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MRI SCREENING OF THE CEREBELLOPONTINE ANGLE AND INNER EAR WITH FAST SPIN-ECHO T2 TECHNIQUE

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INTRODUCTION

Contrast enhanced spin-echo magnetic resonance imaging (MRI) has become the golden standard investigation of the cerebellopontine angle (CPA), internal auditory meatus (IAM) and inner ear. It demonstrates or excludes pathologies of this region with a sensivity and specificity higher than the clinical auditory or vestibular investigations. That is why the number of patients with dizziness, unilateral hearing loss, and/or tinnitus referred to MRI examination has increased significantly in the recent times. MRI is a rather expensive technique, and the use of gadolinium contrast increases the cost even more. Thus, there is a demand for a short and cheap "screening" MRI examination of the CPA, IAM and inner ear.

The gradient echo sequences which can create high resolution images of the inner ear and IAM without contrast (5) are prone to magnetic susceptibility artifacts. The fast spin echo (FSE) images are less affected by these artifacts and thus heavily T2-weighted (T2) images of the inner ear, IAM and CPA can be obtained (17, 14, 1). The technique can be combined with three-dimensional (3D) volume sampling, allowing thinner slices than the 2D sampling technique (0.7 mm compared with 2 mm). The tiny structures of the inner ear can be reliably visualized on the 3D FSE T2 images (13). A cost effective screening for acoustic neuroma by FSE T2 weighted images or by constructive interference in the steady state (CISS) 3D technique were suggested by Allen et al. (1), Stuckey et al. (16) and Hermans et al (7). According to our knowledge this is the first time when 3D FSE T2 images were routinely used on a big patient material in screening for acoustic neuroma (AN). A preliminary report on a smaller series of cases has previously been presented (10).

METHODS

Onehundred and fiftytwo patients with unilateral sensorineural hearing loss and/or balance disorders were examined by this MRI technique at the University Hospital in Linköping between September 1996 and November 1997. Eleven out of them were sent to size-control of a known acoustic neuroma.

The MRI examinations were performed on a superconductive 1.5 T (Signa, General Electric Corp) equipment. After aquisition of 5 and 7 mm thick, sagittal and axial T2-weighted FSE sequences of the whole brain, the thin T2-weighted 3D-FSE images of the CPA (technical description: TR/TE: 3500-4000 ms / 143-243 ms, matrix: 256 x 256, 256 x 192, 256 x 512, FOV: 15 x 15, 22 x 16 cm, slice thickness: 0.7 mm) were performed in every patient. Reconstructions in the axial and coronal planes were obtained in every case and occasionally sagittal images as well. If the findings on the 3D FSE pictures were doubtful (and in every patient with a known neuroma) the study was completed with 3 mm thick T1-weighted axial and coronal images of the CPA area with and without gadolinium contrast. Five mm thick T1 weighted images before and after contrast administration of the whole brain were obtained in a few cases. Twenty-five of the patients (16%) (size controls, twelve cases with suspected neuroma, one with epidermoid and another with suspected vessel loop) were given gadolinium contrast. These patients served as their own controls. Gadolinium administration did not alter the diagnosis in any case.

RESULTS

The full length of the seventh and eighth nerves could be followed accurately in all normal cases on the 3D FSE images, as can be seen on the left hand side of the image shown in figure 1 (which, however, is the patient's right side). The contrast between fluids, nerves, bone and tumor was detected in all cases (for an example, see the right hand side of Figure 1). The tumors were hypointense relative to the cerebrospinal fluid on the thin section T2 weighted images and could be identified with the same accuracy as on the customary T1 series with gadolinium contrast. As also can be seen on figure 1, the lateral extent of the acoustic neuroma into the IAM could be correctly detected with the new sequence. The bright signal of the inner ear could be visualized in every patient.

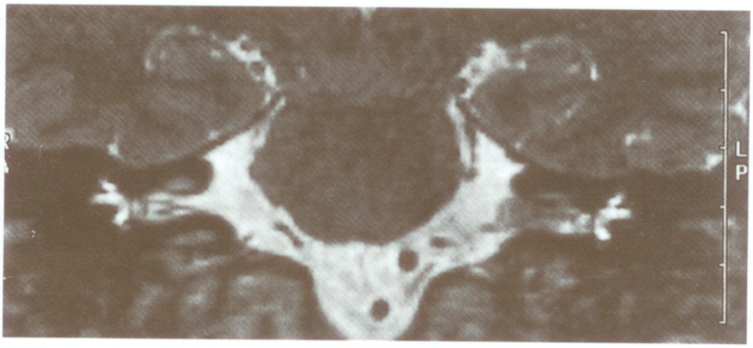

Fig. 1. - *Coronal T2 weighted FSE MR image of a patient with a left sided acoustic neuroma (seen on the right side of the figure).*

On the patient's right side, the seventh and eighth nerves can be followed well. On the patient's left side, the outline of the tumor is clearly demonstrated.

The results are summarized in Table 1. Onehundred-twentyeight of the examined patients (84%) were examined for suspected acoustic neuromas. In six (4.7%) of them the presumed diagnosis was confirmed. Three of the tumors were intracanalicular, and three had extracanalicular growth measuring 10-20 mm.

Table 1. - *Referral questions versus radiology findings in 152 cases.*

REFERRAL QUESTION	RADIOLOGY FINDING
Acoustic neuroma 128 (84%)	Acoustic neuroma 6 (4.7%) Intralabyrinthine schwannoma 1 Epidermoid 1 Ramsey-Hunt syndrome 1 Parasagittal meningeoma 1 Apical lesion 1 Vessel loop 7 Multiple sclerosis 2 Ischemic lesions 28 (22%) (8 in the brainstem) Normal 80 (62%)
Vessel loop 5	Vessel and nerve in contact 2 Normal 3
Open cochlea 5	Not patent 2 Normal 3
Cochlear otosclerosis + AN 1	Cochlear otosclerosis only 1
Op for cholesteatoma 1	Labyrinth destruction 1
Unclear sensory neural hearing loss 1	Bilat dilated vestibular aqueducts 1
Size control of acoustic neuroma 11	No growth 11

Twenty-eight patients (22%) had ischemic disease in the brain. The previously known neuromas not grow. The size of the extracanalicular portions of the re-examined neuromas was between 10-18 mm. Two known tumors were intracanalicular and measured 3 x 6 and 6 x 9 mm, respectively. Follow-up time was around one year.

DISCUSSION

MRI with intravenous administration of gadolinium (Gd-DTPA) was acknowledged as a sensitive tool to look for pathology of the CPA and IAM in the 1980's (9), and MRI was used to demonstrate alterations in the inner ear first at the end of the decade (11). A detailed study of the membranous labyrinth's anatomy by MRI was done a few years later (3). The combination of thin MRI slices and gadolinium contrast can demonstrate pathologies that cause enhancement within the inner ear (2, 12). Gradient echo images (3, 4) as well as steady-state free precession technique (15) allowed using sequences providing thinner slices and better contrast between fluids, nerves and bone than previously. However, the disadvantage of the thin section gradient echo techniques is the magnetic susceptibility signal loss, seen in the temporal bone due to various tissue interfaces inherent to this area (5, 1) or by the bright signal from cerebrospinal fluid (15). These artifacts affect the FSE images less, allowing the acquisition of heavily T2-

weighted images. FSE is a new, fast scanning method which provides conventional spin echo contrast in shorter time by using an altered k-space filling. High resolution, heavily T2 weighted images of the inner ear, CPA and IAM, which provide good contrast between bone, nerves and liquor in the CPA region can thus be accomplished in a reasonable time (often around six minutes). FSE images have been shown to be useful as the preliminary radiology investigation of choice for most of the otoneurological questions (17, 14, 1, 6). Further refinement of the method using 3D volume imaging which allows 0.7-1 mm thin slices (compared to the 3 mm thickness of the 2D images) has been suggested. Naganawa et al (13) demonstrated that the 3D FSE T2 sequences can provide detailed visualization of the labyrinth.

In Allen's and Stuckey's studies (1, 16) the 3 mm thick 2D FSE T2 and CISS images could trustworthily differentiate between normal subjects and tumor patients in most cases. However, the thickness of these images made it difficult to confidentially evaluate the images where the IAM was narrow. The amount of cerebrospinal fluid surrounding the seventh and eighth nerves is decreased in slim IAMs making the interpretation of the images difficult. This problem could be overcome by 3D volume imaging. There are less partial volume averaging in the thinner slices, and the technique allows reconstruction in every direction. Pictures in the sagittal direction were useful to exclude tumors in patients with a narrow IAM. On oblique reconstructions the nerves could be reliably followed in their full length, or an extra view of the cochlea could be obtained. Using 0.7 mm thick 3D Fourier transform constructive interference in steady state (3DFT-CISS) sequence, Hermans et al. (7) achieved a sensitivity of 94% and a specificity of 97% in screening for AN without gadolinium contrast.

The size of the known neuromas sent for followup can be explained by the patient selection. The examined subjects were actively chosen not to be operated (except the one with a 18 mm tumor), and obviously the tumor sizes could not be big.

A critique of the screening for neuroma with unenhanced MRI is that the pathologies detectable only on enhanced images (e.g. labyrinthitis, or neuritis) will be overlooked (8). These lesions are rare and in general not surgically treatable, or present with obvious clinical symptoms, allowing other means of diagnosis. Moreover, if the referring clinician is especially interested in these diseases he can always request for a contrast enhanced MRI of the CPA, IAM and inner ear. There is a little risk for missing a very small neuroma by using T2 images alone. In case of finding a few millimeter tumor, "wait and see" is the policy in Linköping, so the immediate consequences of missing such a small AN are not too grave.

The examination of the entire brain in every patient with suspected CPA tumor is absolutely necessary to cover the full length of the hearing and vestibular pathways. The large number of cases with some kind of central pathology in our material (23% of all patients examined with a referral question of acoustic tumor) confirms the usefulness of imaging the whole brain, though no direct relation between the brain alterations and hearing loss could be detected.

SUMMARY

In patients with unilateral hearing loss and dizziness it is important to rule out a cerebellopontine angle process. This is often done by audiological and otoneurological investigations. However, in many cases we must rely on the imaging of the temporal bone and the cerebello-brainstem area. The paper has presented the three dimensional (3D) Fast Spin-Echo (FSE) T2 weighted, 0.7 mm thick MR images, which in addition to being quick, does not require the use of expensive contrast material. Between September 1996 and November 1997, 152 patients with unilateral hearing loss and/or balance disorders were investigated.

In normal cases the 7th and 8th nerves could be followed accurately from the brainstem to the internal auditory meatus. The found tumors were hypointense compared to the cerebrospinal fluid and could be outlined with reasonable accuracy even without gadolinium contrast. The inner ear had high signal, like cerebrospinal fluid. The patency of the cochlea could be estimated accurately.

Thus, 3D FSE T2 weighted images can reliably differentiate between patients with and without pathologies of the cerebellopontine angle. The use of gadolinium contrast could be avoided in most of the cases, but contrast is necessary for differential diagnostic purposes in patients with alterations in the cerebellopontine angle or in doubtful cases.

Note - In 22 positions below (see "/" symbols) a dash is missing, e.g. "Low-cost" "spin-echo".

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