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Unilateral Deafness Diagnosed using the Brainstem Auditory Evoked Response Test in a Shih-tzu Dog

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Abstract : A 12-year-old castrated male Shih Tzu presented with suspected hearing loss. The patient had no history of head trauma or exposure to ototoxic drugs. The results of neurologic and physical examinations were normal. An otoscopic examination showed that both the tympanic membranes and the external ear canals had a normal appearance. However, the results of brainstem auditory evoked response tests confirmed sensorineural deafness in the right ear and indicated conduction disturbances and brainstem abnormalities in the left ear. Magnetic resonance imaging was performed to confirm the causes of the conduction disturbances and brainstem abnormalities. Inflammatory changes in the left middle ear were highly suspected to be responsible for the findings in the left ear. The results of these examinations confirmed complete hearing loss in the right ear and indicated otitis media in the left ear, which could have been the cause of the conduction disturbances.

Key words **:** brainstem auditory evoked response (BAER), deafness, otitis media, dog.

Introduction

The most commonly observed forms of deafness are inherited congenital sensorineural deafness, acquired late-onset sensorineural deafness (associated with ototoxicity, noise trauma, chronic otitis media, otitis interna, and presbycusis in older animals), and acquired late-onset conductive deafness (associated with chronic otitis externa and otitis media) (2,15). Behavioral testing with sound stimuli produced outside the visual field can be used to assess deafness (1,15,19, 20). However, these assessments are often unreliable and subjective (1,15). The brainstem auditory evoked response (BAER) test allows an objective assessment of auditory function (1,3). This test records neural activity generated in the cochlear nerve and brainstem in response to a controlled sound stimulus (12). The normal BAER consists of five waves (11,15). Wave I is generated by the cochlear portion of the vestibular nerve. Wave II is thought to arise from the cochlear nuclei in the medulla. Wave III is suspected to be generated by the rostral olivary nuclei and the dorsal nuclei of the trapezoid body, both of which are located in the medulla. Wave IV represents the action potentials from the lateral lemniscus and lemniscal nuclei of the pons. Wave V is generated by the caudal colliculi of the midbrain and medial geniculate nuclei of the diencephalon (15). The presence of these waveforms and their shape and latency (the interval between the sound stimulus and the appearance of the wave) are important for interpreting the BAER findings (12,17). We describe the features of BAER waveforms in a canine case of unilateral deafness and discuss the importance of the BAER test in diagnosing unilateral deafness.

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Case

A 12-year-old castrated male Shih-tzu dog presented with suspected hearing loss. The patient had no history of head trauma or exposure to ototoxic drugs. The results of a complete blood count and serum biochemical examinations were unremarkable. The dog responded normally during behavioral assessment. An otoscopic examination showed that both the tympanic membranes and the ear canals had a normal appearance. The results of a radiographic examination were unremarkable.

To assess the patient's auditory function, the BAER test was performed using a standard electrodiagnostic machine (Neuropack M1 MEB-9200; Nihon Kohden, Japan). The patient was sedated for 30 minutes with medetomidine hydrochloride (Domitor®; Pfizer Animal Health, USA) (30 μg/kg, IM) and placed in ventral recumbency (Fig 1). To detect each BAER, stainless steel needle electrodes (Neuroline Subdermal®; Ambu, Malaysia) were placed subcutaneously on the patient's vertex, forehead, and rostral to the tragus of the test ear (Fig 1). A headphone (DR-531; ELEGA, Japan) was placed over the ears and the test ear was stimulated with alternating acoustic clicks while the non-test ear received a masking noise 40 dB less than that on the stimulated side.

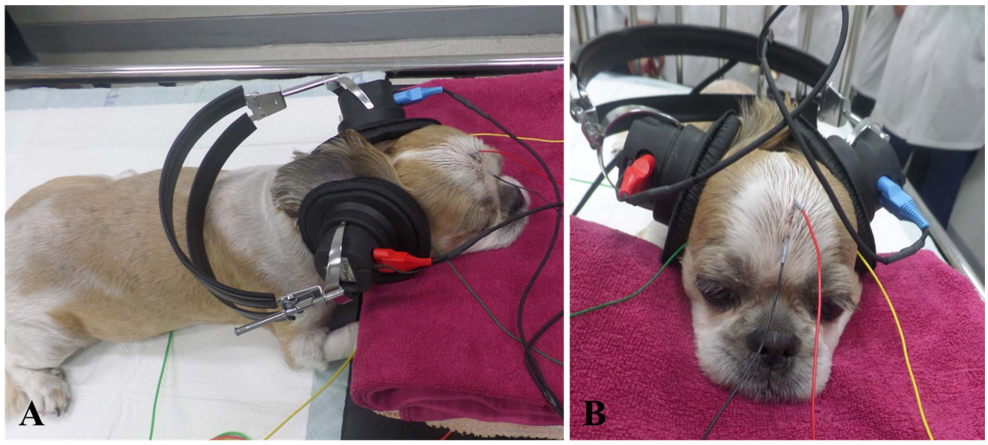
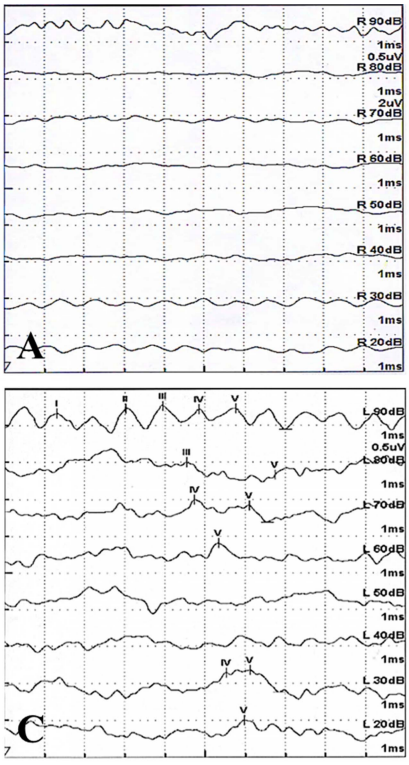


Fig 1. The patient undergoing a brainstem auditory evoked response test. The patient was placed in ventral recumbency (A). Four stainless needle electrodes were placed subcutaneously and the headphone was placed over the ear (B). When the test ear was stimulated with click sounds, the electrical response of the brainstem auditory pathway was recorded on the monitor.



Stim.	Latency (ms)					Interval(ms)		
Left	I	II	III	IV	V	I-III	III-V	I-V
L90dB								
L80dB								
L70dB								
L60dB								
L50dB								
L40dB								
L30dB								
L20dB								

B

Stim.	Latency (ms)					Interval(ms)		
Right	I	II	III	IV	V	I-III	III-V	I-V
L90dB	1.31	3.03	3.95	4.85	5.77	2.64	1.82	4.46
L80dB			4.54		6.75		2.21	
L70dB				4.73	6.10			
L60dB					5.34			
L50dB								
L40dB								
L30dB				5.52	6.14			
L20dB					5.99			

D

Fig 2. The brainstem auditory evoked response recordings in the present case. The flat waveforms were obtained for the right ear (A). The latency and interwave latency of each waveform were not recorded (B). For the left ear, all wave peaks showed an unclear shape from 80 dB to 20 dB (C). The interwave latency between wave III and V was higher at 80 dB compared with that at 90 dB (D).

The clicks were presented with 0.1 ms intervals between consecutive clicks. The stimulus intensities were set at 90, 80, 70, 60, 50, 40, 30 and 20 dB. In each ear, 1,000 repetitions were averaged and replicated. The BAER wave from the right ear appeared as a flat line, showing none of the expected peaks (Fig 2A and 2B). These results are indicative of sensorineural deafness. For the left ear, five distinct waves were detected at 90 dB, but all wave peaks showed unclear shapes at 80 dB (Fig 2C). Therefore, conduction problems in the left ear were highly suspected. In addition, the interwave latency between waves III and V at 80 dB (1.82 ms) was higher than that at 90 dB (2.21 ms) (Fig 2D), and brainstem abnormality also could not be excluded. To confirm the causes of the conduction disturbance and brainstem abnormality, we performed brain magnetic resonance imaging (MRI) using a 0.4 T scanner (APERTO; Hitachi Medical Corporation, Tokyo, Japan) with cerebrospinal fluid (CSF) analysis. T1-weighted (T1W), T2-weighted (T2W), fluid-attenuated inversion recovery (FLAIR), and contrast-enhanced T1W (CET1W) images were obtained from the MRI scans. The

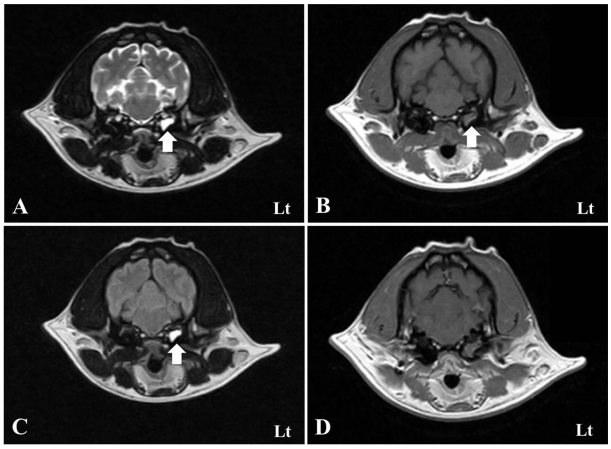


Fig 3. Magnetic resonance imaging findings at the initial examination. A: Transverse T2-weighted (T2W) image. B: Transverse T1W image. C: Transverse fluid-attenuated inversion recovery (FLAIR) image. D: Transverse contrast-enhanced T1W (CET1W) image. The material in the left middle ear was isointense on T1W images, hyperintense on T2W and FLAIR images, and showed no enhancement on CET1W images.

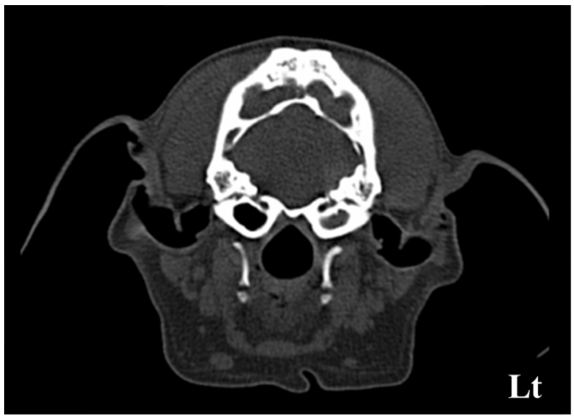


Fig 4. Computed tomography findings obtained 71 days after initiation of treatment. Bone window image. The left tympanic bulla was filled with fluid-attenuation material (Hounsfield unit value, +58), which was highly suspected to indicate otitis media. Contrast study was not performed.

scans showed a lesion in the left middle ear that was isointense on T1W images, hyperintense on T2W and FLAIR images, and showed no enhancement on CET1W images (Fig 3). Brainstem lesions were not identified. Examination of the CSF revealed no remarkable findings. Based on the results of these examinations, sensorineural deafness was diagnosed in the right ear and otitis media was tentatively diagnosed in the left ear.

Amoxicillin/clavulanic acid (Clavamox®; Zoetis Korea, Seoul, South Korea; 12.5 mg/kg, PO, q 12 h) and cefixime (Cefixime Cap. Nelson®; Korea Nelson Pharma., Seoul, South Korea; 5 mg/kg, PO, q 12 h) were prescribed for 2 weeks to treat the suspected otitis media. However, there was no improvement in the patient's hearing. Therefore, we prescribed additional prednisolone (Prednisolone; Korea Pharma., Seoul, South Korea; 0.5 mg/kg, PO, q 12 h). After administration of prednisolone for 7 days, the patient responded to the owner's voice. Approximately 2 months after the initiation of treatment, we performed a brain computed tomography (CT) scan using a two-channel multi-detector row CT scanner (Somatom Emotion, Siemens Medical System, Erlangen, Germany) to assess the patient's response to otitis media treatment. Although otitis media in the left ear was noted on the CT scan (Fig 4), the patient's hearing had improved after receiving medication for otitis media, which interferes with sound conduction, and the owner was satisfied with the improvement. Therefore, all medications were discontinued and no further treatment was performed.

Discussion

The BAER test is widely used to identify complete deafness in individuals of breeds prone to hereditary deafness, such as Dalmatians, Bull terriers, English Setters, Jack Russell Terriers, English Cocker Spaniels, and Australian Cattel Dogs (4,13,16,17,18). In addition to screening for congenital hereditary deafness, the BAER test can evaluate the auditory pathway and reveal various forms of canine deafness (1,11, 19). Canine bilateral deafness may be obvious to the owners, breeders, and clinicians (1,4,17). However, unilateral deafness is difficult to identify because many unilaterally deaf dogs can compensate for their disability (1). Therefore, behavioral assessments are not reliable for detection of unilateral deafness. The BAER test is an objective, accurate, and relatively non-invasive technique to diagnose unilateral deafness (1,20). In the present case, there was no evidence of deafness on behavioral examination. We performed the BAER test to assess the patient's auditory function and diagnosed unilateral deafness on the basis of the BAER test findings.

The appearance of five recognizable waves on a BAER recording confirms the hearing ability on that side (6,11,15). A flat line is evidence of deafness (4,5,12). Increased latency or decreased amplitude of all waves in response to high-intensity stimuli indicates external and middle ear transmission problems, because the stimulus reaching the cochlea is attenuated by pathology (1). For evaluation of brainstem integrity, interwave intervals are calculated by the computer to determine the peak-to-peak latencies between waves I and III, waves III and V, and waves I and V. These intervals should be within the reference ranges, and brainstem lesions can cause conduction delays, which manifest as prolonged latencies that correspond to the anatomic location of the lesion (6,11,14,15). Based on the history, age of the patient, and clinical findings, this patient was confirmed to have age-related deafness (presbycusis) in the right ear. The results of the BAER test for the left ear indicated conduction problems and brainstem abnormalities. MRI examinations showed no brainstem lesions, and otitis media was tentatively diagnosed as the cause of the conduction disturbances. We administered prednisolone and antibiotics to treat the otitis media. Subsequently, the subject responded to the owner's voice. Although the otitis media was not treated completely, we surmised that the patient's auditory function had improved as the stimulus reaching the cochlea of the left ear had increased.

Several factors affecting the BAER data should be considered to accurately obtain and interpret BAER waveforms (7, 9,19). The BAER is not appreciably affected by the state of arousal in patients. Therefore, it can be performed in awake, sedated, or anesthetized patients (4,9,15). However, slight movements of the head and contractions of the head muscles frequently interfere with the recording, because muscle activity is typically measured in millivolts, whereas the neuronal activity in a BAER recording is typically measured in microvolts. Therefore, sedation is essential for acquiring appropriate results without muscle-related artifacts (3,19).

The most common transducers used to record BAER data in dogs are headphones and in-the-ear transducers (insertable earphones). The headphones used for audiometry in humans are designed to fit the anatomical ear structure of humans, and the use of these headphones in dogs can yield unsatisfactory results. Moreover, pressing the headphones on the head over the entrance of the external ear canal can result in compression of the ear canal, which can delay the BAER wave latency by approximately 0.8 to 1.0 ms. Therefore, insertable earphones are preferable over headphones to avoid erroneous prolongation of the BAER wave latency (3,12,19).

Previous studies have suggested that the head size, which accurately reflects brain size, is related to BAER wave latency. The diameter of the brainstem is directly proportional to the latency of the wave (7,10). However, another study showed no significant relationship between head size and wave latency (8). Therefore, the best solution may be to obtain normative BAER data that are specific for the breed being assessed and compare it with the patient's BAER results (19). In the present case, the patient was sedated with medetomidine hydrochloride to minimize muscle-related artifacts. However, the transducer used for this patient was a headphone, and it may have caused compression of the ear canal. Furthermore, we did not obtain normative BAER data for Shih-tzu dogs. Thus, we surmised that the experimental conditions were not sufficiently perfect to yield accurate waveforms and allow their interpretation; this factor may have been responsible for the erroneous prolongation of the latency of waves III and V.

In conclusion, this report describes the features of BAER waveforms for deafness and conduction disturbances in a Shih Tzu dog. Although the patient showed no remarkable findings in behavioral testing, unilateral deafness was diagnosed on the basis of BAER data. Standardization of the factors affecting BAER waves and additional studies on normative BAER data are essential to obtain accurate BAER waveforms and correctly interpret them.

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