Title
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Journal
Neurology, 49(4)

ISSN
0028-3878

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Publication Date
1997-10-01

DOI
10.1212/wnl.49.4.1127

Peer reviewed

Special Article

Neurology 1997;49:1127–1130

Assessment:

Dermatomal somatosensory evoked potentials

Report of the American Academy of Neurology's Therapeutics and Technology Assessments Subcommittee

Overview. Neurophysiologic methods are used to assess the functional status of the CNS and are important adjuncts to the clinical examination. The electroencephalogram (EEG) records spontaneous electrical activity from the cerebral cortex. Visual, auditory, and somatosensory evoked potentials probe the sensory pathways in the spinal cord, brainstem, subcortical regions, or cerebral cortex. Information concerning motor and sensory pathways in these regions is provided by brainstem reflexes (blink, acoustic, and oculographic). Spinal cord and spinal root function is assessed via somatosensory evoked potentials (SEPs), electromyography (EMG), and nerve conduction studies (NCS). Somatic reflex studies provide motor and sensory information about specific segments in the arm (C6) and leg (S1). Needle EMG is an *established* method for providing clinically useful and segmentally specific information in radicular disease affecting arms and legs. The major limitation of EMG, however, is that this technique evaluates only the motor component of radicular function and many patients with radiculopathy only exhibit sensory complaints. SEPs are typically elicited by stimulating mixed nerves (median, ulnar, tibial, and peroneal) to assess sensory pathways. Therefore, the application of standard SEPs to study radicular disease is necessarily limited to investigating the lumbar and cervical regions because of the limited number of sites to stimulate. Dermatomal somatosensory evoked potentials (DSEPs) involve recording cerebral evoked responses from cutaneous stimulation of areas of known dermatomal innervation providing a pure sensory input to any level of the spinal cord. This paper will assess the clinical utility of only DSEPs and will not address other evoked response procedures (visual, auditory, or mixed nerve somatosensory).

Technique. DSEPs are performed in a manner analogous to standard SEP recordings except that stimulating electrodes are placed over a dermatome rather than a specific nerve.[1-8] Recordings are taken from the scalp at locations overlying the appropriate homuncular area of the primary somatosensory cortex. The specific site of stimulation is important because stimulation of a single dermatomal segment is assumed. Therefore, the specific region of skin stimulated should be uniquely associated with a single nerve root. Unfortunately, specific areas of skin are seldom innervated by a single spinal nerve without overlap from adjacent dermatomes.[4,9] However, there are certain areas of skin in which the evoked potential amplitude over a single nerve root is so much larger than the adjacent nerve root that stimulation of the area is considered by some investigators to be equivalent to activation of a single dermatome.[4] For example, most investigators agree that stimulation on the dorsal surface proximal and slightly lateral to the little toe stimulates S1, the dorsal surface proximal to the web space between digits 1 and 2 stimulates L5, and the anteromedial area below the knee stimulates L4.[3,4,10,11] Electrical stimulation of specific dermatomes is typically at two to three times sensory threshold.

Clinical applications. The clinical utility of DSEPs has been most extensively studied in lumbar radiculopathies. Results have differed widely with regard to the actual value of these tests. Early reports successfully identified radiculopathy in as many as 92% of patients with surgically verified root compression at the L5/S1 level (88% had abnormal myelograms).[7] However, the criteria for abnormality were defined arbitrarily, without reference to findings in normal subjects. Other studies have reported

See the Appendix on page 1128 for subcommittee members.

Approved by the Therapeutics and Technology Assessments Subcommittee November 5, 1995. Approved by the AAN Practice Committee December 8, 1995. Approved by the AAN Executive Board January 15, 1996.

Received May 28, 1997. Accepted in final form June 2, 1997.

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similar success. Borrego et al.[12] also showed abnormal DSEPs in 92% of patients with surgically radicular disease (94% had abnormal myelograms). Others, however, have shown no correlation between pathology and DSEPs[13] and when compared with other methods of testing for radicular disease, DSEPs have shown no significant advantage over existing methods.[2,13,14] A strictly defined population of patients with L5 and S1 radiculopathy using rigorous clinical, electromyographic, and imaging criteria showed DSEPs had poor sensitivity.[15]

There is, therefore, considerable variability in conclusions from different studies. A critical and consistent approach is needed so that results from different studies can be interpreted in a clinically relevant context. First, the interpreter should be blinded as to condition. Only then can normal and abnormal findings obtained from this test be assigned diagnostic utility. There are few studies that have analyzed data in this manner and those that have shown relevant sensitivities are less than 50%.[1-3,7,12,16-19] Additionally, study populations should be homogeneous and results should be analyzed for ability of the test to show ipsilateral and segmentally specific abnormalities. Abnormalities in asymptomatic limbs or at different levels cannot be analyzed in the context of diagnostic sensitivity.

Another feature of a useful physiologic test is its ability to detect the presence of subclinical disease. However, in order to do this it is necessary to establish the sensitivity and specificity of the test in patients with unequivocal disease. To establish the reliability of DSEP testing, patients with unilateral and unisegmental radiculopathy should be studied to demonstrate that DSEP findings indicate pathology in the correct root for most patients. Additionally, DSEP findings should be normal at other segmental levels and on the asymptomatic side at the same segmental level. To compare diagnostic utility of DSEP recordings with clinical neurologic examination, the diagnosis of unequivocal radiculopathy would have to be based on criteria that do not include clinical findings (e.g., weakness, sensory loss, or reflex changes) as part of the diagnosis (e.g., operative findings, MRI, CT, EMG, etc.). At present, there is no evidence that DSEP findings provide any reliable information beyond the routine clinical examination[14,16,19] and there is no evidence to suggest DSEPs are superior to already established neurophysiologic techniques.[14]

DSEPs have been reported to be useful in the evaluation of patients with spinal stenosis and in the demonstration of segmental levels in myelopathies, establishing the functional correlates with the radiographic abnormalities.[20] However, these findings were not obtained in a blinded study and were not compared with existing physiologic techniques. The true diagnostic value in this situation remains to be established.

Summary of controversies. The explanation of these divergent findings cannot be attributed to a single factor. One aspect may be based in different criteria used to define abnormalities. Most investigators agree that the use of amplitude and configuration should not be used as criteria for abnormality,[17] but there are those who continue to use these as signs of abnormality.[8,20] A clear consensus for abnormality is needed before diagnostic decisions can be accepted.

Safety and technical considerations. The technique of dermatomal stimulation and cortical recording is safe. The method of stimulation is similar to that used in mixed nerve stimulation in somatosensory evoked responses. Of significant relevance is the specific placement of the electrode that would maximize specific dermatomal stimulation. This continues to be subject to debate. Furthermore, studies addressing the effect of types of electrodes used, limb length, temperature, age, filter settings, and other technical features have not been performed.

Summary. The different conclusions reached by studies investigating the utility of DSEPs prevent a confident conclusion regarding utility. Some investigators are strong believers in the diagnostic usefulness of this technique. Others are more skeptical. One possible cause is variable study design. Most studies provide evidence no higher than level III (case reports, expert opinions). Controlled studies, especially with blinded interpreters of the tests, would provide needed evidence of efficacy in view of the existing confusion in the literature. It is our consensus that the current evidence supporting the diagnostic use of DSEPs is Type D and that DSEPs should be regarded as Investigational, meaning that current evidence is insufficient to determine appropriateness. This group does encourage further study.

Appendix. Therapeutics and Technology Assessments Subcommittee: John H. Ferguson, MD, Chair; Mitchell Brin, MD; Michael L. Goldstein, MD; Philip B. Gorelich, MD, MPH; Daniel F. Hanley, MD; Dale J. Lange, MD; Marc R. Nuwer, MD, PhD; E. Steven Roach, MD; Robert Goldman, MD; Douglas Goodin, MD; and Ann M. Marini, MD.

Acknowledgments

The Therapeutics and Technology Assessments Subcommittee wishes to thank the following Panel Members: Dale J. Lange, MD, facilitator; Michael Aminoff, MD, Andrew Eisen, MD, Ronald Emerson, MD, Douglas Goodin, MD, Werner Trojaborg, MD, PhD.

DEFINITIONS

Safety: A judgment of the acceptability of risk in a specified situation, e.g., for a given medical problem, by a provider with specified training, at a specified type of facility.

Effectiveness: Producing a desired effect under conditions of actual use.

Established: Accepted as appropriate by the practicing medical community for the given indication in the specified patient population.

Possibly useful: Given current knowledge, this technology appears to be appropriate for the given indication in the specified patient population. As more experience and long-term follow-up are accumulated, this interim rating may change.

Investigational: Evidence insufficient to determine appropriateness warrants further study. Use of this technology for given indication in the specified patient population should be confined largely to research protocols.

Doubtful: Given current knowledge, this technology appears to be inappropriate for the given indication in the specified patient population. As more experience and long-term follow-up are accumulated, this interim rating may change.

Unacceptable: Regarded by the practicing medical community as inappropriate for the given indication in the specified patient population.

Quality of Evidence Ratings for Diagnostic Tests

Class I. Evidence provided by one or more well-designed clinical studies of a diverse population using a "gold standard" reference test in a blinded evaluation appropriate for the proposed diagnostic application.

Class II. Evidence provided by one or more clinical studies of a restricted population using a reference test in a blinded evaluation of diagnostic accuracy.

Class III. Evidence provided by expert opinion, nonrandomized historical controls, or observation(s) from case series.

Strength of Recommendations Ratings

Type A. Strong positive recommendation, based on Class I evidence, or overwhelming Class II evidence when circumstances preclude randomized clinical trials.

Type B. Positive recommendation, based on Class II evidence.

Type C. Positive recommendation, based on strong consensus of Class III evidence.

Type D. Negative recommendation, based on inconclusive or conflicting Class II evidence.

Type E. Negative recommendation, based on evidence of ineffectiveness or lack of efficacy, based on Class II or Class I evidence.

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