"Negative" ABR Findings in an Individual with a Large Brainstem Tumor: Hit or Miss?

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Abstract
This case illustrates the importance of determining the precise locus and extent of a lesion when attempting to correlate lesion site with auditory brainstem response (ABR) findings. The failure to document significant ABR findings in an individual with a large mass involving the low brain stem may initially appear to constitute a threat to the sensitivity of the ABR; however, careful review of the radiologic evidence in this case suggests that sensitivity did not suffer, but rather that the specificity of the procedure was upheld. Moreover, the value of electronystagmography (ENG) in the assessment of an individual with a lesion in the region of the low brain stem and severe vestibular symptoms is demonstrated.

Key Words: Auditory brainstem response (ABR), electronystagmography (ENG), ganglionoma, medulla

The sensitivity of the auditory brainstem response (ABR) to VIIIth nerve lesions has been well documented in the literature. Although the ABR has also been shown to be sensitive to lesions in the brain stem, a great deal of variability exists in the findings reported in the literature. For a comprehensive coverage of the topic, the reader is referred to Hall (1992). The variability among the findings for ABR test sensitivity in individuals with brainstem lesions may be due, at least in part, to the failure of some of these investigators to document the exact location of the lesion in each subject. To say it was a brainstem lesion is not sufficient in interpreting the efficiency of the ABR. In this article, we hope to demonstrate some important diagnostic principles that will demonstrate the importance of precise anatomical determination of lesion site when attempting to make correlations between ABR results and brainstem involvement. Also, we will demonstrate the value of electronystagmography (ENG) in the assessment of pathological cases in which dizziness and vertigo are primary symptoms. Some aspects of this case have been presented elsewhere (Musiek et al, 1994). In the present report, we expand upon these findings (ABR and radiologic findings) and discuss a clinical procedure (ENG) that was not presented in detail in the previous presentation of the case.

CASE REPORT

History
This young woman was 18 years of age when she presented in our medical center with a recent history of episodic vertigo and a longstanding history of headaches, poor coordination, and swallowing difficulties. The patient reported that she had first begun to experience vertiginous episodes some 5 to 7 months before she was evaluated at our medical center. These episodes reportedly lasted anywhere from a few seconds up to 10 minutes in duration and were often associated with nausea, but no vomiting. In addition, she mentioned that her vertiginous episodes initially increased in frequency, then plateaued for a brief period of time, and then began to increase once again the month preceding her evaluation to the point where
they were occurring as frequently as two or more times per day. These spells occurred spontaneously but were also precipitated by sudden head movements associated with activities such as rolling over in bed or tilting the head back. There seemed to be no tendency for vertigo to be caused by head turning in one direction versus the other.

Significant medical history included a 5½-year history of recurrent headaches that tended to occur in the occipital area and occasionally involved retro-orbital pain. Review of medical notes from an outside medical facility revealed that the patient had first sought medical evaluation for these headaches in 1986. For 2 to 3 months prior to this evaluation, the patient had been experiencing severe headaches almost daily. These headaches were of two types: (1) pain originating from the back of the neck to the occiput, which was very common; and (2) pounding headache behind the temple, which tended to be associated with noise intolerance and light intolerance. Intermittent dizzy spells were also noted. The results of physical examination at that time were essentially negative, with the only abnormal findings being a persistent right-beating nystagmus on right lateral gaze and a tendency to veer to the left when marching in place with the eyes closed. In addition, a computerized tomography scan ordered at that time was interpreted as normal. Based upon the available diagnostic information, the headaches were diagnosed as migraines and were treated with Cafegot and Advil.

At the time that we saw this young woman, she continued to experience recurrent headaches, although the severity of these headaches reportedly was minimized somewhat by her prescribed medications. During the previous 5 to 7 months, all three symptoms (the headaches, nausea, and dizzy spells) were apparently temporally related. In addition, hearing difficulties for the right ear were reported for approximately 2 months prior to our evaluation. Hearing in that ear was described as being "muffled." The patient also presented with a tendency to veer off from time to time when walking. Although the patient denied any weakness in the extremities, the patient's mother reported that her daughter's coordination had deteriorated over the previous 2 months. She indicated that her daughter could not walk downstairs without the risk of falling. Finally, the patient, as well as her mother, reported that the patient's voice had changed during this time. Her voice was described as being noticeably softer.

Significant family history included the death of her father at an early age due to a brainstem tumor. In addition, there was an indication that the father also had two tumors in the region of the lungs. However, neither the patient nor her mother could provide any additional information regarding these tumors and any possible connections between these and the brainstem tumor. Recently, we have learned that a younger sister is also being followed for symptoms similar to those of this young patient.

**Otologic/Audiologic Exam**

On physical examination at our facility, no open eye nystagmus was noted and cranial nerves II through XII were intact. A Romberg test with the eyes open and closed was normal. With Frenzel glasses, a marked third-degree right-beating spontaneous and gaze nystagmus was noted. Hallpike maneuvers with head hanging head straight position caused vertigo without significant increase in nystagmus, which did not fatigue. A routine peripheral audiologic assessment revealed normal peripheral findings (Fig. 1). Diagnostic impression at that time was a 6-month history of instability with episodic vertigo and a third-degree spontaneous and gaze nystagmus under Frenzel glasses. Although the spontaneous nystagmus appeared to implicate a vestibular lesion, greater compensation would
ABR Findings

The patient was seated in a sound-treated booth with the positive electrode attached to the high forehead and ground and reference electrodes clipped to each earlobe. Electrode impedance was maintained at 5000 ohms or less and balanced. The stimulus was a 100-microsecond rarefaction click transduced through ER-3A insert phones, and the bioelectrical response was filtered at 150 to 3000 Hz. The patient was still throughout testing so that artifact was not a contaminating factor in the recordings. Absolute latencies for waves I, III, and V were normal bilaterally at 85 dB nHL for a 15.7 clicks per second stimulation rate (Fig. 2). The I-III interwave interval was borderline normal for both ears (2.36 msec and 2.32 msec), as was the I-V interwave interval for the right ear (4.32 msec) and the interaural latency difference for wave V (.32 msec). Increasing the click rate to 65.7 clicks per second produced the expected shift in latency of wave V for both ears. Although borderline normal results were noted for several indices, all indices were “normal,” providing no clear evidence of central nervous system (CNS) compromise.

ENG Results

The patient was seated in a darkened room with electrodes applied to record both horizontal and vertical nystagmus and calibration was accomplished. Gaze testing with the eyes open and closed was accomplished in center, right, left, up, and down positions with a significant spontaneous right-beating nystagmus measured for all eye positions (Fig. 3). Visual fixation did suppress this right-beating gaze nystagmus; however, it did not totally obliterate it. In addition, there was a questionable down-beating nystagmus in the right, center, up, and down gaze positions and an obvious up-beating nystagmus in the center and left gaze positions (Fig. 4). Smooth pursuit testing was abnormal with a superimposed right-beating gaze nystagmus observed when the eyes were tracking toward the right. The sinusoidal wave was well formed when tracking was directed toward the left (Fig. 5).

The patient refused both positional and caloric testing as she was extremely vertiginous throughout testing. Although she appeared quite uncomfortable and fearful throughout the evaluation, the test results were judged to be valid. The ENG results were clearly abnormal and judged to be more suggestive of brainstem/CNS pathology than peripheral vestibular dysfunction.

Although all ABR indices were within normal limits according to the clinic norms employed, an asymmetry was evident for the interaural latency difference, which would be considered abnormal in some clinics. The potential anatomical basis for this asymmetry is discussed in the Comments section of this article.

Figure 2 ABR demonstrating “normal” indices for a young woman with a medullary ganglioloma. (Reprinted with permission from Musiek et al, (1994), Neuroaudiology: Case Studies. San Diego: Singular Publishing Group, p. 104.)

Figure 3 Gaze nystagmus recording with the eyes closed and directed to the left. The top tracing shows a right-beating nystagmus recorded from the horizontal leads. The lower tracing represents eye movements recorded from the vertical leads. Similar right-beating nystagmus was evident in all gaze nystagmus recordings.
Radiologic Findings

Magnetic resonance imaging (MRI) scans revealed the presence of an abnormal mass principally involving the right side of the medulla with distortion of the inferior portion of the fourth ventricle. Although quite large and clearly involving the low brain stem, the pons, the pontomedullary junction, and the rostral brainstem structures appeared to have been spared compromise as best as we can tell. There may have been some slight displacement of the pons. Three MRI views have been provided in an effort to clearly delineate the size and locus of the lesion for the reader (Figs. 6–8). The mass was judged to be cystic in nature and initially the possibility of an inflammatory agent was entertained. However, following an initial stereotatic brain biopsy, a subsequent posterior craniectomy with biopsy, and considerable medical consultation, the diagnosis of a medullary ganglioloma was rendered.

Outcome

Following diagnosis, various management options were discussed with the patient. The patient opted for radiation therapy and was irradiated with 6800 cGY in 68 treatments given twice daily over 34 days. Since the completion of her radiation therapy, she has been followed regularly by a staff neurologist at our medical center. Results have been generally positive. Over the past 2 years, the mass has not increased significantly in size. In fact, there is some indication that it may have decreased slightly in size. The patient's symptoms have remained essentially unchanged or in some cases improved. She continues to experience headaches and a mild weakness involving the right side. At the time of her most recent medical evaluation, her course was determined to be stable, with the patient experiencing subtle paresis and hyperreflexia on the right side. The patient denies visual problems and reports that her balance is unaffected at this time. The plan is to continue to monitor her neurologic status.

COMMENTS

Of interest in this case are the “normal” ABR findings. A cursory look at the MRI results reveals a large brainstem lesion and hence one would expect significant ABR findings. However, if one looks more carefully at the MRI results, then the ABR findings may be more accurate than initially believed. The lesion, as far as we can tell, was limited to the rostral medulla with no invasion of the pons or the pontomedullary junction. Some compression of the rostral part of the fourth ventricle was likely. Given the locus of the lesion, it may be reasonable to
assume that the auditory structures in the brain stem were not directly compromised. The "borderline" normal results of the ABR may be related to fourth ventricle compression and/or indirect and minimal pontine displacement. In this case, the ENG results were more sensitive to the presence of central dysfunction and provided positive indicators of CNS involvement.

The presence of abnormal gaze nystagmus implicated brainstem involvement primarily due to its persistent nonfatiguable characteristic in all eye positions. In spite of the fact that the observation of spontaneous nystagmus usually points to end organ as opposed to central involvement, the presence of unidirectional gaze nystagmus with eyes open and closed, obvious up-beating nystagmus, and questionable down-beating nystagmus clearly implicates CNS pathology. Specifically, down-beating nystagmus has been linked to lesions of the cerebellum and up-beating nystagmus is most often associated with lesions involving the central medulla (Baloh and Yee, 1989). The case clearly demonstrates the need to consider carefully the history of the patient when selecting test procedures. The spontaneous nystagmus would typically implicate vestibular end organ involvement, but the persistence of the nystagmus for several months without adaptation pointed to the possibility of central involvement. The ABR is typically the first diagnostic procedure invoked when a brainstem lesion is suspected. However, in this case, the results were inconclusive at best and did not assist in the identification of dysfunction at the level of the brain stem. We did identify some "borderline normal findings" for the right ear, but in terms of customary clinical decision making, these results would typically be classified as normal. If these results were taken as normal and the patient's history of spontaneous nystagmus
had not been documented, then the identification of the brainstem involvement might have been delayed.

The sensitivity of the ENG test over ABR in this case is not surprising if one considers the locus of the lesion and the anatomy of the central portion of the vestibular system. Recall that the superior and inferior branches of the vestibular nerve merge at Scarpa's ganglion in the internal auditory meatus and then pass medially through the cerebellopontine angle to enter the brain stem just above the medulla and immediately below the pons. The afferent fibers then transverse either directly to the cerebellum and to the spinal canal (i.e., the vestibulo-spinal afferents) or to one or more of four major vestibular nuclei (i.e., the superior, medial, lateral, and descending vestibular nuclei) positioned on the lateral floor of the fourth ventricle (i.e., the vestibulo-ocular afferents). The second order vestibular fibers originate in the vestibular nuclei and then travel via the medial longitudinal fasciculus to the ocular motor nuclei (i.e., the nuclei of the IIIrd and VIth cranial nerves). These motor nuclei then influence the activity of the extraocular muscles (i.e., the superior rectus, lateral rectus, inferior rectus, inferior oblique, and superior oblique muscles), thereby completing the vestibulo-ocular reflex arc (Baloh and Honrubia, 1982). Given the location of the lesion in this case, it is likely that neural pathways underlying the vestibulo-ocular reflex were affected.

CONCLUSIONS

A number of previous investigations have shown the ABR to have good sensitivity when used to evaluate individuals with lesions involving the brain stem. This case demonstrates that the ABR is also likely to have good specificity. That is, if the auditory centers are not compromised either directly or indirectly, then the ABR should be normal. Although the ABR is likely to pick up many cases with brainstem pathology, it may not detect those lesions that do not result in compromise of the auditory nuclei and/or pathways. Therefore, the audiologist needs to be aware that in some cases, additional test procedures may be indicated. In this case, the presence of persistent spontaneous nystagmus and vertiginous symptomatology created a high index of suspicion that the brain stem was compromised despite the “normal” ABR findings. This case demonstrates the importance of considering not only the diagnostic profile but also the presenting symptomatology when evaluating a patient with possible CNS involvement. It also points to the value of using vertical leads during ENG testing as the presence of significant CNS findings may be missed if only horizontal recordings are obtained. Finally, it demonstrates that precise anatomical evidence is essential when evaluating the value of ABR.

REFERENCES


