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MR Imaging of Epidermoids at the Cerebellopontine Angle

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The most common location of intracranial epidermoid is the cerebellopontine angle (CPA). The present study compared the visibility of epidermoid at the CPA in various pulse sequences. Seven patients with epidermoid at the CPA underwent conventional MR imaging (T1-, T2- and proton density-weighted imaging) as well as diffusion-weighted echo-planar imaging. Fast fluid-attenuated inversion recovery (FLAIR) sequences, magnetization transfer contrast (MTC) sequences, and MR cisternography were employed for selected patients. The signal intensity of the lesions relative to cerebrospinal fluid (CSF), the degree of lesion demarcation and the displacement of surrounding structures were evaluated. Proton density-weighted imaging depicted the lesions as hyperintense to CSF with clearer delineation than T1- and T2-weighted imaging. Diffusion-weighted imaging depicted all lesions as strongly hyperintense relative to CSF and brain tissue. FLAIR sequences depicted the lesions with mixed signal intensities but with poor-to-medium demarcation. MTC imaging increased delineation of the lesions to some degree. MR cisternography depicted the lesions as hypointense to CSF and clearly showed the anatomical relation to neighboring nerves and vessels. We concluded that diffusion-weighted imaging could specifically reveal an epidermoid at the CPA as a strongly hyperintense lesion, and that MR cisternography is mandatory for preoperative planning.

Keywords: epidermoid, cerebellopontine angle, magnetic resonance imaging, diffusion-weighted imaging, MR cisternography

Introduction

Epidermoids and epidermoid cysts are congenital lesions arising from the inclusion of ectodermal epithelial tissue into the neural tube during the 5th to 6th weeks of fetal life. They tend to occur in the paramidline location.1 Epidermoids represent 0.2% to 1.8% of all primary intracranial tumors.2 The cerebellopontine angle (CPA) is the most common location of this lesion, as it is the site of 40% to 61% of intracranial epidermoids.3,4 In addition, epidermoids represent 5% of mass lesions in that location, ranking third behind acoustic neuromas and meningiomas.1,3 Various symptoms are observed, as the lesions insinuate themselves into the cisterns adjacent to the skull base, which are rich in cranial nerves and vessels.6 Trigeminal neuralgia is the most frequent symptom. Surgical treatment offers good results, but tumors may residue or recur due to the capsule’s strong adherence to the surrounding structures. Since computed tomography has limited value for detecting lesions at the skull base, magnetic resonance (MR) imaging is expected to provide more precise information on tumor extent and characterization.

The present study compared the visibility of epidermoids at the CPA in various MR sequences, including T1-, T2- and proton density-weighted sequences, fluid-attenuated inversion recovery (FLAIR) sequences, magnetization transfer contrast (MTC) imaging, diffusion-weighted imaging and heavily T2-weighted MR cisternography. Below we discuss the appropriate selection of MR sequences for the diagnosis of intracranial epidermoids at the CPA.

Materials and Methods

Seven consecutive patients (four females and three males) diagnosed with epidermoid at the CPA were studied between January 1998 and December
Fig. 1. Case 4. Right CPA epidermoid in a 58-year-old male patient.

a: A contrast-enhanced T₁-weighted image (431/13/1).
b: A T₂-weighted image (2500/90/1), show a widened arachnoid cistern in the right CPA and preptine region (arrows), preventing the lesion from being defined as CSF.
c: A proton-density image (2500/20/1) shows the lesion (arrow) as hyperintense to CSF.
d: A FLAIR image (6000/150/1, inversion time 2000) shows the lesion (arrow) as mixed hyperintense relative to CSF.
e: A diffusion weighted image (1600/80 with b value of 800 s/mm², FOV 230) shows the lesion (arrow) as characteristic high intensity for the epidermoid.
f, g: Heavily T₂-weighted MR cisternography (3000/650/1) shows the tumor as a lobulated hypointense lesion to CSF. The right trigeminal nerve (arrow) is displaced toward the right (f). The right cavernous portion of the internal carotid artery (arrow) is displaced to the cranial (g).
h: Postoperative diffusion weighted imaging (1600/80 with a b value of 800 s/mm², FOV 230) shows a residual tumor in the left preptine cistern (arrow).
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Fig. 2. Case 3. Right CPA epidermoid in a 35-year-old female patient

a: A diffusion weighted image (1600/80 with a b value of 800 s/mm², FOV 230) reveals the lesion (arrow) as bright and hyperintense relative to the brain and CSF.

b, c: Heavily T₂-weighted MR cisternography (2400/450/1) shows the tumor as a lobulated slight hypointense mass relative to CSF and extended to left side of the basilar artery (b, arrow).

c: The trigeminal nerve (arrow) is encased by the tumor and slightly strained.

d: Postoperative diffusion weighted image (1600/80 with a b value of 800 s/mm², FOV 230) shows a high signal nodule (arrow) measuring 4.5 mm ventral to the pons, suggesting a residual tumor.

2002. Three patients underwent surgical treatment and the diagnosis was proven histologically. In the remaining four patients the diagnosis was based on both imaging findings and clinical findings with follow-up exceeding six months. Subjects ranged between 17 and 68 years of age (mean, 49 years). Lesions were located in the right (n = 6) and left CPA cisterns (n = 1). Maximum tumor diameter ranged from 10 mm to 78 mm (mean, 44.4 mm).

Patients were imaged with a 1.5T MR unit (Philips Gyroscan ACS-NT) equipped with a head coil. Imaging included T₁-weighted spin-echo imaging (repetition time/echo time/excitation, 431/13/1), T₂-weighted fast spin-echo imaging (2500/90/1 or 3641/100/1), fast proton-density weighted imaging (2500/20/1), fast FLAIR sequencing (6000/150/1, inversion time 2000), T₂-weighted (668/12/1, flip angle, 35.0°) or spin-echo T₁-weighted (514/13/1) MTC imaging on gradient, diffusion weighted echo-planar imaging (1600/80) and heavily T₂-weighted MR cisternography (2400/450/1 or 3000/650/1). Other imaging parameters for each sequence included a matrix size of 195 × 256 or 205 × 256; a section thickness of 5.0 mm or 6.0 mm with 0.5- or 1.0-mm intersection gaps; and field of view of 220 mm for T₁-, T₂-, proton density, FLAIR and MTC imaging. Diffusion imaging was obtained with a matrix size of 100 × 256, a section thickness of 4 mm with 0.4-mm intersection gaps, and a field of view of 230 mm. Anisotropic diffusions in three directions (x-, y- and z-axes) and isotropic diffusions were acquired with b values set.
Fig. 3. Case 5. Right CPA epidermoid in a 56-year-old female patient

\textbf{a}: A T$_2$-weighted image (3641/90/1) shows the mass as isointense to CSF at the right CPA (arrow).

\textbf{b}: A gradient T$_2$-weighted MTC image (668/12/1, flip angle, 35.0°) shows the lesion (arrow) as hypointense to CSF.

to 400, 800 or 1000 s/mm$^2$ and baseline imaging (b value = 0 isotropic diffusion). Heavily T$_2$-weighted MR cisternography was obtained with a matrix size of 231 $\times$ 512, a section thickness of 1.4 mm with $-0.7$-mm intersection gaps and a field of view of 208 mm.

Two radiologists independently reviewed all MR images and reached consensus. Radiologists were not blinded to diagnosis or pulse sequences. The signal intensities of the lesions were graded as hypo-, slightly hypo-, iso-, slightly hyper-, and hyperintense relative to that of CSF. The lesion demarcations were also graded as poor, medium or clear. Additionally, the anatomical relationship was evaluated on heavily T$_2$-weighted MR cisternography with special attention to the 5th, 7th and 8th cranial nerves, the internal carotid and the vertebral artery.

Results

T$_1$- and T$_2$-weighted and diffusion-weighted images were obtained from all seven patients. Contrast-enhanced T$_1$-weighted images were obtained from three patients. Proton density-weighted images and MR cisternography were obtained from four and five patients, respectively. MTC images were obtained from three (one with a spin-echo T$_1$-weighted sequence and two with gradient T$_2$-weighted sequences). FLAIR images were obtained from two.

T$_1$- and T$_2$-weighted imaging depicted lesions as isointense or slightly hyperintense to CSF with homogeneity or heterogeneity. Contrast-enhanced T$_1$-weighted images revealed either no or thin-rimmed enhancement (Figs. 1a, b and 3a). Proton density-weighted imaging depicted all lesions as hyperintense to CSF, with medium or clear demarcation (Fig. 1c). Diffusion-weighted images depicted all lesions as strongly hyperintense relative to CSF and brain tissue with homogeneity or heterogeneity (Figs. 1e and 2a). Spin-echo T$_1$-weighted MTC images from one patient revealed slight hyperintense to CSF and medium demarcation. Gradient T$_2$-weighted MTC images from two patients showed hypointense to CSF with medium and clear demarcation (Fig. 3b). MR cisternography depicted all tumors in five patients as slightly hypointense or hypointense to CSF. The relationships to the nerves and vessels were clearly displayed (Figs. 1f, g and 2b, c). MR findings are listed in Table 1. The trigeminal nerves were displaced in five patients ($n=5$) and were surrounded by tumors in two ($n=2$). Both the facial and auditory nerves were displaced in two ($n=2$) and destroyed in one ($n=1$). The basilar artery, vertebral artery and cavernous portion of the internal carotid artery were displaced in one patient each (Fig. 1h). The brainstem (n = 2), pons (n = 3) medulla oblongata (n = 1) and cerebellum-fourth ventricle (n = 2) were displaced in two, three, one and two, respectively. In one case (case 2), a T$_2$-hyperintense area was seen in the right upper pons due to chronic compression. Hydrocephalus was not seen in any patient. As for clinical symptoms, four out of the five patients showing involvement of the trigeminal nerves complained of trigeminal neuralgia. The remaining two had headache (n = 2).
Table 1. Findings on epidermoids in each MR pulse sequence

<table>
<thead>
<tr>
<th>Patient/age/sex</th>
<th>T1</th>
<th>T1 + C</th>
<th>T2</th>
<th>PD</th>
<th>FLAR</th>
<th>MTC</th>
<th>DW</th>
<th>Cisternography</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/17/m</td>
<td>sli-hyper (-)</td>
<td>iso</td>
<td>hyper mixed signal</td>
<td>(T₁)</td>
<td>sli-hyper (-)</td>
<td>strong hyper, uneven strong hyper, uneven</td>
<td>5th, 7th, 8th CNs displaced (-)</td>
<td></td>
</tr>
<tr>
<td>2/42/m</td>
<td>sli-hyper (-)</td>
<td>iso</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
<td>strong hyper, uneven</td>
<td>5th CN encased and strained, 7th, 8th CNs displaced 5th CN and ICA-CP displaced (-)</td>
</tr>
<tr>
<td>3/35/f</td>
<td>iso not enhanced iso hyper (-)</td>
<td>strong hyper, uneven</td>
<td>5th CN and VA displaced (-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/58/m</td>
<td>iso not enhanced iso</td>
<td>hyper mixed signal</td>
<td>(T₂) hypo strong hyper strong hyper</td>
<td>5th CN and VA displaced (-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/56/f</td>
<td>iso sli-hyper (-)</td>
<td>iso</td>
<td>hyper (-)</td>
<td>(T₂) hypo strong hyper strong hyper</td>
<td>5th CN and VA displaced (-)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/67/f</td>
<td>sli-hyper</td>
<td>iso</td>
<td>sli-hyper</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
<td>strong hyper, uneven</td>
<td>5th CN and VA displaced (-)</td>
</tr>
</tbody>
</table>

Abbreviation: + C = contrast enhanced, PD = proton density, DW = diffusion weighted, iso = isointensity, hyper = hyperintensity, hypo = hypointensity to CSF, sli = slight, CN = cranial nerve, ICA = internal carotid artery, CP = cavernous portion, VA = vertebral artery, (-) = not performed

Table 2. Clinical characteristics of the patients

<table>
<thead>
<tr>
<th>patient</th>
<th>location</th>
<th>size (mm)</th>
<th>symptom</th>
<th>diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R-CPA→R-CMA</td>
<td>20×32×38</td>
<td>headache</td>
<td>imaging and clinical</td>
</tr>
<tr>
<td>2</td>
<td>R-CPA→supraseller and R-CMA</td>
<td>66×20×30</td>
<td>L-hemiplegia</td>
<td>imaging and clinical</td>
</tr>
<tr>
<td>3</td>
<td>R-CPA→R-side of basilar artery</td>
<td>10×10×8</td>
<td>R-tri neuralgia</td>
<td>surgical confirmation</td>
</tr>
<tr>
<td>4</td>
<td>R-CPA→supraseller, L-CPA and R-CMA</td>
<td>50×20×40</td>
<td>R-tri neuralgia</td>
<td>surgical confirmation</td>
</tr>
<tr>
<td>5</td>
<td>R-CPA</td>
<td>21×25×15</td>
<td>headache</td>
<td>imaging and clinical</td>
</tr>
<tr>
<td>6</td>
<td>L-CPA→L-CMA</td>
<td>28×7×35</td>
<td>L-tri neuralgia</td>
<td>surgical confirmation</td>
</tr>
<tr>
<td>7</td>
<td>R-CPA, sphenoid sinus extending to supraseller and R-middle cranial fossa</td>
<td>78×50×28</td>
<td>R-tri neuralgia, R-hearing impairment and otorrhea</td>
<td>imaging and clinical</td>
</tr>
</tbody>
</table>

Abbreviation: R = right, L = left, tri = trigeminal, CMA = cerebellomedulla angle

Left hemiplegia was present in one (case 2). Other symptoms included right hearing impairment and otorrhea. Details are listed in Table 2.

Discussion

We found several radiological reports describing the conventional MR findings for intracranial epidermoids.\(^3,4,7\) In a study of the largest series with 23 intracranial epidermoids, 20 lesions (95%) showed hyperintensity to CSF in proton density-weighted imaging, whereas most lesions could not be well visualized with either T₁- or T₂-weighted imaging.\(^4\)

Among T₁-, T₂- and proton density-weighted images, our results resembled those of previous studies. Whereas the lesions showed a similar intensity to CSF in both T₁- and T₂-weighted sequences, the lesions could be distinguished from CSF as a hyperintense structure in proton density-weighted images.

Karantanas A. H. et al. described the usefulness of FLAIR sequences in intracranial epidermoids.\(^1\) A series of eight patients examined under FLAIR displayed a higher contrast ratio and contrast-to-noise ratio of tumor to CSF than conventional MR imaging.\(^8\) The lesions were depicted as hyperintense to CSF with uneven intensities. In our two patients who underwent FLAIR examination, the lesion showed mixed increased signal intensity to CSF, but lesion delineation was not sufficient (Fig. 1d). FLAIR images reduce the image quality in the areas

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of prepontine and basal cisterns due to CSF inflow artifacts.\textsuperscript{1,2}

MTC imaging is a relatively new imaging technique based on the interactions between bound and free protons. Application of irradiation that selectively saturates the energy level of bound protons induces an exchange of magnetization between bound and free protons, reducing the signal intensity of bound protons.\textsuperscript{9} This technique has been utilized to study various intracranial diseases, including multiple sclerosis, metastatic lesions, glial tumors, abscesses, myotonic dystrophy, and adrenoleukodystrophy.\textsuperscript{9–13} Only one case report exists of MTC being applied to the visualization of intracranial epidermoid.\textsuperscript{14} Given the high sensitivity of MTC to the macromolecular content of the tissues, the technique was applied to three patients in the present study. Two lesions were visualized as hypointense to CSF on gradient T2-weighted imaging (Fig. 3b), and one was visualized as hyperintense to CSF with spin-echo T1-weighted imaging. MTC imaging enhanced the visibility of the lesions. However, we had only limited experience with MTC imaging, and use of the technique for epidermoids warrants further investigation.

Tsuruda J. S. et al. first reported the usefulness of diffusion-weighted imaging in 1990.\textsuperscript{15} Before the introduction of diffusion-weighted imaging, CPA epidermoids were difficult to differentiate from arachnoid cysts.\textsuperscript{16,17} The value of diffusion-weighted imaging has been highlighted for the purpose of separating the bright epidermoid cyst from the dark CSF space and arachnoid cyst.\textsuperscript{8,18} Among intracranial and extra-axial cystic lesions viewed with diffusion-weighted imaging, cholesteatoma and abscesses could be as hyperintense as epidermoid cysts.\textsuperscript{19} However, abscesses could be well differentiated from epidermoids by thick-rim enhancement and by clinical findings indicating inflammatory processes. Cholesteatoma could be differentiated from epidermoids by a lack of characteristic temporal bone destruction. Diffusion-weighted images are thought to offer findings specific to the diagnosis of epidermoid. In the initial study, the origin of the hyperintense signals was attributed to the restricted diffusion of water molecules, whereas a recent study suggests that the T2 shine-through effect plays an important role. In the diffusion-weighted images in our study, all lesions showed bright hyperintensity relative to the brain tissue and CSF, reconfirming the results of previous studies (Figs. 1 and 2). Diffusion-weighted imaging is also very useful for postoperative assessment of small residual foci or recurrent lesions (Figs. 1h and 2d).

Heavily T2-weighted MR cisternography is an excellent screening tool for the evaluation of various pathologic processes in the CPA.\textsuperscript{20,21} High spatial resolution and good contrast between CSF and solid brain structures are provided by very thin sections.\textsuperscript{20} The technique effectively compensates for the low signal-to-noise ratio and vague anatomical delineation of diffusion-weighted imaging. MR cisternography allows for reliable structural imaging of the nerves and vasculature inside the CPA. The space occupying lesion is also clearly visible as a hypointensity to CSF. A previous neurosurgical study established findings for nerves, arteries and tumors in MR cisternography, coinciding well with operative findings.\textsuperscript{7} In our study, the relationship between epidermoids and cerebral nerves and vessels was clearly demonstrated and MR cisternography proved very useful for preoperative planning.

In conclusion, diffusion-weighted imaging is highly sensitive and specific for the diagnosis of intracranial epidermoid at the CPA, and MR cisternography should also be performed for precise delineation of the surrounding anatomical structures prior to surgical treatment.

Acknowledgments

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References


