MRI and histological studies on healthy subjects (e.g. Melhem et al., 1998) the labyrinthine volumes of our population seem to be slightly elevated. Moreover, in contrast to recent CT-studies (Krombach et al., 2005) we detected a significant increase of the intralabyrinthine volume depending on the duration of the disease maybe based on pressure-dependent osseous reconstruction processes. Further MRI-investigations concerning this finding with a healthy control group are needed.

For the first time the patient's acceptance for Endolymphatic Hydrops MRI was tested. The high grade of personal benefit for the patient and the high acceptance of contrast-enhanced MRI-examinations should be taken into consideration for coming diagnostic guidelines.

Personal information

This study has been supported by a travel grant (Bilateral Exchange Program) of the Japan Society for the Promotion of Science (JSPS) for Georg Homann.

References

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