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Magnetic Resonance Imaging and Sudden Deafness

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Abstract: Sudden deafness is a disorder defined as acute sensorineural deafness of unknown etiology. To determine whether establishing the pathogenesis of this disease is possible, this study analyzed the magnetic resonance imaging (MRI) of early stages of sudden deafness in combination with the clinical results of treatments. The MRI findings of 18 patients with sudden deafness included three cases of slow blood flow of the vertebrobasilar system, one case of abnormal course of the vertebrobasilar system, and one case of labyrinthine enhancement. MRI showed many abnormal findings in the temporal bone of sudden-deafness patients who also complained of vertigo. As compared with normal cases, the cases showing abnormal findings on MRI did not respond well to treatment. We concluded that MRI is indispensable for examining patients with sudden deafness, especially those who have accompanying vertigo.

Key Words: magnetic resonance imaging; sudden deafness

Sudden deafness is a disorder characterized by an abrupt sensorineural hearing loss of unknown etiology. Many theories seek to explain the etiology of sudden deafness; however, its exact causes are not specified. Recently, magnetic resonance imaging (MRI) has become an important method for evaluation of ear diseases. To determine whether establishing the pathogenesis of sudden deafness is possible, we analyzed MRI scans of early stages of sudden deafness in combination with the clinical results of treatments.

Sudden deafness is defined by a high degree of abrupt sensorineural hearing loss without clear causes for the loss. If it is not cured at an early stage, deafness can be permanent; thus, an early and accurate diagnosis is essential. Various suspected causes of sudden deafness include circulation disorder of the inner ear, viral infection, rupture of the cochlear membrane, syphilis, and allergy. However, no theory has yet been established for the causes of this disease, so making a definite diagnosis is very difficult. To discover the exact causes of sudden deafness, the authors examined the relationships between patients' symptoms and the results of acoustic and vestibular function tests by analyzing abnormal findings on MRI, in particular the slow blood flow (SBF) of the vertebrobasilar system (VBS) and labyrinthine enhancement on MRI augmented by gadolinium (Gd-DTPA).

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METHOD

Eighteen patients who had received MRI examinations were chosen from patients complaining of sudden deafness. They were hospitalized at Pusan National University Hospital from November 2000 to May 2001. The average age of the 18 subjects (11 female and 7 male patients) was 46 years, and the subjects' initial hearing threshold by pure-tone audiogram average at 0.5, 1.2, and 3.0 kHz was 73 dB.

Pure-tone audiometry and short-increment sensitivity index tests were conducted on all patients. The vestibular function test consisted of air-caloric tests, and the results were measured with electronystagmography. The 4-mm-thick axial and coronal MRI tests produced T_1-weighted images, Gd-enhanced T_1-weighted images, proton density images, and T_2-weighted images. All

Table 1. Patients and Magnetic Resonance Imaging Results

Patient	Age (Gender)	Initial Pure-Tone Audiogram	Last Pure-Tone Audiogram	Symptom	Canal Paresis	MRI Result
1	45 (F)	31	24	Tinnitus	–	—
2	54 (M)	76	70	Tinnitus, vertigo	+	SBF
3	48 (F)	61	21	Tinnitus	–	—
4	55 (F)	102	75	Tinnitus, vertigo	+	—
5	50 (M)	51	14	Tinnitus, vertigo	+	T-VBS
6	77 (M)	54	51	Vertigo	+	SBF
7	36 (F)	60	16	Tinnitus	–	—
8	35 (F)	45	15	Tinnitus	–	—
9	56 (M)	105	95	Tinnitus, vertigo	+	LE
10	40 (M)	71	21	Tinnitus	–	—
11	25 (F)	75	50	Tinnitus, vertigo	–	—
12	46 (F)	105	105	Tinnitus, vertigo	+	—
13	54 (F)	105	105	Tinnitus, vertigo	+	SBF
14	16 (M)	59	10	Vertigo	–	—
15	30 (F)	105	55	Tinnitus	–	—
16	58 (F)	65	50	Tinnitus	+	—
17	33 (F)	75	30	Tinnitus	–	—
18	70 (M)	69	49	Tinnitus, vertigo	+	—

LE = labyrinthine enhancement; MRI = magnetic resonance imaging; SBF = slow blood flow; VBS = vertebrobasilar system; T-VBS = tortuous vertebrobasilar system.

patients were managed with same treatment protocol, which consists of high-dose steroid, low-molecular-weight dextran, and carbogen (95% O_2 + 5% CO_2) therapy.

RESULTS

MRI Results

The MRI results of the patients are shown in Table 1. Figure 1 shows the Gd-DTPA-enhanced T_1-weighted coronal image of patient 9, who had vertigo and sudden deafness in the left ear; the image reveals increased gadolinium enhancement in the left labyrinth. Figure 2 shows the proton density axial image of patient 2, who had vertigo and sudden deafness in the right ear; this image displays increased signals in the basal artery, due to the SBF of the basal artery. Figure 3 depicts the proton density axial image of patient 6, who had vertigo and sudden deafness in the left ear; this image shows increased signals in the left vertebrobasilar artery, due to the SBF. Figure 4 shows the proton density axial image of patient 5, who had vertigo and sudden deafness in the right ear; the image exhibits an abnormal course of the right vertebrobasilar artery.

To summarize, among the 18 subjects, 3 of the 5 patients (17%) with sudden deafness showing abnormal MRI findings had SBF of the VBS, 1 (5%) had an abnormal course of the VBS, and 1 (5%) had labyrinthine enhancement.

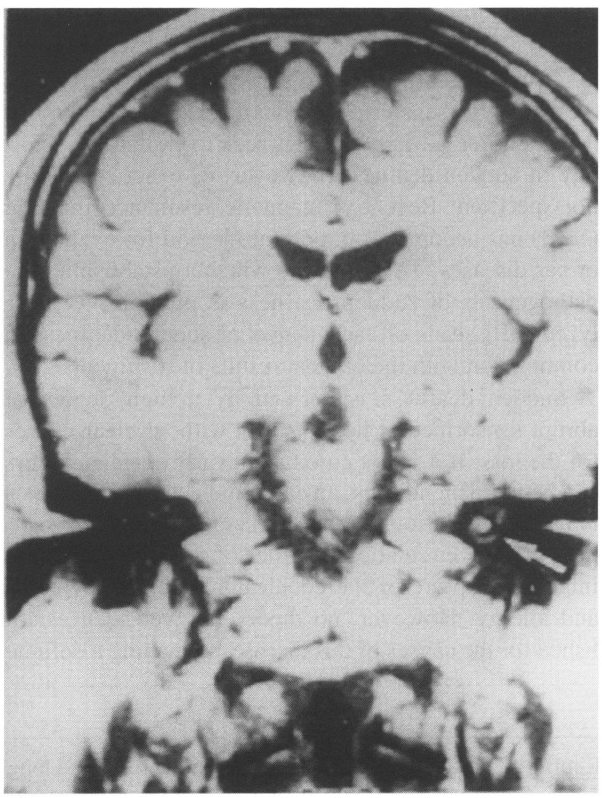

Figure 1. Gd-DTPA T_1-weighted coronal image in left ear of subject with sudden deafness with vertigo. Gadolinium enhancement is observed in left cochlea (*arrow*).

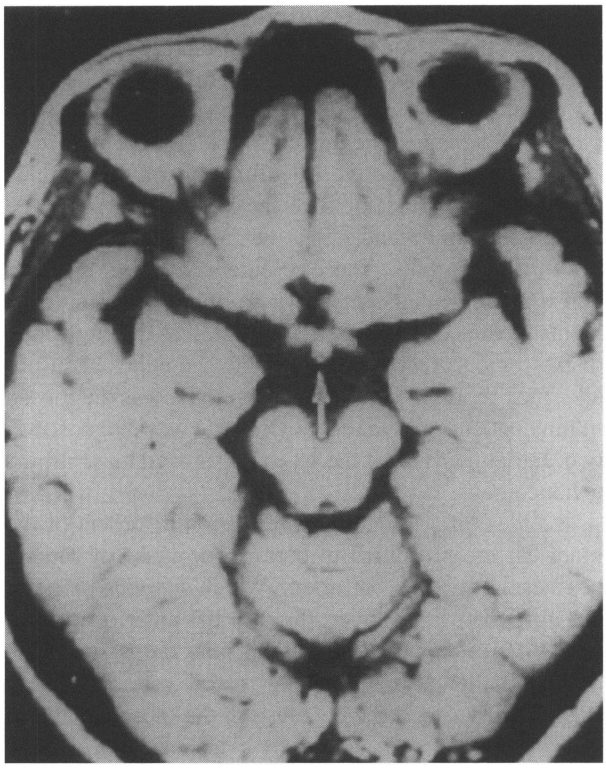

Figure 2. Proton density axial image in right ear of subject with sudden deafness with vertigo. High signal indicating slow blood flow is observed in caudal basilar artery (*arrow*).

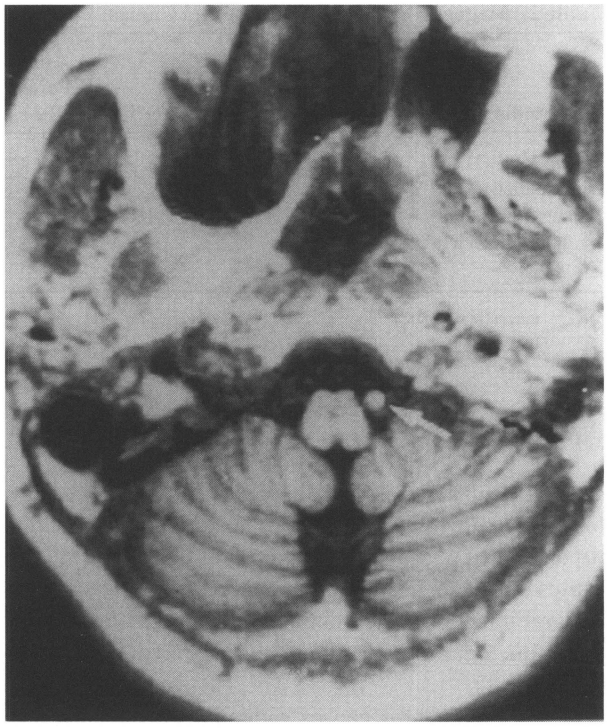

Figure 3. Proton density axial image in left ear of subject with sudden deafness with vertigo. High signal indicating slow blood flow is observed in left vertebrobasilar artery (*arrow*).

Relationships Among MRI and Acoustic and Vestibular Function Tests

All three patients having SBF of the VBS showed vertigo and canal paresis. The patient having an abnormal course of the VBS and the patient having labyrinthine enhancement also showed vertigo and canal paresis. In addition, the patients showing abnormal MRI findings did not respond well to treatment as compared to those with normal MRI findings (Table 2).

Figure 4. Proton density axial image in right ear of subject with sudden deafness with vertigo. Tortuous right vertebrobasilar artery is observed (*arrow*).

Table 2. Magnetic Resonance Imaging and Clinical Findings

MRI Finding (No.)	Initial Pure-Tone Audiogram	Final Pure-Tone Audiogram	Vertigo	Canal Paresis (+)
SBF in VBS (3)	84	82	3/3	3/3
Labyrinthine enhancement (1)	51	14	1/1	1/1
Tortuous VBS (1)	105	95	1/1	1/1
Normal (13)	67	42	6/13	4/13

MRI = magnetic resonance imaging; SBF = slow blood flow; VBS = vertebrobasilar system.

DISCUSSION

Sudden deafness refers to abrupt sensorineural hearing loss of unknown etiology, often accompanied by tinnitus and vertigo. Many studies are in progress to find the causes of sudden deafness. Generally, labyrinthitis caused by viral infection, blood circulation disorders, or rupture of the inner ear membrane are believed to cause sudden deafness [1].

Viral labyrinthitis causes sudden deafness owing to infections caused by such viruses as measles or mumps, and it may occur without any other general symptoms. Schuknecht and Donovan [2] reported that the pathological findings of the temporal bones of patients having idiopathic sudden deafness showed an atrophy of the striae vascularis, the tectorial membrane, and the organ of Corti; these pathological findings are similar to those of a viral cochlear inflammation. The inflammation in the inner ear membrane can be found by conducting an antibody (Ab) test for viruses in the blood of affected patients. Mark et al. [3] and Seltzer and Mark [4] reported that viral labyrinthitis, which is caused by viral infection of the cochlea and the vestibule, showed a gadolinium enhancement of the cochlea and the vestibule on Gd-DTPA-enhanced T_1-weighted images.

In the past, MRI was mostly used for the diagnosis of lesions of the internal auditory canal and of the cerebellopontine angle, and particularly for acoustic neuroma in deaf patients [5]. MRI seldom was used to diagnose labyrinthine diseases. In normal cases, the bony portion of the temporal bone shows low signals on T_1-weighted MRI; the membranous labyrinth and the perilymph show intermediate signals; and the cochlea and the vestibule show high signals on T_2-weighted MRI [6]. Also, gadolinium enhancement on T_1-weighted sequences indicates leakage toward the lesion site, owing to damage of the blood-brain barrier (i.e., the rupture of the basal membrane of the labyrinthine blood vessel). Therefore, gadolinium enhancement of the labyrinth is characteristic of labyrinthine diseases [3,4,6].

Seltzer and Mark [4] also reported that the MRI results of all five patients experiencing sudden deafness showed Gd-DTPA enhancement of the cochlea and the vestibule. Reporting on the results of the MRI tests of 12 patients, Mark et al. [3] showed that all cases displaying the enhancement of the cochlea were related to subjective and objective hypofunction of the cochlea and that the enhancement of the vestibule was related also to subjective and objective functional abnormalities of the vestibule. These researchers further reported that when the enhancement was confined to certain segments of the cochlea, deafness existed at the frequency of the region predicted by the enhancement. Additionally, they reported that viral labyrinthitis was diagnosed in nine patients and leutic labyrinthitis was diagnosed in two. In our study, 1 of the 18 cases showed labyrinthine enhancement.

Besides viral infections, circulation disorders of the inner ear are presumed to be a major cause of sudden deafness. The inner ear artery, which supplies blood to the inner ear, is provided through the anterior inferior cerebellar artery, the basal artery, and the posteroinferior cerebellar artery with the rostral vertebral artery [6]. In many cases, the decrease in the blood supply to the inner ear artery is caused by a decrease in the blood supply to the VBS or by vascular obstruction of the inner ear artery itself [7,8]. Regarding a method for evaluating inner ear circulation disorders, Fish et al. [9] directly measured the perilymphatic oxygen tension by using perilymphatic surface electrodes. Nakashima et al. [10] obtained the same measurement by conducting myringotomy and attaching a laser Doppler probe to the promontory. By using MRI, Yamasoba et al. [11] explained how to evaluate SBF findings of the VBS that supplies blood to the inner ear artery. The latter group also reported that the SBF of the VBS demonstrated high-signal proton density images [12–14].

In addition, Yamasoba et al. [11] reported that 12 of 57 patients (21%) having sudden deafness showed SBF on MRI; these were predominantly men older than 50 years, representing 36% of the 33 patients aged 50 or older in this subject pool. In this study, 3 of 18 patients (17%) who underwent MRI examination showed SBF of the VBS. Although the exact mechanism and significance of SBF in sudden deafness are unknown, a temporary decrease in blood flow occurred at the onset of sudden deafness [11].

Regarding the relationship between the abnormal findings on MRI and vertigo, our study found that all the cases showing abnormalities on MRI also showed canal paresis. These results are consistent with those in the study by Yamasoba et al. [11], in which all the patients showing SBF on MRI also complained of vertigo. In particular, 5 of the 11 (45%) patients with sudden deafness and accompanying vertigo showed abnormalities

on MRI, and 3 of the 11 patients (27%) showed SBF. These results are a little lower than those in a study by Kikuchi et al. [15], in which 37 (36%) of 102 patients having vertigo showed SBF on MRI.

No significant relationship was found between MRI results and the type of audiogram or degree of hearing loss. The response to treatment tended to be slow in patients with abnormal MRI findings, as compared with patients in whom MRI findings were normal. However, the number of cases examined in this study was small; therefore, no statistical significance is claimed.

CONCLUSION

Until now, the exact cause of sudden deafness has not been clarified, but abnormal blood flow of the inner ear is known as a cause of this disorder. MRI is regarded as one method for evaluating inner ear circulation disorders. Therefore, we concluded that MRI is indispensable for examining patients with sudden deafness, especially those patients with accompanying vertigo.

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