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Assessment: EEG brain mapping

Report of the American Academy of Neurology, Therapeutics and Technology Assessment Subcommittee

"EEG brain mapping" is a term commonly used for several quantitative EEG techniques. These include (a) EEG frequency analysis, (b) topographic display, (c) statistical comparisons to a normative database, and (d) other similar computer-based calculations based on EEG or evoked potentials. EEG brain mapping can help highlight or identify regional features of the EEG. Occasionally, this will identify subtle features that escaped identification by traditional visual inspection of the polygraph EEG alone. EEG brain mapping can also help in communication of EEG features and their localization, especially for communication to persons who are not expert in EEG. Quantifying of EEG features can help in the assessment of whether some features are present to an abnormal degree. Computer-based EEG processing can also calculate abstract features that cannot be visualized.

However, despite these potential advantages, the clinical application of EEG brain mapping is still very limited. Most scientific reports on these techniques have demonstrated research applications rather than clinical usefulness. Among those clinical reports, few have been prospectively verified or reproduced. Techniques used in EEG brain mapping vary substantially between laboratories, and any clinical usefulness found with one specific technique may not apply when using a different technique. A substantial number of technical and clinical problems interfere with many simple clinical applications. These problems can easily mislead interpretation, sometimes in subtle ways. Traditional EEG artifacts can appear in unusual and surprising ways, and new artifacts can be caused by the data-processing and computer-processing algorithms. For example, epileptic spikes are generally overlooked or considered artifactual. Also, transient slowing can be missed or washed out. The computer may consider as "abnormal" some of the unusual EEG activity known to have no clinical importance such as mu, psychomotor variant, alpha harmonics, and other normal variants. Automated assessment of normality would have to take into account the subject's age, state of alertness, medication, and other facts, but ways to do this are still not defined, especially when the patient is receiving CNS-active medication. Substantial unresolved statistical issues are critical in automated assessment of normality.

Little has been published on how these various tests could affect the diagnosis or treatment of individual patients. Cerebrovascular disease is one area in which these tests may fill occasional specific needs. Several quantified EEG parameters are highly correlated with regional blood flow. Sensitivity is high for detection of ischemia-related cerebral impairment, and false positive rates are low. These tests can be quite abnormal even when the CT is still normal, such as in the first 2 to 3 days after stroke or when the degree of ischemia is mild enough to cause dysfunction without infarction. However, localization ability is very inferior to that found with CT or MRI. EEG changes are unable to differentiate infarction from hemorrhage, tumor, or other focal cerebral lesions.

EEG brain mapping cannot diagnose epilepsy. Some computer techniques can help to differentiate primary generalized discharges from secondary bilateral synchrony, or can help determine the location of a focus.

In dementia evaluations, the finding of an EEG abnormality can suggest an organic basis rather than depression. However, the tests cannot yet reliably distinguish between types of dementia. Most EEG changes of early dementia are seen well on routine EEG testing, and the extra yield for EEG brain mapping is small.

On the basis of the present medical literature, the sensitivity and specificity fail to substantiate a role for these tests in the clinical diagnostic evaluation of individual patients for possible tumors, multiple sclerosis, minor head trauma, dyslexia, attention deficit disorder, schizophrenia, depression, alcoholism, or drug abuse. Some research studies have shown small, reproducible differences between groups of such patients and groups of normal subjects, but the group findings are not directly relevant for diagnosis in an individual patient care situation. If EEG brain mapping is done in any of those settings and an abnormality is found, the abnormality may suggest an organic impairment, but it is nonspecific for the cause or type of pathology and does not necessarily correspond to any patient symptom. Careful clinical correlation is required for interpretation of any such abnormality.

Long-latency evoked potentials have also been used in brain mapping techniques. At present, insufficient information is available about evoked potential topographic mapping to assess its normal variants, normal limits, effects of medication, and other relevant technical and patient-related factors. No reproduced, prospectively verified clinical studies are available to dem-

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onstrate the sensitivity and specificity of topographic mapping of long-latency evoked potentials for diagnosis in individual patient care settings. When sensitive statistical tests (eg, z-scores) do detect changes in topographic maps of long-latency EP amplitudes, the reader is not able to differentiate between chance events, normal variants, and true pathology. Overall, long-latency evoked potential topographic brain mapping is still investigational.

Any clinical use of EEG brain mapping must be a direct extension of routine EEG testing. The actual EEG polygraph waveforms must be preserved on paper or on magnetic or optical storage medium. These EEG tracings must be interpreted thoroughly before interpretation of the computer-based analysis. The technical quality of these EEG readings must be satisfactory for purposes of clinical interpretation, according to accepted guidelines (for example, the American EEG Society "Guidelines in EEG and Evoked Potentials," and the International Foundation of Societies of Electroencephalography and Clinical Neurophysiology, "Recommendations for the Practice of Clinical Neurophysiology"). At present, there is no clinical application for computer-based clinical EEG analysis separate from analysis of the polygraph EEG. In order for these tests to be useful in clinical settings, they should be interpreted only by physicians with satisfactory skills, knowledge, and abilities in routine EEG as well as additional knowledge and experience with the relevant additional technical problems, artifacts, normal variants, and statistical issues encountered in EEG brain mapping.

Overall, these techniques have a very limited clinical usefulness. They are best used by physicians highly skilled in clinical EEG. The tests are only an adjunct to and should be used in conjunction with traditional EEG testing. They are useful in only a small subset of patients who have been well selected on the basis of the clinical setting and results of more standard testing, such as MRI.

Executive summary. EEG brain mapping is of limited usefulness in clinical neurology. The tests are best used by physicians highly skilled in EEG, in conjunction with analysis of the concurrent polygraph EEG.

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Assessment: Intensive EEG/video monitoring for epilepsy

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Intensive EEG/video monitoring is widely accepted as a safe and clinically effective method for evaluating highly selected patients with seizure disorders. In this technique, 16 to 64 channels of EEG are recorded continuously onto a magnetic or optical storage medium while the patient remains in front of a closed-circuit television camera. There are several clinical indications for this: diagnosis, classification, localization, and other reasons. For *diagnosis*, monitoring can help diagnose whether episodic spells are epileptic as opposed to nonepileptic. Disorders that may be confused with epilepsy include psychogenic seizures, syncope, cardiac arrhythmias, transient ischemic attacks, narcolepsy, other sleep disturbances, and other behavioral disorders. Although most of these disorders can usually be clearly distinguished from epilepsy on other clinical grounds, a

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