Evoked Potentials

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Introduction

Evoked Potentials are electrophysiologic responses following a variety of stimuli to the nervous system. Sensory evoked potentials measure the electrical activity of a stimulation such as sight, sound or touch travel along the periphery to the brain. These signals are then transferred to a computer, where the signals are averaged, amplified and displayed. The major types of sensory evoked potentials are Visual Evoked Potentials (VEP), Brainstem Auditory Evoked Potentials (BAEP) and Somatosensory Evoked Potentials (SSEP). Recording from a specific muscle group following direct stimulation of the motor cortex that assesses the functional integrity of the pyramidal tract tests the Motor Evoked Potentials (MEP) [1, 2].

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The purpose of EP tests are as follows:

1. To help assess the function and integrity of the nervous system. This may be especially helpful in cases where patients have unclear levels of consciousness, such as in a comatose patient.
2. To aid in the diagnosis of nervous system lesions and abnormalities.
3. To assist in monitoring the progression or treatment of certain degenerative diseases.
4. To monitor brain activity and nerve signals during delicate spine and brain surgeries while under anesthesia.

Visual Evoked Potentials

The visual evoked potentials (VEPs) assess the function of the visual pathway from the retina to the occipital cortex. VEPs measure nerve conduction velocity starting from the optic nerve, optic chiasm and optic radiations to the occipital cortex. They are useful in detecting optic nerve functions but less likely to prove useful in assessing post-chiasmatic disorders. The reasoning behind the latter is because the axons from the nasal half of the retina decussate at the optic chiasm but not at the temporal axons, hence lesions involving the temporal axons and retrochiasmatic diseases will be missed. It should be noted that VEPs are useful for detecting an anterior

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visual conduction disturbance, but is not specific with regard to etiology. Therefore, clinical history and advanced imaging such as magnetic resonance imaging (MRI) is necessary to establish etiology [1].

VEPs stimuli use diffuse-light flash, checkerboard and grating patterns. Diffuse-light flash has been limited in its use to testing infants with poor visual acuity due to high variability when utilized. The checkerboard uses light and dark squares, while grating uses stripes of equal sizes and are presented as one image at a time on a computer screen [1].

VEPs waves are designated by using capital letters stating if the peak is positive (P) or negative (N) followed by a number which indicates the average peak latency for the particular wave, e.g. (P50) [1].

Brainstem Auditory Evoked Potential

Brainstem Auditory Evoked Potentials (BAEP) measure signals that are generated in response to sound stimuli through the ascending auditory pathway. BAEPs test the integrity of the cochlea, as it goes through the cochlear nerve, through the cochlear nucleus, superior olivary complex, medial lemniscus, to the inferior colliculus, in the midbrain on to the medial geniculate body and finally to the cortex. BAEPs are used to estimate or aid in the assessment of hearing loss. They also helps identify patients who might benefit from hearing aids and can be used as a screening test for acoustic neuroma an in multiple sclerosis [1].

For clinical purposes, the short-latency BAEP is generally used. The test can be performed with the patient under general anesthesia or sedation. This tells us that BAEPs are very resistant to alteration by anything other than the structural abnormality in the brainstem auditory pathway. The frequency of stimulation is in the range of 50–70 Hz. BAEPs activate the pathways in the brainstem that are ipsilateral to the side of click stimulation. However, disorders of the peripheral vestibular system do not affect BAEPs [1].

Somatosensory Evoked Potential

Somatosensory Evoked Potentials (SSEP) measure the integrity of the dorsal column in the spinal cord, the lemniscal and thalamocortical pathways in the brain. Recordings from peripheral nerve stimulations, most commonly tibial nerve, median nerve or ulnar nerve are used and the responses are recorded from the patient's scalp.

The amplitude and latency of the peaks are the two most valuable parameters used to assess somatosensory functions. Dramatic increases in latency and decreases in amplitude from the baseline are indicative of neurological dysfunction. SSEPs monitoring is commonly used during spine surgeries and thoracoabdominal aortic surgery to assess spinal cord ischemia. Utilizing SSEPs lower the potential risk of post-operative neurologic injury [1, 2].

SSEPs are often abnormal in patients with neurologic diseases such as multiple sclerosis (MS), myelopathy, brachial plexus injury and spinal cord syndromes. Particularly in patients with MS, SSEPs are used in conjunction with VEPs and BAEPs; although the most sensitive among the three are SSEPs. The utility of SSEPs for diagnosing radiculopathy is still controversial due to the non-specific nature of the test. Electromyelography (EMG) remains the most sensitive test to diagnose radiculopathy [1].

When used for intraoperative monitoring, anesthetics as sevoflurane and propofol prolong latency and decrease amplitude, that is why agents as hypnotic and narcotic based techniques are commonly used. Ketamine and Etomidate increase amplitude and can be used to enhance SSEPs in certain conditions that lead to their suppression. Certain preexisting diseases, such as diabetes, might also interfere with SSEPs testing.

Motor Evoked Potentials

Motor Evoked Potentials (MEPs) are tools to measure neurological signals secondary to stimulation of spinal cord, peripheral nerves and muscles. This is used as an adjunct to complement

other EPs in the assessment of nervous system pathology as well as neurophysiologic intraoperative monitoring.

There are different modes for stimulation but the most common approach is transcranial electrical stimulation of the motor pathway that utilizes scalp electrodes By using "d-waves," direct activation of motor fibers, that are recorded as the electrical activity travels along the corticospinal tract. However, this method is invasive and reserved for spinal tumors. After the electrical activity has reached the periphery, muscle contractions are then recorded with the use of intramuscular needle electrodes [3].

Changes in MEPs are measured by amplitude, presence/absence of myogenic potentials and threshold necessary to trigger an action potential. A decrease in amplitude, absence and/or disappearance of MEPs and significant increases in voltage required to generate MEPs are indicative of pathology or evolving injury [2, 3].

The clinical utility of MEPs includes the diagnosis of MS and a prognostic indicator for stroke motor recovery.

High Yield Points

- Evoked potentials (EPs) are diagnostic tools to identify abnormalities of the central and peripheral nervous systems.
- EPs are used in situations where an abnormality is not readily visible with imaging modalities or a particular imaging modality is not cost-effective or feasible.
- VEPs are useful in assessing optic nerve function in the anterior (prechiasmatic) lesion but not retrochiasmatic lesions.
- BAEPs are useful in assessing auditory pathway.
- SSEPs and MEPs are tools to determine if there is a compromised function along the central nervous system conduction.
- EPs testing may provide timely information in the operating room that has the potential to improve neurosurgical or neurovascular surgical outcomes.

Questions

1. Which among the evoked potential tests is most resistant to the effect of anesthetics?
   A. Brainstem Auditory Evoked Potentials (BAEPs)
   B. Motor Evoked Potentials (MEPs)
   C. Sensory Evoked Potentials (SEPs)
   D. Visual Evoked Potentials (VEPs)
   Answer: A
2. A 35 year-old female is undergoing scoliosis repair, which of the following SSEPs findings is most suggestive of impaired neurologic function?
   A. Decreased latency, Decreased amplitude
   B. Decreased latency, Increased amplitude
   C. Increased latency, Decreased amplitude
   D. Increased latency, Increased amplitude
   Answer: C
3. A patient undergoing VEP testing, which of the following clinical conditions will not be detected by full-filled checkerboard stimulation.
   A. Craniopharyngioma
   B. Multiple Sclerosis
   C. Optic neuritis
   D. Retrochiasmatic tumor
   Answer: D

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