Case report

Case report: Near-complete cortical hearing loss caused by sequential development of bilateral putaminal hemorrhage

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ABSTRACT

Intracerebral hemorrhage with sudden hearing loss as the initial symptom is rare. A right-handed man with a history of right putaminal hemorrhage developed near-complete hearing loss and right hemiplegia and was taken to our hospital by ambulance. Non-contrast computed tomography demonstrated acute intracerebral hemorrhage in the left putamen. A region of old right putaminal hemorrhage involving the right temporal stem was also shown on fluid-attenuated inversion recovery. Standard pure-tone audiometry showed right-dominant bilateral sensorineural hearing loss. More than 2 months after onset, the bilateral sensorineural hearing loss gradually improved without interfering with daily life. Detailed history-taking indicated that the old hemorrhage in the right putamen 12 years previously had caused sudden left-dominant bilateral hearing impairment due to asymmetric but bilateral innervation from the auditory nerve. The bilateral damage to the temporal stem involving acoustic radiation resulted in temporary near-complete hearing loss after the recurrence, but the amelioration of edema in the left temporal stem may have resulted in partial recovery of the hearing loss. This patient's clinical progression suggests that the auditory tract ascends mainly on the side opposite the ear and may explain the left dominance in the level of acoustic radiation.

1. Introduction

Sudden deafness as the initial symptom of intracerebral hemorrhage, especially supratentorial intracerebral hemorrhage, is rare. Cortical hearing loss is generally caused by bilateral intracerebral hemorrhage because of the bilateral innervation of the auditory nerve. However, the bilateral innervation is known to be asymmetric, and a recent line of evidence suggests left dominance in terms of the hemispheric difference in hearing function [1]. We herein describe a patient who experienced partial hearing loss due to right putaminal hemorrhage and near-complete hearing loss 12 years later due to recurrent left putaminal hemorrhage, and partial recovery of hearing function with amelioration of perilesional edema.

2. Case history and clinical examination

A patient with a history of right putaminal hemorrhage 12 years previously reported that he had been experiencing hearing difficulty in the left ear, and he had not made a telephone call using the left ear. He was taken to our hospital by ambulance because of sudden near-complete bilateral hearing loss and right hemiplegia on day 1. On presentation, his blood pressure was 190/100 mmHg. Neurological examination revealed bilateral hearing loss, dysarthria, right hemiplegia, and right sensory loss. Non-contrast computed tomography revealed acute intracerebral hemorrhage in the left putamen. He was diagnosed with nontraumatic intracerebral hemorrhage, and antihypertensive therapy with nicardipine and the osmotic agent glycerol was immediately initiated. Fluid-attenuated inversion recovery confirmed a hematoma in the left putamen and showed old hemorrhage as an area of low signal intensity in the right putamen extending to the right temporal stem region. Auditory brain stem response testing showed normal latencies of waves I to V, suggesting no abnormality between the inferior colliculus and the cochlear nerves. Standard pure-tone audiometry showed right-dominant bilateral sensorineural hearing loss. The patient did not exhibit obvious aphagia. After admission, the bilateral hearing loss gradually recovered to the extent that he was able to understand some
oral instructions on day 3 and all oral instructions on day 14. The patient was transferred to a rehabilitation hospital with a National Institutes of Health Stroke Scale score of 2 on day 16 and discharged home 2 months after symptom onset. Pure-tone audiometry 2 months after onset showed improvement of the bilateral sensorineural hearing loss, especially in the low-tone range. The patient's hearing did not interfere with daily life. Three months after onset, fluid-attenuated inversion recovery showed shrinkage of the edematous lesions posterior to the left putaminal hemorrhage (Fig. 1).

(A) Non-contrast computed tomography showed a hematoma in the left putamen (volume, 8.5 cm$^3$). (B) Fluid-attenuated inversion recovery magnetic resonance imaging showed a hematoma in the left putamen (white arrow) and residual hemorrhage in the right putamen extending into the right temporal stem. (C) Three months after the second episode of hemorrhage, fluid-attenuated inversion recovery magnetic resonance imaging showed improvement of the edematous lesions posterior to the intracerebral hemorrhage (yellow arrow). (a) Standard pure-tone audiometry on day 4 showed right-dominant bilateral sensorineural deafness. (b) Standard pure-tone audiometry on day 11 did not show significant improvement compared with day 4. (c) Two months after onset, standard pure-tone audiometry showed remarkable improvement in the patient’s deafness, especially in the low-tone range.

R: right side. ×: air conduction of right ear, ×: air conduction of left ear, ⊕: bone conduction of right ear, ⊖: bone conduction of left ear.

3. Discussion

In the present case, partial hearing loss caused by right putaminal hemorrhage became near-complete by recurrent left putaminal hemorrhage. The conversion of partial (left-ear-dominant) to near-complete hearing loss suggests that the bilateral hemispheres control auditory function and that the auditory tract ascends mainly on the side opposite the ear. The hearing loss was recovered by amelioration of the edema associated with the left putaminal hemorrhage. The conversion from partial to near-complete hearing loss by recurrent left putaminal hemorrhage and the good recovery of hearing function by amelioration of the left putaminal hemorrhage may explain the left dominance in the level of acoustic radiation.

Auditory nerve fibers ascend the superior olivary complex bilaterally to the auditory cortex [2]; therefore, the auditory function is innervated from the bilateral auditory tract. Previous reports describing cases of cortical hearing loss after the occurrence of bilateral putaminal lesions indicated that damage to the acoustic radiation passing between the caudal side of the putamen and the internal capsule was responsible for the cortical hearing loss [3,4]. Koyama and Domen [5] reported that the neurological lesions in a patient with cortical hearing loss were present in the bilateral caudal putamen and could be visualized with fiber-tracking techniques. Furthermore, a recent report indicated left-hemispheric lateralization in acoustic radiation reconstruction [1]. Cortical hearing loss generally develops when bilateral lesions occur with concurrent or sequential onset in the auditory tract [6]. Based on these findings, the course of damage to the auditory tract could be investigated in our patient (Fig. 2 A). Our case was unique in that stepwise hearing loss was confirmed. The damage to the auditory tract had been exacerbated from unilateral to bilateral by intracerebral hemorrhage. The first episode of hemorrhage in the right putamen caused partial hearing loss with dominance in the left ear, but the right ear was barely impaired because of the intact auditory tract arising from
the right auditory nerve. The auditory tract ascends mainly on the side opposite the ear, although the intensity of hearing dominance may vary among individuals. However, the second episode of hemorrhage in the left putamen with surrounding edema resulted in damage to the left acoustic radiation with subsequent disconnection of the bilateral auditory pathways, leading to near-complete hearing loss (Fig. 2B). Auditory function is commonly considered bilaterally innervated. Central facial nerve palsy, which, like auditory function, is considered bilaterally innervated, has also been reported to exist in patients with central facial nerve palsy, which, like auditory function, is considered bilaterally innervated. Central facial nerve palsy associated with unilateral stroke [7]. In this literature, the proposed mechanism underlying the onset of central facial palsy after unilateral stroke was the asymmetric contributions of the bilateral cortex. Furthermore, the asymmetry was found to vary among individuals, and central facial nerve palsy developed when the dominant hemisphere was larger. This suggests that cortical hearing loss may also be symptomatic in patients with unilateral lesions when the dominant hemisphere of cortical hearing loss is larger. The reasons for the lack of literature describing why stroke-induced unilateral lesions cause hearing loss are as follows. First, stroke is more likely to occur in patients of advanced age, making it challenging to determine whether current hearing loss is presbycusis or a new symptom due to the index stroke. Second, diagnosing mild hearing loss in patients with severe stroke who have disturbance of consciousness, motor paralysis and aphasia is often difficult. Therefore, hearing loss may be overlooked, possibly explaining why it has not been mentioned in the stroke literature to date.

(A) The auditory tract generally starts at the cochlea (a), ascends to the superior olivary complex bilaterally (b), passes through the inferior colliculus (c), and reaches the medial geniculate (d). From here, the acoustic radiation (e) conveys the auditory information to the auditory cortex (f). In the present case, the first episode of hemorrhage (blue ellipse) in the right putamen damaged the right acoustic radiation, and the second episode of hemorrhage (red ellipse) in the left putamen damaged the left acoustic radiation. (B) In this schema, the red arrow indicates the auditory information from the right ear, the blue arrow indicates the auditory information from the left ear, and the line thickness reflects the amount of auditory information. The first episode of hemorrhage in the right putamen severed the thick blue and thin red arrows, resulting in severe hearing loss in the left ear and only slight hearing loss in the right ear. However, the second episode of hemorrhage in the left putamen severed almost all arrows, resulting in near-complete hearing loss. After the brain edema associated with the second episode of hemorrhage was relieved, the hearing loss associated with the second episode of hemorrhage partially recovered.

The degree of hearing damage and recovery is related to the hemorrhage site, the amount of hemorrhage, and the timely administration of appropriate treatment [6]. In previously reported cases of bilateral supratentorial hemorrhage, hearing loss recovery began around 2 months after the onset of symptoms, and complete recovery was reported at about 6 months [3,4]. Our patient significantly recovered in 2 months. Because the auditory tract was injured by the perilesional edematous change but not by the left putaminal hematoma per se, hearing loss recovered after amelioration of the edematous change. Although our evaluation was limited by the fact that the results of standard pure-tone audiometry after the first episode of right putaminal intracerebral hemorrhage were unavailable, the damage to the left acoustic radiation by the edematous change markedly worsened the patient's hearing loss in the acute phase after the second episode of left putaminal hemorrhage, whereas the hearing loss was mild after the first episode of right putaminal hemorrhage. Amelioration of the edematous change of the left acoustic radiation markedly improved the hearing loss in the chronic phase. Based on our patient's clinical course, the left dominance in the level of acoustic radiation may also explain the conversion from partial to near-complete hearing loss and the good recovery of hearing function [1]. In addition, our patient's hearing loss improved, especially in the low-tone range. In the primary auditory cortex, the posterior part is responsive to high tones and the anterior part to low tones [8]. In this case, part of the acoustic radiation connected to the anterior part of the primary auditory cortex may have been impaired. Still, no report to date has indicated the innervation associated with the tone range in the level of acoustic radiation. In reports of patients with brain stem hematomas, more significant improvement occurred in the high-than low-tone range [9,10]. The positions of the pathway with respect to pitch tones might depend on the auditory tract level.

4. Conclusion

We have reported a case of near-complete cortical hearing loss caused by sequential development of bilateral putaminal hemorrhage. The asymmetric but bilateral innervation from the auditory nerve accounted for the conversion from partial to near-complete hearing loss after the second episode of left putaminal hemorrhage. Stroke-related hearing loss is a medical emergency that needs prompt treatment.

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Ethical standards

The manuscript contains patient data.

CRediT authorship contribution statement

Yoshito Arakaki: Writing – original draft, Data curation. Takeshi Yoshimoto: Writing – original draft, Data curation, Supervision.
Hiroyuki Ishiyama: Data curation, Supervision. Tomotaka Tanaka: Supervision. Yorito Hattori: Supervision.

Declaration of Competing Interest

None.

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