Journal of Zhejiang University-SCIENCE B (Biomedicine & Biotechnology)
ISSN 1673-1581 (Print); ISSN 1862-1783 (Online)
www.zju.edu.cn/jzus; www.springerlink.com
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Case Report:

Pure word deafness associated with extrapontine myelinolysis*

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Received June 2, 2010; Revision accepted Sept. 25, 2010; Crosschecked Sept. 27, 2010

Abstract: Extrapontine myelinolysis and pure word deafness are very uncommon disorders. Here, we report a case of a 19-year-old woman who suffered from osmotic demyelination syndrome with coincidence of typical pure word deafness. As a consequence of rapid correction of hyponatremia, the patient demonstrated an initial onset of cortical deafness, and then progressed to generalized auditory agnosia, which eventually developed into confined verbal auditory agnosia (pure word deafness). Bilateral extrapontine myelinolysis was confirmed using brain magnetic resonance imaging. This case suggests that verbal and nonverbal stimuli may involve separate thalamocortical pathways.

Key words: Pure word deafness, Auditory agnosia, Osmotic demyelination syndrome, Extrapontine myelinolysis, Cortical deafness

doi:10.1631/jzus.B1000200 **Document code:** A **CLC number:** R74

1 Introduction

Pure word deafness is a rare auditory disorder that is characterized by a selective deficit in comprehending spoken words, while the identification of nonverbal sounds remains intact (Lichtheim, 1885; Kanter *et al.*, 1986; Mendez and Geehan, 1988). The brain damage that causes pure word deafness generally involves unilateral dominant lesions of the Heschl's gyrus (Gazzaniga *et al.*, 1973; Albert and Bear, 1974; Denes and Semenza, 1975; Wang *et al.*, 2000) or bilateral lesions of the temporal lobe (Griffiths *et al.*, 1999; Wirkowski *et al.*, 2006) but only rarely at the subcortical or brainstem levels, such as bilateral lesions of the inferior colliculi (Johkura *et al.*, 1998; Vitte *et al.*, 2002) or damage to thalamocortical auditory pathways (Taniwaki *et al.*, 2000; Shivashankar *et al.*, 2001; Hayashi and Hayashi, 2007). According to the literature, cortico-subcortical auditory disorders are most frequently associated with cerebrovascular accidents (Buchman *et al.*, 1986). These have not been reported in any extrapontine myelinolysis (EPM) cases. Here, we report on a patient with EPM whose main cognitive complaint was an inability to understand spoken language.

2 Case report

A 19-year-old right-handed Chinese woman (in the second year of high school) was initially diagnosed with pulmonary tuberculosis in a local hospital because of coughing and low fever on Apr. 10, 2008; she received regular antituberculosis therapy. Fourteen days later, she presented with hemoptysis and

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* Project supported by the Science Research Foundation of the Ministry of Health of China (No. WKJ2010-2-009), the Science and Technology Department of Zhejiang Province (No. 2007C33007), the Key Project of Education Department of Zhejiang Province (No. Z2008 05185), and the Natural Science Foundation of Zhejiang Province (No. Y2080132), China

was treated with 72 U pituitrin for 20 h. Soon after, she had recurrent severe nausea and vomiting, which was followed by poor appetite. Subsequently, she felt sluggish and presented a slight twitch (starting at noon on May 27). A serum electrolyte test revealed normal natremia (134.3 mmol/L) on Apr. 26; however, she presented with acute hyponatremia (111.6 mmol/L) on Apr. 28. Her serum sodium increased to 138.3 mmol/L the following day after hypertonic sodium chloride treatment (unfortunately, we do not have a detailed account of the treatment administered at the hospital). The following morning, the patient suffered tinnitus and a slight headache, with hearing degeneration, and by dusk had developed deafness. When she was admitted to our hospital, she had been deaf for 5 d, and the deafness was accompanied by a slight headache, inarticulacy, sluggishness, and a recurrent twitch in the left hand (four to five times a day, with spontaneous relief within 3 min).

Her general physical condition was normal. Neurological examination revealed that she had mild weakness of the left lower face and left upper arm, dysarthria, and no response to a 128-Hz tuning fork. Results from a cerebrospinal fluid examination were normal. Magnetic resonance imaging (MRI) showed the presence of symmetrical lesions involving bilateral putamina, the head of the caudate nucleus, and partial splenium of the corpus callosum, but sparing the temporal lobe or other cortical regions (Figs. 1a–1d). A week later, although the patient remained deaf to any oral commands, she seemed to turn towards the ringing of a cell phone and other sudden environmental sounds. We then proceeded to test her hearing functions more precisely, with an emphasis on her verbal auditory function. Additional MRI was performed (Figs. 1e–1h).

Standard pure tone threshold audiometry and speech threshold audiometry conducted one week after admission to our hospital showed a moderate to severe bilateral sensorineural hearing impairment. However, a week later, brainstem auditory-evoked potentials (BAEP) exhibited normal bilateral latency and left amplitudes, although slightly impaired in the right ear hearing (lower I, II, and III amplitudes, Fig. 2). A set of auditory evaluations was carried out on the patient to characterize her auditory deficit further (Table 1). This revealed that her hearing had returned to normal.

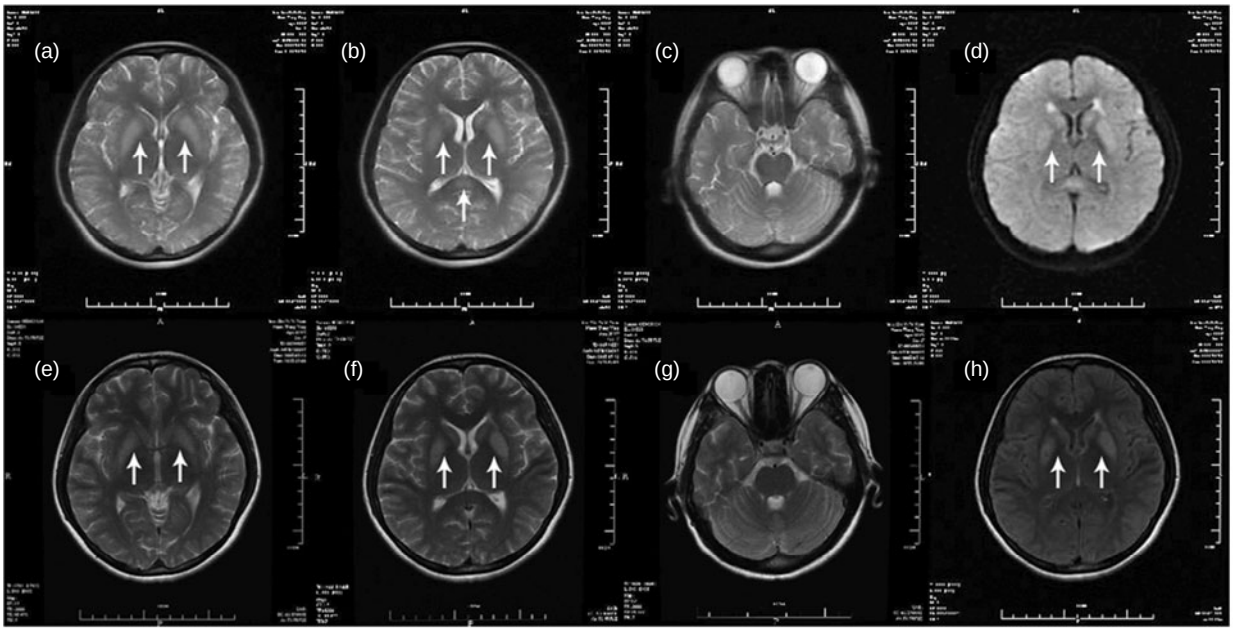

Fig. 1 Brain MRI scans taken 5 d (a–d) and 13 d (e–h) after the onset of EPM

T2-weighted images (a–c) showed symmetrical lesions (abnormally high signal intensities (arrows)) involving bilateral putamina (a), the head of caudate nucleus (b), and partial splenium of corpus callosum (b), but sparing the pons (c). (d) Diffusion-weighted images show high signal intensities (arrows) in the corresponding areas. T2 (e–g) and T2-Flair (h) MRIs taken 13 d after the onset of EPM showed increased signal in those areas (arrows) described in (a)–(d), respectively, but with the boundary clearer and the volume decreased

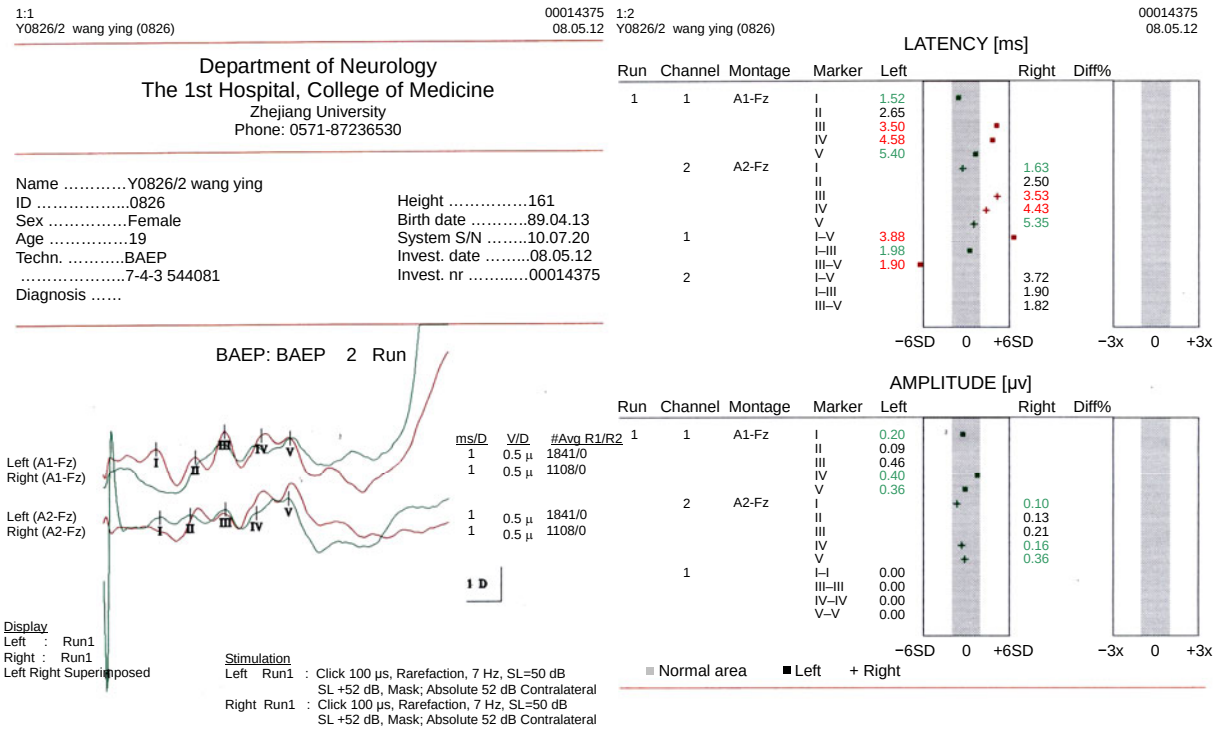

Fig. 2 BAEP (102 dB, 0.1 ms click, with mask) taken 12 d after the onset of EPM

Bilateral latency and left amplitudes are normal, although right amplitudes of I, II, and III are slightly lower

Table 1 Auditory profile of the patient

Date	Audiological tests	Left ear	Right ear
May 12, 2008	Pure tone audiometry, all frequency average	Air-conduction 56 dB; bone-conduction 54 dB	Air-conduction 70 dB; bone-conduction 52 dB
	Pure tone audiometry, speech frequency average (500, 1000, 2000 Hz)	50 dB	75 dB
	BAEP (102 dB, 0.1 ms click, with mask)	Normal	Slightly impaired with lower I, II, III
May 20, 2008	Tympanometry	Normal	Normal
	TEOAE	Could be elicited	Could be elicited
May 21, 2008	ABR (70 dBnHL click with threshold detected)	Normal with a threshold <10 dBnHL	Normal with a threshold 20 dBnHL
	Speech discrimination threshold	Could not evaluate	Could not evaluate

BAEP: brainstem auditory-evoked potentials; TEOAE: transiently evoked otoacoustic emission; ABR: auditory brainstem response

Neuropsychological evaluations were performed three weeks after the onset of her deafness (May 21). Because of her inability to comprehend spoken language, written instructions were used. She obtained a score of 28/30 on the Mini Mental State Exam (MMSE) and a score of 58/60 on the Boston Naming Test and had no visual/spatial impairment. Language assessment using the Aphasia Battery of Chinese (Gao *et al.*, 1992) revealed that she had significant deficits in auditory comprehension, repetition, and writing to dictation, despite the presence of good reading, fluent speech, and spontaneous writing, without evidence of aphasia. Subsequently, the patient was asked to identify a set of recorded common environmental sounds of daily life (e.g., a telephone bell or a dog barking). Surprisingly, she responded correctly to 29 out of 30 of these sounds, within 5 s (May 23). As she loved to listen to pop music before the onset of her deafness, we presented six songs that were familiar and six songs that were unfamiliar to

her. She could tell immediately whether the song was familiar or not and she was able to name all six familiar songs. However, she could not recognize the lyrics, with the exception of some words that she had memorized. Conversely, and even for the unfamiliar songs, she could tap to the melody of the song and distinguish whether the singer was male or female.

No symptoms remained when she was dismissed after a 30-d hospitalization, with the exception of a slight impairment in her verbal auditory perception. At the six-month follow-up, she exhibited a significant improvement in the comprehension of verbal sounds only when she could read lips; however, she still had difficulty talking on the telephone and listening to comprehension tests in school.

3 Discussion

Hyponatremia is the most common electrolyte disorder (Sterns *et al.*, 1986; Schrier *et al.*, 2006). Two possible causes of hyponatremia should be considered for this patient. The first and most important one is the infusion of pituitrin, which is often used to treat hemoptysis (especially for patients with tuberculosis), as it is widely associated with hypervolemic hyponatremia (Gu *et al.*, 1991; Yang, 2000; Wu and Li, 2005; Xiao *et al.*, 2005; Cai *et al.*, 2007; Chen, 2010; Ma and Qi, 2010). In hypervolemic hyponatremia, excess water dilutes the concentration of sodium and enters cells, causing swelling (e.g., brain edema). This results in low sodium levels, which are accompanied by symptoms of nausea, vomiting, headache, confusion, lethargy, fatigue, appetite loss, restlessness, muscle weakness, spasms or cramps, seizures, and decreased consciousness or coma (Gu *et al.*, 1991; Yang, 2000; Wu and Li, 2005; Xiao *et al.*, 2005; Cai *et al.*, 2007; Chen, 2010; Ma and Qi, 2010). Decreased levels of serum sodium are associated with the development of prominent and serious symptoms (Yang, 2000; Cai *et al.*, 2007). Commonly, the level of sodium in the serum is normal 24 h after the infusion of pituitrin and drops (to some extent) 48 h later (Wu and Li, 2005). Neurological symptoms caused by brain edema often develop when a patient's serum sodium levels are very low (usually <115 mmol/L) (Yang, 2000; Cai *et al.*, 2007; Ma and Qi, 2010). The second possible cause of our patient's hyponatremia could have been her severe vomiting and poor appetite after the pituitrin therapy (Gu *et al.*, 1991; Ma and Qi, 2010).

The patient's auditory disorders developed 1 d after the rapid correction of the hyponatremia. Her clinical manifestations (e.g., dysarthria and muscle cramps) and the lesions found on the MRI strongly suggested EPM. This osmotic demyelination syndrome (ODS) is characterized by demyelination of the pons [central pontine myelinolysis (CPM)] and extrapontine areas (EPM). Rapid correction of chronic hyponatremia is the most important cause of ODS, especially when sodium levels are >12 mmol/L per day (Sterns *et al.*, 1986). The manifestations of myelinolysis usually develop several days after the correction of hyponatremia. Myelinolysis is more likely to occur after treatment for chronic, rather than acute, hyponatremia and in the presence of a rapid rate of correction. In more than 10% of patients with CPM, demyelination also occurs in extrapontine regions, including the mid brain, thalamus, basal nuclei, and cerebellum. However, the exact pathogenesis of ODS has not been determined (Laureno and Karp, 1997; Snell and Bartley, 2008). Georgy *et al.* (2007) suggested that CPM is a complication of the treatment for chronic hyponatremia (hyponatremia >48 h), particularly in alcoholics. Because of the scarcity of case reports of EPM induced by hyponatremia correction (Seok *et al.*, 2007; Lin and Po, 2008), it has not been determined whether the location of a lesion (CPM, EPM, or both) is associated with the causes or the correction speed of hyponatremia. However, sodium levels in all three cases were corrected from severe hyponatremia within 48 h: 100 to 126 mmol/L (Seok *et al.*, 2007), 110 to 137 mmol/L (Lin and Po, 2008), and 111.6 to 138.3 mmol/L (our case), respectively. EPM of our patient occurred as a consequence of rapid correction of acute hyponatremia, although the histories of the other two were not very clear. However, only two out of 200 cases of CPM reviewed by Martin (2004) resulted from rapid correction of acute hyponatremia. Whether the location of the lesion of ODS (EPM or CPM) is associated with rapid correction of acute/chronic hyponatremia warrants further research.

At the acute phase of EPM, demyelination involving fibers, together with the peripheral edema effect, may disconnect the bilateral acoustic radiation.

Those stretches from the medial geniculate body to the primary auditory cortex and the auditory association cortex may then have resulted in the general cortical deafness observed in our patient. Twelve days later, the peripheral edema faded away, and some fibers recovered, contributing to some improvement of her hearing (environmental sounds). This case suggests that subcortical lesions involving bilateral thalamocortical pathways caused by ODS may result in cortical deafness, general auditory agnosia, and auditory verbal agnosia. We found that verbal and nonverbal stimuli may travel independently, which is consistent with the hypothesis that the auditory processing mechanisms for verbal and environmental sounds are different, even at the subcortical level (Motomura *et al.*, 1986; Taniwaki *et al.*, 2000; Shivashankar *et al.*, 2001). Furthermore, a previous case of bilateral putaminal hemorrhage presented with cortical deafness and generalized auditory agnosia, followed by auditory agnosia restricted to environmental sounds (Taniwaki *et al.*, 2000). This sharp contrast suggests that verbal and nonverbal conduction tends to be separate.

4 Conclusions

In summary, the complication of hyponatremia should be noted when pituitrin is used to treat hemoptysis. Most importantly, the speed of correction of hyponatremia must be kept under strict control during unfavorable outcomes to prevent the development of additional complications, e.g., ODS.

5 Acknowledgements

We thank Dr. Xu-chu WENG (Laboratory for Higher Brain Function, Institute of Psychology, Chinese Academy of Sciences) for help with the manuscript. We also thank the cooperation of Miss Ying WANG and her family.

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