Complications of Atticoantral Cholesteatoma: MR Manifestations

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Cholesteatoma of the temporal bone usually occurs in the attic (epitympanic cavity) and extends easily into the mastoid antrum through the aditus ad antrum. Since atticoantral cholesteatoma can lead to clinically serious complications, successful patient management requires an accurate knowledge of the extent of the condition. All complications of cholesteatoma are in fact related to bony erosion and may be classified as labyrinthitis, extracranial complication, meningitis, dural sinus obstruction, or parenchymal inflammation. This paper describes the diverse MR manifestations of the complications arising from atticoantral cholesteatoma.

Index words: Ear, MR, Cholesteatoma

The serious or fatal complications associated with cholesteatoma prior to the antibiotic era have diminished remarkably, and intracranial complications now occur in less than 0.3% of all cases (1). This incidence is not decreasing further, however; indeed, an increase is now apparent. Cholesteatoma of the temporal bone usually occurs in the attic (epitympanic cavity) and extends easily into the mastoid antrum through the aditus. All complications of cholesteatoma are in fact related to bony erosion (2). The nature of the pathogenesis of bony change has provoked controversy, and various causes have been suggested. These include pressure phenomena, the elaboration of collagenase by granulation tissue, invasive fibroblasts, and osteoclastic stimulation (3). Common complications of cholesteatoma include ossicular erosion, labyrinthine fistula, facial nerve canal fistula, and hearing loss (1), and the condition sometimes leads to serious and potentially fatal intracranial complications including meningitis, dural sinus thrombosis, and parenchymal inflammation (2). High resolution computed tomography (HRCT) of the temporal bone has been quite useful for the diagnosis of cholesteatoma (4), but if bony erosion of the tegmen tympani or sinus plate occurs, or serious complications are suspected, MRI is preferred (5).

The pages which follow provide a description of the diverse MR manifestations of the complications arising from atticoantral cholesteatoma.

MR Imaging

The typical MR characteristics of cholesteatoma are its isointensity to cerebral parenchyma, as seen on T1 weighted images, and its moderate hyperintensity on T2 weighted images (1, 2, 4-7), characteristics which are due to keratin materials (2, 4-6). When a contrast agent is administered, cholesteatoma other than those surrounded by granulation tissue do not show enhancement; when this tissue is present, there may be peripheral rim enhancement (2) (Fig. 1). In order to distinguish non-enhancing cholesteatoma from enhancing granula-
tion tissue, or to depict enhancement of the labyrinth or facial nerve which suggests inflammatory change induced by bony fistula, the use of contrast-enhanced M-RI is important.

Complications

Labyrinthitis

Labyrinthine fistula is one of the common complications of cholesteatoma and is associated with considerable morbidity; most authors have reported an incidence of 5-10% (4). Due to its proximity, the most common site of bony fistula is the lateral semicircular canal, and this is, therefore, the site at which labyrinthitis commonly occurs (5, 8, 9). The imaging finding of labyrinthitis is enhancement of the membranous labyrinth, as seen on contrast-enhanced T1-weighted images (1, 7, 10). Such enhancement is normally faint and is typically detected during the subacute stage of the disorder (11) (Fig. 2). Progression to the chronic stage leads to fibroblast proliferation. T2-weighted images disclose fibrous replacement of the fluid-filled spaces of the labyrinth. Further degeneration results in labyrinthine ossification over a period varying between several months and years. Cochlear fistula is less common and is usually located at the level of the promontory between the round and oval windows occurring secondary to pars tensa cholesteatoma. Facial nerve paresis occurs preoperatively in approximately one percent of cholesteatoma patients and is usually caused by bony erosion of the facial nerve canal (1).

Fig. 1. MR findings of atticoantral cholesteatoma
A. On axial T1-weighted image, cholesteatoma is hypointense (asterisk) to the cerebral white matter.
B. On T2-weighted image, it is a moderately hyperintense lesion, mixed with a hypointense portion (asterisk) within the atticoantral cavity.
C. Contrast-enhanced T1-weighted image shows a non-enhanced mass (asterisk) within the atticoantral cavity. Note peripheral thin rim enhancement (arrows) which means inflammatory change of the atticoantral cavity.

Fig. 2. Labyrinthitis
A. Axial precontrast T1-weighted image shows focal hyperintensity at the vestibule and lateral semicircular canal (long arrows).
B. Contrast-enhanced T1-weighted image shows strong enhancement of the membranous labyrinth of the vestibule and lateral semicircular canal (long arrows). It was caused by a bony fistula of the lateral semicircular canal.

Fig. 3. Subperiosteal abscess
Subperiosteal abscess is associated with soft tissue enhancement in preauricular area (open arrows) on contrast-enhanced axial T1-weighted image.
Extracranial inflammation

Cholesteatoma may spread via a bony defect in the external mastoid cortex to form a subperiosteal abscess. In general, because of the thin trabecular bone found there, this is found in the postauricular region (1, 7). If the infection spreads preferentially along the zygomatic arch, preauricular extension is, however, also possible (7) (Fig. 3). A Bezold abscess presenting as a tender mass beneath the sternocleidomastoid muscle may be the result of diffusion through the large, thin-walled cells internal to the digastric groove of the mastoid tip. Now that antibiotics are common, this complication, however, rarely encountered.

Meningitis

Meningitis is a serious complication, and may be localized or diffuse. A bony defect of the tegmen tympani permits access to the adjacent dura, and acute pyogenic meningitis may develop via direct extension of the inflammatory process through the defect (Fig. 4). If patients with cholesteatomas are not treated promptly, localized meningitis can spread over a wider area and leads to more serious complications such as choroid plexitis, ventriculitis or extracerebral empyema (Fig. 5, 6). The last-mentioned occurs in the subdural or epidural space, in which crescentic or lentiform extra-axial fluid collections mildly hyperintense to CSF are seen on T2-weighted images. Contrast-enhanced T1-weighted images show strong enhancement and thickening of the meninges, a phenomenon which occurs on cerebral convexities or in the interhemispheric fissure. Subarachnoid space compromised by extensive fibropurulent exudate may cause extraventricular obstructive hydrocephalus, whereas ventriculitis with cerebral aqueductal ependymitis leads to intraventricular hydrocephalus (12).

Dural sinus obstruction

Bony defects in the internal mastoid cortex permit access to the sigmoid sinus and adjacent dura (5). Simple obstruction of the dural sinus may occur through extrinsic compression by a large atticoantral cholesteatoma, diffuse ventriculitis with hydrocephalus. Note thickening and enhancement of the meninges on the inferior surface of the left temporal lobe (long arrows) adjacent to the cholesteatoma (asterisk), which suggests localized meningitis.

Fig. 4. Localized meningitis
A. Coronal high resolution CT shows a soft tissue mass in the left middle ear cavity (asterisk), bony defects on the tegmen (curved white arrow), scutum (short black arrow), and facial nerve canal (long black arrow).
B. Contrast-enhanced T1-weighted image of MRI clearly depicts localized meningitis (short arrows) associated with enhancement of the facial nerve (long arrow) and otitis externa (curved arrows).

Fig. 5. Ventriculitis
A. Contrast-enhanced axial T1-weighted image shows enlargement of the forth ventricle and intense enhancement of the both cerebellopontine cistern (curved arrows) and ependymal lining of the ventricle (short arrows). Large cholesteatoma (asterisk) extends through the plate of the sigmoid sinus. Note also obstruction of the left sigmoid sinus (long arrow).
B. Contrast-enhanced coronal T1-weighted image clearly demonstrates
but dural sinus thrombophlebitis may occur through bony defects in the sigmoid sinus plate via direct extension (Fig. 7). The latter gives rise to hematogenous dissemination and extensive thrombophlebitis (7). On occasion, MRI reveals the thrombosis either directly, within the lumen of the dural sinus or indirectly, as the absence of flow void on spin-echo images and of flow-related enhancement on gradient-echo images (1, 7). After injection of the contrast agent, an occluded sinus and intraluminal thrombus appear as filling defect surrounded by enhanced engorged dural cavernous spaces, meningeal tributaries, or collateral venous channels producing the so-called empty delta sign (12). Due to increased venous pressure, enhancement and thickening of the meninges and tentorium occur on the ipsilateral side, and a venous ischemic lesion may sometimes be associated. For evaluation of this dangerous clinical condition, MR venography is useful (7).

**Parenchymal inflammation**

Brain abscess is one of the most serious complications. Initially, infectious agents can cause focal cerebritis, which leads to a brain abscess via direct extension through bony defects (Fig. 8). The cause may, however, also be either retrograde thrombophlebitis or adjacent empyema or meningitis. The temporal lobe is the most vulnerable site of the brain (1, 7, 12). On MR, the central necrotic area is typically hyperintense to cerebral white matter.

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**Fig. 6.** Epidural empyema with diffuse meningitis

A. Axial T2-weighted image shows lentiform fluid collection in the epidural space (arrows) mildly hyperintense compared to CSF with the thickened dura.

B. Contrast-enhanced coronal T1-weighted image demonstrates diffuse thickening and enhancement of the meninges along the cerebral convexity (arrows). Note close relationship between epidural empyema and cholesteatoma (asterisk) in the left antral cavity.

**Fig. 7.** Sigmoid sinus thrombophlebitis

A. Precontrast axial T1-weighted image shows hypointense thrombus within the lumen of the enlarged sigmoid sinus (short arrows).

B. On axial T2-weighted image, the lesion is mildly hyperintense (short arrows) to the CSF.

C. Contrast-enhanced axial T1-weighted image shows relatively hypointense occluded sinus and periosteal abscess surrounded by the enhanced engorged dura (long arrows).

D. Coronal MR image shows antral cholesteatoma (asterisk) and engorged tentorium (short arrows) due to obstruction of the sigmoid sinus.
matter, as seen on proton-density and T2-weighted images. The thin-walled, well-demarcated rim appears iso- to mildly hyperintense on T1-weighted images, iso- to relatively hypointense on proton-density and T2-weighted images, and enhances intensely following contrast administration. Peripheral edema is usually present.

In conclusion, MRI can give useful information about various complications of atticoantral cholesteatoma, especially when bony defects of the tegmen tympani or sinus plate are revealed by HRCT of the temporal bone. MRI, including the use of a contrast agent, plays an important role in demonstrating the serious complications which can arise from a cholesteatoma. An understanding of the variety of these will facilitate the evaluation of MRI of the temporal bone in patients with atticoantral cholesteatoma.

Fig. 8. Brain abscess and subdural empyema
A. Precontrast axial T1-weighted image shows hypointense lesion with isointense thin, well-demarcated rim (arrows) in the right temporal lobe.
B. On axial T2-weighted image, the central hypointense lesion and the rim becomes hyperintense to the brain parenchyma (arrows). Note peripheral hyperintensity due to edema around the abscess.
C. Contrast-enhanced T1-weighted image shows strong enhancement of the rim of the abscess cavity (arrows).
D. Contrast-enhanced coronal T1-weighted image shows cholesteatoma (asterisk) in the right attic adjacent to thick enhancing meninges (curved arrows) and abscess cavity. Note subdural empyema (short arrows) in the interhemispheric space.

References