Brainstem auditory evoked response

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Policy contains: Auditory brainstem response; auditory neuropathy; evoked responses; hearing loss.

This policy is a Sandhills Center Clinical Coverage Policy adopted from AmeriHealth Caritas of North Carolina. These clinical policies are used to assist with making coverage determinations. Sandhills Center's clinical policies are based on guidelines from established industry sources, such as the Centers for Medicare & Medicaid Services (CMS), state regulatory agencies, the American Medical Association (AMA), medical specialty professional societies, and peer-reviewed professional literature. These clinical policies along with other sources, such as plan benefits and state and federal laws and regulatory requirements, including any state- or plan-specific definition of "medically necessary," and the specific facts of the particular situation are considered by Sandhills Center when making coverage determinations. In the event of conflict between this clinical policy and plan benefits and/or state or federal laws and/or regulatory requirements, the plan benefits and/or state and federal laws and/or regulatory requirements shall control. Sandhills Center clinical policies are for informational purposes only and not intended as medical advice or to direct treatment. Physicians and other health care providers are solely responsible for the treatment decisions for their patients. Sandhills Center's clinical policies are reflective of evidence-based medicine at the time of review. As medical science evolves, Sandhills Center will update its clinical policies as necessary. Sandhills Center clinical policies are not guarantees of payment.

Coverage policy

Brainstem auditory evoked response is clinically proven and, therefore, medically necessary as a primary (first-line) test when any of the following criteria are met (American Academy of Audiology, 2020; American Academy of Family Physicians, 2013; Ptok, 2011; The Joint Committee on Hearing, 2019):

- For initial screening for hearing loss in newborns (using limited auditory evoked potentials only).
- To assess infants and children under age 5 years for hearing loss, for one of the following conditions:
  - When pure tone screening is not developmentally appropriate (ability levels less than 36 months).
  - When the member passed neonatal hearing screening, but is at risk of having sensorineural hearing loss.
  - When the member did not pass the initial hearing screening and requires diagnostic confirmation of a hearing disorder.
- To assess infants and children suspected of having a hearing disorder when either:
  - Behavioral audiometry is not reliable.
  - Ear-specific thresholds cannot be obtained.
  - Results from other tests are inconclusive regarding the type, degree, or configuration of hearing levels.
- To assess suspected hearing disorders in individuals of any age who are unable to cooperate in other methods of hearing testing (e.g., behavioral audiometry).
- To assess acoustic neuroma in patients for whom magnetic resonance imaging is contraindicated or results are equivocal (Stachler, 2012; American College of Radiology, 2018).

- To determine the degree and configuration of hearing deficiency in each ear for the fitting of amplification devices using frequency-specific brainstem auditory evoked response testing in persons with a permanent hearing deficit.
- To assess the auditory system through the level of the brainstem when its neurological integrity is in question.

Brainstem auditory evoked response is clinically proven and, therefore, medically necessary when primary (standard) testing fails to provide a diagnosis for any of the following clinical conditions (American Academy of Pediatrics, 2007; American Society of Neurophysiological Monitoring, 2021):

- Cerebellopontine angle lesions (acoustic neuromas).
- Demyelinating disease, such as multiple sclerosis.
- Chiari malformation and syringomyelia.
- Asymmetric hearing loss.
- Unilateral tinnitus.
- Sudden hearing loss.
- Functional hearing loss.
- Ototoxic drug therapy monitoring, including chemotherapy or antibiotics.
- Auditory neuropathy.
- Preoperative baseline: posterior fossa surgery or cochlear implant.
- Postoperative testing for cochlear implant.

Limitations

All other uses of brainstem auditory evoked response are not medically necessary.

Alternative covered services

- Acoustic immittance measures.
- Conventional and high-frequency audiometry.
- Electrocochleography.
- Electroencephalography.
- Electromyography.
- Gadolinium-enhanced magnetic resonance imaging.
- Motor-evoked potentials.
- Otoacoustic emissions testing.
- Somatosensory-evoked potentials.
- Speech recognition tests.
- Tympanometry.
- Visual-evoked potentials.

Background

Hearing loss is a major public health issue and is the third most common such affliction after arthritis and heart disease. According to the National Institute on Deafness and Other Communication Disorders (2016), an estimated two to three of every 1,000 children in the United States are born with a detectable level of hearing loss, and approximately 15% (37.5 million) of American adults report some degree of hearing loss, with the prevalence of reported hearing loss increasing with age.

A variety of tests can be used to identify and diagnose a hearing loss. The method used depends in part on the age and competency of the individual and clinical indication. Behavioral pure tone audiometry is the standard for hearing evaluation (Cunningham, 2003). Other tests include:

- Speech testing.
- Tests of the middle ear.
- Otoacoustic emissions.
- Brainstem auditory evoked response.

Brainstem auditory evoked response measures auditory nerve and auditory pathway structural integrity in the brainstem rather than central hearing deficits (Paulraj, 2015). The test involves placing electrodes on the scalp and earlobes and delivering auditory stimuli, such as tones or clicking noises, to one ear. The sound stimulation moves through the outer ear (canal), through the middle ear (tympanic membrane and ossicles) to the inner ear (cochlea), through the vestibular and eighth cranial nerve to the brain. The electrodes sense an electrical response from the brainstem. Auditory evoked potential response reflects the individual's hearing perception level.

The auditory evoked potential signal consists of reproducible positive or negative peaks, latency, and amplitude that correlate with underlying structural pathology (Paulraj, 2015). It does not require any attention or feedback response from the tested individual and would be suitable for persons who lack verbal communication and muscle movements. Brainstem auditory evoked response is also referred to as auditory brainstem response, auditory evoked response, auditory evoked potential, evoked auditory potential, brainstem auditory evoked potential, and brainstem evoked response audiometry.

Findings

There is a great deal of evidence regarding brainstem auditory evoked response, adding weight to decisions relative to clinical support and use of this technology. The preponderance of evidence of clinical effectiveness from systematic reviews and other high-quality analyses consists of several clinically important domains:

- Early childhood screening and diagnosis for hearing impairment.
- Diagnosing retrocochlear disease, specifically acoustic neuroma.
- Managing patients with Chiari malformation.
- Predicting outcomes in coma.

While the rationales for using brainstem auditory evoked response make it a potentially attractive option for many clinical indications, no systematic reviews were identified that would support other clinical uses. For other popular indications, namely, ototoxicity monitoring and intraoperative neuromonitoring, the evidence is confined to case series and anecdotes that suggest the feasibility of using brainstem auditory evoked response but are insufficient to determine diagnostic efficacy or impact on treatment management or patient outcomes.

Universal early childhood screening for hearing impairment

Because approximately half of the children with hearing loss have no identifiable risk factors, several professional societies recommend universal screening (as opposed to targeted screening) in newborns prior to hospital discharge and in young children to avoid delaying diagnosis beyond the age of language acquisition, which may result in life-long psychological and cognitive handicaps (American Academy of Family Physicians, 2013; American Academy of Pediatrics, 2007; Harlor, 2009).

Neonatal screening methods include a limited brainstem auditory evoked response test using a significantly low intensity level (35 to 40 dB) and otoacoustic emissions testing either alone or sequentially if the first test fails (Ptok, 2011). Infants who fail the first screening test are rescreened, and those who fail rescreening are referred

for additional outpatient testing and diagnostic evaluation. Diagnostic evaluation may consist of repeat otoacoustic emissions screenings, comprehensive diagnostic brainstem auditory evoked response testing, behavioral audiometry at an appropriate age, tympanometry, and otoscopy (Ptok, 2011).

Brainstem auditory evoked response and otoacoustic emissions screening tests have comparable sensitivities and specificities when employed individually or in combination as part of a screening protocol. Limited evidence suggests early intervention using either test is associated with positive developmental outcomes (New York State Department of Health Early Intervention Program, 2007; Wolff, 2010). One cost-effectiveness analysis found otoacoustic emissions testing at birth followed by repeat testing at follow-up demonstrated the lowest cost ($13 per infant) and had the lowest cost-effectiveness ratio — $5,100 per infant with hearing loss identified (Kezirian, 2001). Screening brainstem auditory evoked response test at birth with no screening test at follow-up showed greater effectiveness, but was associated with higher costs ($25 per infant) and a higher cost-effectiveness ratio ($9,500 per infant with hearing loss identified).

There is a lack of consensus among professional societies regarding the frequency of screening, the most appropriate tests for different age groups, and when brainstem auditory evoked response or otoacoustic emissions testing is appropriate outside of the screening setting (Ptok, 2011). The American Academy of Pediatrics Joint Committee on Infant Hearing (2007) recommends automated brainstem auditory evoked response technology as the only appropriate technique for screening infants in the neonatal intensive care unit. The American Academy of Pediatrics recommends otoacoustic emissions for children of any developmental age, and automated brainstem auditory evoked response testing for infants with a developmental age between birth and 9 months (Harlor, 2009). The American Academy of Audiology (2011) recommends otoacoustic emissions for preschool- and school-age children for whom pure tone screening is not developmentally appropriate (ability levels less than 3 years).

Either brainstem auditory evoked response or otoacoustic emissions testing is appropriate for making a confirmatory diagnosis of hearing disorders in infants and children (developmental age of birth to 36 months) who did not pass the initial screening test (American Academy of Pediatrics, 2007). When a permanent hearing deficit is detected, frequency-specific brainstem auditory evoked response testing is appropriate to determine the degree and configuration of hearing deficiency in each ear for fitting of amplification devices.

When there are risk indicators for neural hearing disorders, click-evoked brainstem auditory evoked response testing using both condensation and rarefaction single-polarity stimulus are needed to determine if a cochlear microphonic is present (American Academy of Pediatrics, 2007). Brainstem auditory evoked response is an appropriate test for children suspected of hearing loss with risk factors for hearing loss or who are being evaluated for amplification and are developmentally delayed or too young (under 5 months) for reliable conditioned behavioral testing procedures (New York State Department of Health, 2007).

Retrocochlear pathology

Retrocochlear diseases may involve the vestibulocochlear nerve, brainstem, or central nervous system. Among the most common pathologies affecting the vestibulocochlear nerve are vestibular schwannoma (also called acoustic neuromas, acoustic schwannoma, acoustic neuromas, and vestibular neurilemoma).

Brainstem auditory evoked response demonstrates high sensitivity and specificity for screening clinically suspected moderate to large vestibular schwannoma, but significantly lower values in patients with a low clinical suspicion for disease, particularly those with tumors less than 1 cm (Fortnum, 2009; Koors, 2013). Brainstem auditory evoked response failed to provide clinically useful results in patients with severe to profound hearing impairment — typically a hearing threshold greater than 70 dBHL at 4 kHz (Fortnum, 2009).

Magnetic resonance imaging is the method of choice for confirming diagnosis of retrocochlear pathology. However, brainstem auditory evoked response may have a role when magnetic resonance imaging is

contraindicated or its results are equivocal. Brainstem auditory evoked response and gadolinium-enhanced magnetic resonance imaging are used to discriminate among idiopathic, viral, and other causes of sensorineural hearing loss (American College of Radiology, 1996). The American Academy of Otolaryngology supports magnetic resonance imaging, brainstem auditory evoked response, or audiometric follow-up to evaluate adult patients with sudden sensorineural hearing loss for retrocochlear pathology, based on observational studies with a preponderance of benefit over harm, but identifying this pathology may not influence outcomes in all cases (Stachler, 2012). Therefore, brainstem auditory evoked response and follow-up audiometry would be acceptable alternatives for the initial follow-up of sudden sensorineural hearing loss in adults, as long as there is appropriate counseling about the limitations of these modalities.

Chiari malformations

Chiari malformations — also called Arnold-Chiari malformations — are structural defects in the cerebellum, which can block the flow of cerebrospinal fluid and cause a range of symptoms, including dizziness, muscle weakness, numbness, vision problems, headaches, and problems with balance and coordination (National Institute of Neurological Disorders and Stroke, 2014). Brainstem auditory evoked response has been proposed in patients with Chiari malformation or myelomeningocele to assess the degree of damage to the brainstem and predict which infants may go on to develop symptoms. No evidence-based guidelines were identified on this topic.

Predicting outcome in comatose patients

The American Academy of Neurology found insufficient evidence to support brainstem auditory and visual-evoked tests and event-related potential tests for prognosis in anoxic-ischemic encephalopathy (Wijdicks, 2006). Findings from a recent large case series of more than 100 subjects suggest brainstem auditory evoked response may be best suited to patients with massive hemispheric infarction to predict poor outcome (Zhang, 2011). Unfavorable electroencephalography patterns showed the highest sensitivity (96.3%, 95% confidence interval 86.2% to 99.4%), while bilateral absence of somatosensory evoked potentials (N20 component) and wave V showed the highest specificity (100%, 95% confidence interval 85.9% to 100%) and positive predictive value (100%, 95% confidence interval 80.8% to 100%), but these results require further confirmation.

Intraoperative neuromonitoring

Intraoperative neuromonitoring is performed to minimize neurological damage during surgery and to identify important neural structures in the operative field with the goal of avoiding and/or limiting significant postoperative impairments. The evidence is insufficient to support the clinical role of brainstem auditory evoked response in assessing hearing preservation during excision of vestibular schwannoma. The maintenance of waves I and V corresponds to the peripheral cochlear nerve and the inferior colliculus, respectively (Oh, 2012). While some evidence from surgical case series suggests preservation of waves I and V correlates with better postoperative hearing preservation rates, others have found poor hearing outcomes despite wave preservation. When actual changes are seen on brainstem auditory evoked response, the severity or presence of postoperative deficits cannot be predicted reliably. While such brainstem auditory evoked response waveform irregularities may alert the surgeon to potential cranial nerve damage, the evidence for affecting surgical decisions and patient outcomes is anecdotal.

There is no consensus on the exact alarm criteria of intraoperative brainstem auditory evoked response changes for intraoperative neural damage and subsequent postoperative hearing loss (Kim, 2013; Oh, 2012). Significant time delay inherent in signal averaging, the high prevalence of false-positive results, and the dependence on the individual's baseline results further limit the clinical utility of brainstem auditory evoked response. The auditory preservation rates of combined techniques that incorporate brainstem auditory evoked response do not yet approximate those of facial nerve preservation. Further efforts and investigations are needed to study and incorporate adjunctive Intraoperative neuromonitoring techniques such as brainstem auditory evoked response in an attempt to improve preservation of auditory function.

No evidence-based guidelines were identified that addressed the clinical use of brainstem auditory evoked response for intraoperative neuromonitoring. Brainstem auditory evoked response provides direct evidence of a change in function along the auditory pathway that may warrant the immediate attention of the surgical team (American Society of Neurophysiological Monitoring, 2019).

Ototoxicity monitoring

Common drugs such as aminoglycosides, chemotherapeutic agents, and heavy metals are known for their ototoxic potential. The goal of monitoring for ototoxicity is to identify cochlear dysfunction early in an effort to reduce or prevent further auditory damage.

No evidence-based guidelines were identified. There is little consensus on the optimal protocol for monitoring ototoxicity using objective measures, but the potential for brainstem auditory evoked response in this context is an active area of investigation (American Academy of Audiology, 2009). Otoacoustic emissions or brainstem auditory evoked response may be used to monitor for ototoxicity in children with limited attention spans and in patients who are unable to provide reliable behavioral data; brainstem auditory evoked response may be more appropriate than otoacoustic emissions for patients with abnormal middle ear function and baseline hearing loss greater than about 40 dB HL.

In 2015, a contemporary cohort study found no association between the wave component of brainstem auditory evoked response and cumulative lead values in 130 children with a history of low blood lead levels, suggesting that brainstem auditory evoked response may not be the most sensitive method in this population (Alvarenga, 2015). A narrative review noted that hypoacusis is the most prevalent sensory disability in the world and is amenable to effective hearing screening tests using electroencephalography technologies (Paulraj, 2015). Electroencephalography-based hearing threshold level determination is most suitable for persons who lack verbal communication and behavioral response to sound stimulation, while brainstem auditory evoked response reflects the auditory ability level of an individual. Systematic evaluation of electroencephalography hearing perception level may predict hearing loss in newborns, infants, and children.

Results of a case series (n = 46 participants) at a single institution found that intraoperative neuromonitoring and post-operative auditory brainstem response monitoring in patients who undergo vestibular schwannoma excision, suggest ongoing changes of auditory brainstem response quality and hearing function during and after surgery (Hummel, 2016a, 2016b). Both tests may be predictive of postoperative course and hearing outcome, and monitoring immediately after surgery may be able to identify patients at risk of a secondary hearing deterioration. It is unclear whether these results would affect intraoperative or post-operative decision-making, and these findings should be replicated in studies at other institutions before widespread use.

To improve identification of patients at high risk of vestibular schwannoma, a new systematic review and meta-analysis assessed the diagnostic accuracy of non-imaging screening protocols for patients presenting with asymmetrical sensorineural hearing loss and/or unilateral audiovestibular dysfunction (Hentschel, 2017). While more than 95% of magnetic resonance imaging tests are negative, non-imaging protocols, including those with brainstem auditory evoked response, were less accurate and would offer no improvement in patient selection.

In 2018, we added no new information to the policy. No policy changes are warranted.

In 2019, we identified no newly published, relevant literature to add to the policy. The policy ID was changed from CP# 09.01.06 to CCP.1109.

In 2020, we added two guidelines (American Academy of Audiology, 2020; American Academy of Pediatrics Joint Committee on Hearing, 2019), updated the revision date of the American College of Radiology guidance (2018), and deleted four citations from the references (Evans, 2017; Jacob, 2006; Mitchell, 2004; National Library of Medicine, 2017). The new information is consistent with the current policy, and no policy changes are warranted.

In 2021, we identified no new relevant literature to add to the policy.

References

On January 29, 2021, we searched PubMed and the databases of the Cochrane Library, the U.K. National Health Services Centre for Reviews and Dissemination, the Agency for Healthcare Research and Quality, and the Centers for Medicare & Medicaid Services. Search terms were “brainstem auditory evoked response,” “brainstem auditory evoked potentials,” “auditory brainstem response,” "evoked potentials, auditory" (MeSH), “retrocochlear,” “vestibular schwannoma,” “acoustic neuroma,” “Chiari malformation,” and “coma.” We included the best available evidence according to established evidence hierarchies (typically systematic reviews, meta-analyses, and full economic analyses, where available) and professional guidelines based on such evidence and clinical expertise.

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Policy updates

5/2014: initial review date and clinical policy effective date: 10/2014

5/2015: Policy references updated.

5/2016: Policy references updated.

5/2017: Policy references updated.

5/2018: Policy references updated.

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