J Am Acad Audiol 19:564–570 (2008)

The Importance of Audiologic Red Flags in Patient Management Decisions

DOI: 10.3766/jaaa.19.7.6

David A. Zapala*
Kathryn Shaughnessy†
Jill Buckingham*
David B. Hawkins*

Abstract

Background: It is essential that nonbenign forms of hearing impairment are recognized and addressed before audiological management is entertained.

Purpose: To present an illustrative case and focused literature review of early red flag indicators for retrocochlear impairment, as might be discerned from a patient's history or physical examination.

Results: The presenting history and clinical course of a female patient with fatal adenocarcinoma presenting as a suspected retrocochlear mass is reviewed over the last four months of her life. Clinical signs, symptoms and test results pointing to the diagnosis of ''acoustic neuroma'' and then ''metastatic neoplasm'' are reviewed along with selected supporting reference literature. The ambiguous clinical pictures at various points in her history are analyzed, with an effort to point out how early audiological decisions may significantly impact patient's overall health.

Conclusions: Clear communication with primary care physicians, vigilance when audiological results are ambiguous for active disease, and pre-established referral relationships with practitioners in the neurologic and otologic disciplines are stressed as important requirements for audiologists who serve as entry points into hearing healthcare.

Key Words: Cerebellopontine angle, cranial nerves, retrocochlear

Abbreviations: ABR = auditory brainstem response; CN = cranial nerve; CPA = cerebellopontine angle; OAE = otoacoustic emission

Sumario

Antecedentes: Es esencial que las forma no benignas de trastorno auditivo sean reconocidas y enfrentadas antes de la realización del manejo audiológico.

Propósito: Presentar un caso ilustrativo y una revisión de la literatura concentrada en los indicadores tempranos de alerta de trastornos retrococleares, conforme puedan discernirse de la historia del paciente o su examen físico.

Resultados: La historia y el curso clínico de una paciente femenina con un adenocarcinoma fatal, que se presentó como una sospecha de masa retrococlear se revisa en los últimos cuatro meses de su vida. Se revisaron los signos y síntomas clínicos y los resultados de los exámenes apuntaban al diagnóstico de ''neurinoma del acústico'' y luego de ''neoplasia metastásica'', apoyados en referencias seleccionadas de la literatura. El cuadro clínico ambiguo en varios puntos de su historia fue analizado, en un esfuerzo por destacar cómo decisiones audiológicas tempranas pueden impactar significativamente la salud global del paciente.

Conclusiones: Una comunicación clara con el médico de atención primaria, vigilancia cuando los resultados audiológicos son ambiguos para una enfermedad activa, y relaciones pre-establecidas de referencia con especialistas de las disciplinas neurológicas y otológicas se enfatizan como requisitos importantes para los audiólogos, que sirvan como puntos de entrada al cuidado de la salud auditiva.

*Mayo Clinic Florida; †University of Memphis

David A. Zapala, Ph.D., Audiology Section, Mayo Clinic Florida, 4500 San Pablo Rd., Jacksonville, FL 32224; Phone: (904) 953-0468; Fax: (904) 953-2489; E-mail: Zapala.David@mayo.edu

Palabras Clave: Ángulo pontocerebeloso, nervios craneales, retrococlear

Abreviaturas: ABR = respuesta auditiva del tallo cerebral; CN = nervio craneal; CPA = ángulo pontocerebeloso, OAE, emisión otoacústica

Students in audiology are constantly reminded about the importance of detecting retrocochlear problems. The case described in this report demonstrates the importance of early detection in helping to manage patients and their well-being. We have found this case to be useful for audiologists and Au.D. students to review the various "red flags" and to show how audiologic decisions can affect a patient's overall health care.

Audiologists have two critical responsibilities. First, audiologists are responsible for developing evidence that distinguishes between benign and nonbenign forms of hearing impairment as part of a comprehensive audiologic evaluation. By analyzing data such as pure-tone asymmetries, word-recognition scores, acoustic reflex thresholds and decay, auditory brainstem responses (ABRs), otoacoustic emissions (OAEs), electrocochleography, and the vestibular battery (computerized dynamic posturography, electronystagmography or videonystagmography, rotary chair, and vestibular evoked myogenic potentials), the audiologist can make a valuable contribution to the diagnostic decisions concerning auditory and vestibular pathologies. Second, audiologists are trained to treat medically benign hearing impairment (or nonbenign conditions in conjunction with treating physicians) using discipline-specific audiologic management methods. These methods include approaches such as hearing aids, cochlear implants, assistive listening devices, tinnitus treatment, and aural rehabilitation. It is essential, however, that nonbenign forms of hearing impairment are recognized and addressed before other audiologic management plans are entertained. This case highlights many of the red flag conditions that would prompt medical referral for a potentially nonbenign condition.

CASE STUDY

The patient's case history, not the audiologic findings, is the focus of this article, as it gives clues as to the nature of the problem and the progression of a variety of symptoms. The patient was a 56-year-old female who was referred to the Mayo Clinic Florida for evaluation of auditory, vestibular, and visual difficulties. She had been followed by her primary care physician and her gynecologist as a long-term uterine cancer survivor who had a total abdominal hysterectomy 23 years prior and had received multiple radiation treatments. The patient reported having difficulty with her left ear 12 years earlier, with the initial symptom being fluctuating unilateral tinnitus. Three years later, she became aware of decreasing hearing in the left ear. Over the next two years, she noticed increasing difficulty understanding speech in group situations. She reported receiving a hearing test around this time but could not remember specifics other than being told she "had a hearing loss" and "nothing could be done." No further testing or follow-up was recommended or discussed, by the patient's recollection.

The patient did not experience any other new symptoms over the next seven years until two months prior to presentation at the Mayo Clinic, when she awoke one morning with blurred vision. She began experiencing horizontal diplopia and had difficulty reading and driving.[1] She scheduled an ophthalmology evaluation, which occurred within three weeks of the onset of the blurred vision. The ophthalmology evaluation demonstrated normal visual acuity bilaterally. However, a small left hypertropia on left gaze was observed.[2] A computed tomography (CT) scan was scheduled for the following week. The CT scan revealed a 3 cm left cerebellopontine angle (CPA) tumor, with the radiology report stating the tumor was "most likely an acoustic neuroma." As a result of the tumor, the patient was referred to Mayo Clinic Florida for neurosurgery.

In the three weeks between her CT scan and her appointment at Mayo Clinic, the patient began to develop several new symptoms. She began experiencing severe nausea and true vertigo. She could no longer lie flat on her back without provoking these symptoms. Walking had become a dangerous activity, and she began to fall on a daily basis. She sustained several bruises on her face from these accidents. Her visual disturbances increased, resulting in constant diplopia, blurred vision, and poor depth perception.

The patient's first appointment at Mayo Clinic was a consult with neurosurgery. During this examination it was discovered that the patient had partial IVth (trochlear) and VIth (abducens) nerve palsy but normal facial sensation. She presented with bilateral gaze nystagmus and a very wide, ataxic gate. The neurosurgery impression was that the large CPA mass was the source of the patient's symptoms. A surgery plan for a suboccipital craniotomy with resection of the left CPA tumor was entertained, and a magnetic resonance imaging (MRI) study was ordered for verification of the diagnosis.

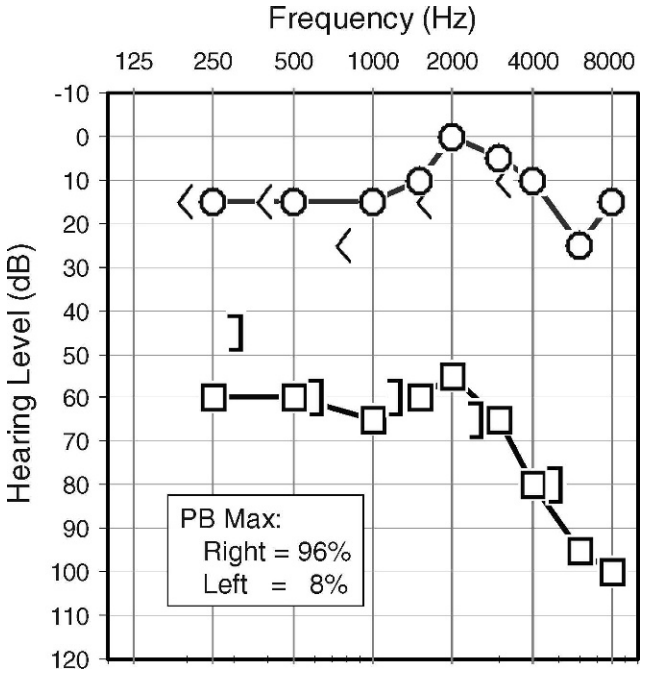

Figure 1. Audiologic findings showing moderate to severe sensorineural hearing loss with poor word recognition on the left.

Following this appointment, the patient was seen in the audiology department. Figure 1 shows the results of the audiologic evaluation. Hearing sensitivity in the right ear was largely within normal limits, and the left ear showed a moderate sloping to profound sensorineural hearing loss. Word recognition was good (96%) in the right ear and very poor (8%) in the left ear. Immittance testing revealed normal, type "A" tympanograms bilaterally, but only right ipsilateral reflexes were present. The abnormally reduced word-recognition score and the absent reflexes in the left ear were consistent with retrocochlear rather than cochlear involvement. Due to the radiological evidence of a left CPA tumor and the degree of hearing loss in the left ear, no further special audiologic testing (such as ABR, OAE, etc.) was deemed necessary for diagnostic purposes.

An otology consult resulted in the following diagnosis: left CPA lesion, causing mass effect and cranial neuropathies with diplopia. Surgery was scheduled for the following day, pending the preoperative test results.

The radiology scans were processed later that day and revealed multiple lung masses. There were pulmonary nodules (largest measured 5.5 cm) at the left lung base, pulmonary nodules (largest measured 6.5 cm) in the right lung base, and bilateral adrenal metastases. A biopsy performed later that week was positive for malignancy, metastasis from a gynecologic primary.

The MRI scan also revealed multiple cerebellar masses. The left CPA mass (3.8 × 3.2 × 2.8 cm) can be seen in Figure 2. Along with the CPA mass, a right paramedian posterior parietal lesion, an anterior-inferior right posterior fossa lesion, and a lesion on the superior aspect of the right cerebellar vermis were also present.

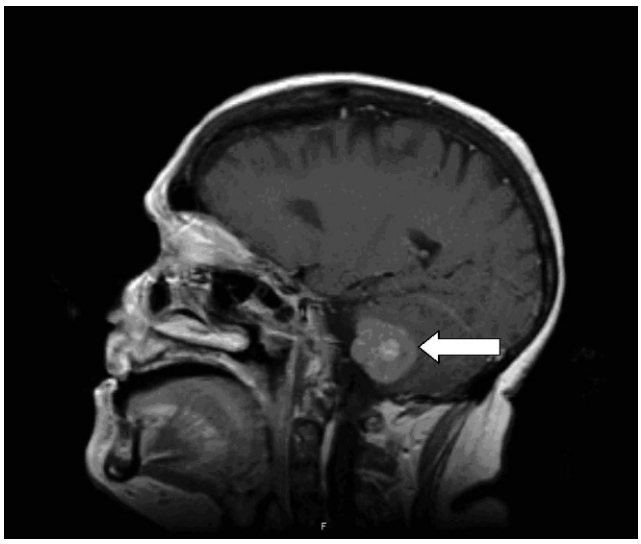

Figure 2. Gadolinium contrast-enhanced T2-weighted MRI of the head, parasaggittal plane. Mass in the area of the cerebellopontine angle (see arrow) was initially mistaken for a vestibular schwannoma (acoustic neuroma) on an earlier CT scan.

In light of these findings, the surgery was cancelled, and the patient was referred for a hematology/oncology consultation. The diagnosis was stage 4 metastatic cancer with a very poor prognosis. The patient decided on chemotherapy rather than surgery as her treatment option.

Three and a half months following her visit and the stage 4 diagnosis, the patient died. Her cause of death was documented as multisystem failure as a result of metastatic adenocarcinoma.

DISCUSSION

This case is instructive on several levels. First, it highlights many of the red flag conditions that would prompt medical referral for a potentially nonbenign condition. Second, it demonstrates how early detection of various pathologies might influence other health care decisions.

Clinical Manifestation of CPA Tumors

The following is a list of symptoms commonly associated with acoustic tumor (vestibular schwannoma), facial nerve schwannoma, or other tumors of the internal auditory canal and adjacent CPA:

Unilateral or asymmetric sensorineural hearing loss, typically gradually progressive but may be suddenly developing. In numerous studies, hearing loss is the most common clinical symptom of CPA tumor, regardless of tumor size (Johnson, 1977; Selesnick et al, 1993; Dornhoffer et al, 1994; Berrettini et al, 1996; Matthies and Samii, 1997; Stipkovits et al, 1998; Myrseth et al, 2006; Myrseth et al, 2007). The incidence of unilateral

or asymmetrical hearing loss varies according to study, ranging from 67 to 95 percent of cases (Johnson, 1977; Dauman et al, 1987; Dornhoffer et al, 1994; Rosenberg, 2000; Myrseth et al, 2006; Myrseth et al, 2007). Sudden hearing loss has been documented as a presenting symptom in 5 to 16 percent of patients with CPA lesions (Hirsch and Anderson, 1980; Pensak et al, 1985; Dauman et al, 1987; Harder, 1988; Moffat et al, 1994; Matthies and Samii, 1997; Rosenberg, 2000).

Unilateral or asymmetric tinnitus. Tinnitus is often reported as the second most common clinical symptom of CPA lesion, cited as affecting 56 to 76 percent of cases (Selesnick et al, 1993; Dornhoffer et al, 1994; Berrettini et al, 1996; Matthies and Samii, 1997; Myrseth et al, 2006; Myrseth et al, 2007). For instance, Selesnick, Jackler, and Pitts (1993) report a 56 percent incidence of unilateral tinnitus in a group of 126 consecutive patients with acoustic neuroma.

Unilateral aural fullness, pressure, "stuffed-up ear," or "distorted hearing." Although it is less commonly documented than other clinical symptoms, at least one study recorded the incidence of aural pressure or fullness among patients with CPA lesions. A study by Rosenberg (2000) followed 80 patients with acoustic neuroma who did not opt for surgical treatment. This group reported an incidence of aural fullness of 5 percent. In a second group of 49 acoustic neuroma patients who opted for surgical resection of their tumors, 4 percent reported aural fullness.

Progressive diminution in vestibular function, typically manifested as a progressive loss of balance. Vestibular symptoms in VIIIth nerve tumor patients are difficult to generalize across studies due to the differing definitions researchers may use to document such complaints as vertigo, dizziness, unsteadiness, or general imbalance. In a study of 78 patients with tumors of the cerebellopontine angle, Harder (1988) reports 63 percent of patients had vestibular complaints. Of these, 41 percent reported continuous dizziness, 10 percent reported intermittent dizziness, and 12 percent reported vertigo. Matthies and Samii (1997) report on the clinical symptoms of 962 patients with 1000 confirmed vestibular schwannomas. Of these 962 patients, 61 percent presented with vestibular symptoms. Whereas 31 percent of patients complained of only one symptom, 30 percent reported a combination of dizziness, unsteadiness, and vertigo. Furthermore, 44 percent classified these symptoms as constant or progressive in nature. Myrseth and colleagues (2006) report a 41 percent incidence of vertigo and 39 percent incidence of unsteadiness in 199 patients with vestibular schwannoma. Myrseth and colleagues (2007), in a study of 301 vestibular schwannoma patients, report vertigo in 43 percent and unsteadiness in 12 percent. It is unclear whether these two study populations were independent of each other. In a population of 80 patients with nonsurgically treated acoustic neuromas, Rosenberg (2000) documented a 20 percent occurrence of imbalance and a 16 percent occurrence of vertigo. In a population of 49 patients who pursued surgical options for acoustic neuroma, 37 percent reported imbalance.

Unilateral numbness of the face or facial animation asymmetry, possibly indicating early cranial nerve VII involvement. Facial nerve symptoms vary by definition and study, ranging from 4.1 to 13 percent of patients and described as "facial nerve symptoms," "facial numbness," "impaired sensation of the face," or "facial weakness" (Selesnick et al, 1993; Matthies and Samii, 1997; Rosenberg, 2000; Myrseth et al, 2006; Myrseth et al, 2007). In addition, impaired taste ability has been cited in 5 percent of patients with CPA growths (Myrseth et al, 2006; Myrseth et al, 2007).

Diplopia. Double vision has been reported by 1.8 to 3 percent of patients (Selesnick et al, 1993; Matthies and Samii, 1997). Diplopia, in this case, would represent cranial nerve VI involvement as the tumor begins to emerge from the internal auditory canal into the CPA.

The case study patient demonstrated all of the above symptoms except for transient numbness of the face. When the tumor reaches the cerebellum and pons, the following symptoms typically begin to emerge (Kaplan, 1951; National Institutes of Health, 1991):

- Headache
- Staggering or ataxic gait
- Cerebellar signs (dysmetria)
- Compressive cranial neuropathies
  - Cranial nerve (CN) V (trigeminal): facial pain, numbness, corneal insensitivity
  - CN VI (abducens): horizontal diplopia
  - CN VII (facial): unilateral facial spasm, weakness, or paralysis
  - CN IX (glossopharyngeal), CN X (vagus), and CN XI (accessory): difficulty speaking, swallowing, phonating; unilateral loss of neck or shoulder strength
- Contralateral hemiparesis
- Nystagmus (often Brun's type of gaze-evoked nystagmus)
- Nausea, vomiting, lethargy
- Hydrocephalus (excessive accumulation of cerebrospinal fluid in the brain) and papilledema (swelling of the optic disc) with increased intracranial pressure
- Coma, respiratory depression, and death

In following this patient's course through the last six months of her life, many of these symptoms were observed.

Audiologists typically approach the task of distinguishing between cochlear and retrocochlear involvement based on audiologic test data. This is an important

strategy whenever retrocochlear involvement is a possibility. Audiologic test abnormalities are among the first signs of CPA tumor, and these tests have measurable sensitivity and specificity. For the most part, the likelihood of being correct or incorrect is known.

It is important to recognize that while the audiovestibular test battery is successful in identifying many anomalies, some lesions of the CPA present with no accompanying symptoms. Clemis and Mastricola (1976) report that in 118 patients with surgically confirmed acoustic neuromas, 11 percent had no audiologic signs. Hirsch and Anderson (1980) report that 28 of 96 patients with acoustic neuroma illustrated normal hearing thresholds, and Selesnick, Jackler, and Pitts (1993) report two patients of 126 as asymptomatic.

Other tumors of the CPA, most commonly meningiomas, present symptoms based on their location. When the nerves of the internal auditory canal are involved, symptoms similar to vestibular schwannoma may evolve. However, large lesions in the CPA can exist with only minimal auditory signs. The presence of an unexplained unilateral hearing loss or hearing asymmetry is the most common symptom reported in CPA tumors affecting the vestibulocochlear nerve.

It stands to reason that unexplained hearing asymmetry with other audiologic signs of retrocochlear involvement, coupled with normal cranial nerve and neurologic function, increase the likelihood of a lesion in the internal auditory canal. The audiologic signs of retrocochlear involvement are well known to the audiologist. They include unexpectedly poor word recognition (Clemis and Matricola, 1976; Johnson, 1977; Thomsen et al, 1981), rollover in word-recognition performance (Jerger and Jerger, 1971; van Dijk et al, 2000), elevated acoustic reflex thresholds, abnormal acoustic reflex decay (Johnson, 1977; Hirsch and Anderson, 1980; Dauman et al, 1987; Harder, 1988; Godey et al, 1998), and abnormal auditory brainstem responses (Harder, 1988; Gordon and Cohen, 1995; Godey et al, 1998; Schmitt et al, 2001; Don et al, 2005).

It also stands to reason that unexplained hearing loss in the setting of abnormal function in the cranial nerves adjacent to the vestibular cochlear complex or other signs of impairment in the CPA increase the likelihood of CPA neoplasm (Astor et al, 1997). Many of the nonauditory signs and symptoms of a CPA tumor are heuristically based and require a careful history and focused physical examination to recognize. Both formal audiologic testing and a careful history and physical examination are necessary to develop evidence for or against retrocochlear or neurologic conditions associated with hearing loss. Regardless of whether the evidence for retrocochlear involvement is auditory or cranial nerve based, patients self-referring for audiologic management of hearing loss with retrocochlear symptoms would be properly referred for medical assessment and management.

But what of the case where an unexplained asymmetry in hearing is detected without co-occurring signs of otologic or neurologic dysfunction? What is the risk of retrocochlear involvement? This patient demonstrated an asymmetric hearing loss and fluctuating unilateral tinnitus 11 years prior to the discovery of the CPA tumor. Were these two symptoms heralding the development of a CPA neoplasm? Asymmetric hearing loss is a common and predominant symptom of retrocochlear lesion. However, its importance as a marker for retrocochlear disease is controversial (Margolis and Saly, forthcoming). The problem is that asymmetric hearing loss is a common occurrence in patients without retrocochlear involvement. There is no clear definition for asymmetric hearing loss that accurately distinguishes retrocochlear from non-retrocochlear cases (Fisher et al, 1994; Schlauch et al, 1995; Urben et al, 1999). As an isolated finding, then, does asymmetric hearing loss warrant medical referral? Consider this case again.

Uterine adenocarcinoma accounts for approximately 15 percent of vaginal cancers (National Cancer Institute, 2007). The disease has a predilection for pulmonary metastases and supraclavicular and pelvic node involvement. Survival rates at five and 10 years depend on the stage and location of the disease. Importantly, while most recurrences occur within three years, recurrences after over 20 years have been reported (Russell et al, 2004). A question that cannot be answered in this case is whether earlier detection of the CPA tumor might have led to the discovery of the beginning stages of the metastatic cancer. If the audiologic red flags of unilateral tinnitus and asymmetric hearing loss had triggered further audiologic testing (e.g., acoustic reflexes, ABR), perhaps an MRI would have been initiated and early cancer might have been detected.

On the other hand, we cannot be certain that the asymmetric hearing loss and tinnitus had a benign presentation at the time of evaluation. We were unable to obtain any documentation of the patient's prior hearing test due to the rapid evolution of symptoms and the immediate needs of the family. Nevertheless, if the hearing loss was an isolated finding, meaning that audiologic tests, case history, physical examination information, and perhaps even an MRI did not raise the suspicion of retrocochlear involvement, what would have been the ideal management plan for this patient? We would argue that the risk of clinically silent retrocochlear involvement should remain a consideration whenever a patient presents with unexplained unilateral hearing loss with or without co-occurring otologic or neurologic symptoms. At a minimum, monitoring for progression of hearing loss, tinnitus, or neurologic symptoms would be important.

So what would an optimal treatment plan have been for this patient? First, recognizing the ambiguity of an unexplained unilateral hearing loss and tinnitus presentation, communication with the patient's primary care provider would be the obvious first step. The patient's "medical home" is where information from all specialists should converge so that the "whole picture" can be developed by the practitioner with the closest relationship to the patient. A patient or an audiologist may not recognize the relationship between the hearing loss and "cured cancer." However, the primary care provider is in a position to recognize the relationship and be vigilant for other problematic signs and symptoms.

Certainly, if this patient had not seen an otolaryngologist during that first hearing evaluation, such a referral would have been an obvious recommendation. If this patient's initial hearing evaluation was the result of a self-referral to an audiologist, it would fall to the audiologist to make sure that there was good communication with the patient's primary care provider, stressing the importance of follow-up surveillance for progressive hearing loss as well as recommendation for otolaryngology referral.

Red Flags in the Audiologic Evaluation

In this article, we have reviewed some of the symptoms or observations that would constitute red flags in an audiologic evaluation and prompt medical referral. Moreover, any unstable (fluctuating) or unilaterally progressive auditory or ear-related symptom must first be considered within the context of disease.

An audiologist might believe, perhaps rightly so, that monitoring for retrocochlear processes falls to the treating physician, particularly when audiologic tests are performed in a physician's offices. Further, audiologists might perceive that their role consists of documenting the results of an audiologic evaluation through an audiogram and perhaps a letter to the patient's physician describing the test results from an audiologic perspective, that is, patient is or is not a hearing aid candidate. Certainly, there is historical precedence for this approach in several healthcare settings. However, as audiology emerges as an entry point for hearing-related health care, we must remain vigilant for conditions and symptoms that, although rare, are not benign. Sometimes, the evidence for increased risk of a nonbenign hearing loss is found in the case history or physical examination and not in isolated audiologic test results. We argue that, from an audiologic perspective, any unexplained asymmetry in hearing or tinnitus should be considered a possible indication of an otologic or neurologic disease regardless of any additional audiologic test result. If a self-referred patient were to present with this history, audiologists would be well advised to initiate a medical referral.

Symptoms of otologic disease are well known by audiologists. They include unexplained hearing loss (typically unilateral, progressive, or fluctuating), aural pain (otalgia), aural pressure, aural fullness, unilateral tinnitus, dizziness, and imbalance. Certainly signs of active otologic disease such as conductive hearing loss, otorrhea, middle ear effusion, and so on also warrant medical referral. Common symptoms pointing to the neural axis include cranial nerve deficits beyond CN VIII (auditory) and, in particular, the "five D's" of vertebral basilar artery insufficiency. The five D's include *D*izziness, *D*iplopia, *D*ysphagia, *D*ysarthria, and other *D*isturbances of the sensory or motor system such as limb ataxia. The five D's are a common mnemonic in medicine (see, e.g., Ruckenstein, 1995; Solomon, 2000). They serve as a useful reminder to look for other symptoms referable to the brain stem or cerebellum, as these structures receive their blood supply from the vertebral basilar artery system. The presence of two or more D's increases the risk of retrocochlear involvement.

Three simple recommendations seem warranted. First, audiologists should always be vigilant in detecting the red flags presented during the case history and evaluation. Second, reports and other communications with physicians should explicitly indicate when these flags are detected and that they raise the possibility of nonbenign conditions. Finally, audiologists should establish referral patterns within their own community to direct self-referring patients with potentially nonbenign ear or neurologic disease for primary care, otologic, or neurologic management as appropriate. Students benefit from exposure to these principles early in their training.

NOTES

1. Horizontal diplopia is the perception of double vision (diplopia) with two identical visual images set side by side (horizontally). Horizontal diplopia typically implies weakness in one of the medial or lateral rectus muscles of the eye. In this case, the presence of horizontal diplopia was likely the result of cranial nerve VI (abducens nerve) palsy. The abducens nerve emerges from the cerebellopontine angle, just medial to cranial nerve VII (facial nerve).

2. Hypertropia means that the axis of the eye is elevated upward. In this case, the left lateral rectus muscle was weak (from the underlying developing abducens nerve palsy), resulting in lack of muscle drive when the eyes were deviated toward the lesion. As a result, the vertically oriented eye muscles displaced the eye upward when lateral gaze was attempted. Both this observation and the observation of a slight proptosis (bulging eye) were mentioned on the outside ophthalmology report. They were not subsequently noted when the patient was seen at the clinic. Most likely, this was because her symptoms had progressed such that her gaze nystagmus and saccadic deficits became more apparent.

REFERENCES

Astor FC, Lechtenberg CL, Banks RD, et al. (1997) Proposed algorithm to aid the diagnosis of cerebellopontine angle tumors. *South Med J* 90(5):514–517.

Berrettini S, Ravecca F, Sellari-Franceschini S, et al. (1996) Acoustic neuroma: correlations between morphology and otoneurological manifestations. *J Neurol Sci* 144(1–2):24–33.

Clemis JD, Mastricola PG. (1976) Special audiometric test battery in 121 proved acoustic tumors. *Arch Otolaryngol Head Neck Surg* 102:654–656.

Dauman R, Aran JM, Portmann M. (1987) Stapedius reflex and cerebellopontine angle tumors. *Clin Otolaryngol* 12(2):119–123.

Don M, Kwong B, Tanaka C, et al. (2005) The stacked ABR: a sensitive and specific screening tool for detecting small acoustic tumors. *Audiol Neurootol* 10(5):274–290.

Dornhoffer JL, Helms J, Hoehmann DH. (1994) Presentation and diagnosis of small acoustic tumors. *Arch Otolaryngol Head Neck Surg* 111(3):232–235.

Fisher EW, Parikh AA, Harcourt JP, Wright A. (1994) The burden of screening for acoustic neuroma: asymmetric otological symptoms in the ENT clinic. *Clin Otolaryngol* 19:19–21.

Godey B, Morandi X, Beust L, et al. (1998) Sensitivity of the auditory brainstem response in acoustic neuroma screening. *Acta Otolaryngol* 118:501–504.

Gordon ML, Cohen NL. (1995) Efficacy of auditory brain stem response as a screening test for small acoustic neuromas. *Am J Otolaryngol* 16:136–139.

Harder H. (1988) Audiovestibular tests in the diagnosis of cerebellopontine angle tumors. *Acta Otolaryngol Suppl* 452: 5–11.

Hirsch A, Anderson H. (1980) Audiologic test results in 96 patients with tumors affecting the eighth nerve. *Acta Otolaryngol Suppl* 369:1–26.

Jerger J, Jerger S. (1971) Diagnostic significance of PB word functions. *Arch Otolaryngol Head Neck Surg* 93:573–580.

Johnson EW. (1977) Auditory test results in 500 cases of acoustic neuroma. *Arch Otolaryngol Head Neck Surg* 103:152–158.

Kaplan A. (1951) Pathology of the brain and spinal cord. *Clin Symp* 3(3):97–104.

Margolis RH, Saly GL. (2008) Asymmetric hearing loss: definition, validation, and prevalence. *Otol Neurotol.*

Matthies C, Samii M. (1997) Management of 1000 vestibular schwannomas (acoustic neuromas): clinical presentation. *Neurosurgery* 40(1):1–9.

Moffat DA, Baguley DM, von Blumenthal H, et al. (1994) Sudden deafness in vestibular schwannoma. *J Laryngol Otol* 108(2):116–119.

Myrseth E, Moller P, Wentzel-Larsen T, et al. (2006) Untreated vestibular schwannomas: vertigo is a powerful predictor for health-related quality of life. *Neurosurgery* 59(11):67–76.

Myrseth E, Pedersen PH, Moller P, Lund-Johnson M. (2007) Treatment of vestibular schwannomas. Why, when and how? *Acta Neurochir (Wien)* 149:647–660.

National Cancer Institute. (2007) Vaginal cancer treatment (PDQ®). Retrieved October 13, 2007, from www.cancer.gov/cancertopics/pdq/treatment/vaginal/healthprofessional#Reference1.3.

National Institutes of Health. (1991) Acoustic Neuroma. NIH Consens Statement Online Dec 11–13; 9(4):1–24.

Pensak ML, Glasscock ME, Josey AF, et al. (1985) Sudden hearing loss and cerebellopontine angle tumors. *Laryngoscope* 95: 1188–1193.

Rosenberg S. (2000) Natural history of acoustic neuromas. *Laryngoscope* 110:497–508.

Ruckenstein MJ. (1995) A practical approach to dizziness. Questions to bring vertigo and other causes into focus. *Postgrad Med* 97(3):70–7275–78, 81.

Russell AH, Seiden MV, Duska LR, Goodman AK, Lee SI, Digumarthy SR, Fuller AF. (2004) Cancers of the cervix, vagina, and vulva. In: Abeloff MD, Armitage JO, Niederhuber JE, Kastan MB, McKenna WG, eds. *Clinical Oncology*. 3rd ed. Philadelphia: Elsevier Churchill Livingstone.

Schlauch RS, Levine S, Li Y, Haines S. (1995) Evaluating hearing threshold differences between ears as a screen for acoustic neuroma. *J Speech Hear Res* 38:1168–1175.

Schmitt RJ, Sataloff RT, Newman J, et al. (2001) The sensitivity of auditory brainstem response testing for the diagnosis of acoustic neuromas. *Arch Otolaryngol Head Neck Surg* 127(1):19–22.

Selesnick SH, Jackler RK, Pitts LW. (1993) The changing clinical presentation of acoustic tumors in the MRI era. *Laryngoscope* 103:431–436.

Solomon D. (2000) Distinguishing and treating causes of central vertigo. *Otolaryngol Clin North Am* 33(3):579–601.

Stipkovits EM, van Dijk JE, Graamans K. (1998) Profile of hearing in patients with unilateral acoustic neuromas: the importance of the contralateral ear. *Am J Otolaryngol* 19(6):834–839.

Thomsen J, Nyboe J, Borum P, et al. (1981) Acoustic neuromas: diagnostic efficacy of various test combinations. *Arch Otolaryngol Head Neck Surg* 107:601–607.

Urben SL, Benninger MS, Gibbons ND. (1999) Asymmetric sensorineural hearing loss in a community-based population. *Arch Otolaryngol Head Neck Surg* 120:809–814.

van Dijk JE, Duijndam J, Graamans K. (2000) Acoustic neuroma: deterioration of speech discrimination related to thresholds in pure-tone audiometry. *Acta Otolaryngol* 120:627–632.