Evoked Potentials for Monitoring Surgery

All physicians are vulnerable to malpractice suits these days, but few are as vulnerable as neurosurgeons. Nerves damaged during surgery can leave the patient with a permanent—and highly actionable—injury. Not surprisingly, says Peter Raudzens of the Barrow Neurological Institute in Phoenix, Arizona, "There is a really compelling need to monitor the central nervous system during surgery just as the heart is monitored."

Raudzens is among those who are attempting to use evoked potentials to do just that. Although this approach is not without problems, results he presented last month at a Conference on Evoked Potentials sponsored by the New York Academy of Sciences suggest that evoked potentials can be used to detect nerve damage during neurosurgery, in some cases allowing the surgeon to alter his technique in time to avert permanent damage.

Evoked potentials, like electroencephalograms (EEG's), are tracings of brain waves measured at various places on the surface of the head. Unlike EEG's, however, evoked potentials are elicited by specific stimuli. Any type of stimulus will do, although the most commonly used are those of the visual, auditory, and somatosensory (touch and pain) systems. One of the great advantages of evoked potential measurements is that they can give information about how well these systems are working in subjects who are unable to communicate, even in subjects who are unconscious.

According to Raudzens, brainstem auditory evoked potentials (BAEP's) proved to be most reliable for predicting nerve damage. Six of the 66 patients who underwent surgery in the auditory nerve region showed an abrupt and permanent loss of BAEP's in response to a clicking noise. All of these individuals were left with a marked hearing loss, Raudzens told the conference. The BAEP's of another ten patients began to show abnormal changes, but returned to normal when the surgeon temporarily stopped what he was doing. None of these patients had significant hearing losses. The results suggest, Raudzens concludes, "that evoked potentials may be used to guide the surgeon to alter his technique to prevent a reversible lesion from becoming a nonreversible one."

Attempts to use visual evoked potentials (VEP's) elicited by a flashing light proved less satisfactory. "We were encouraged at first," Raudzens says, "but serious problems developed." Often the potentials were too variable to be reliable predictors of neurological injury. He still hopes that with a suitable stimulus VEP's might be used for monitoring.

Least successful were attempts to use somatosensory evoked potentials (SEP's) during spinal cord surgery. "We could find no correlation between sensory deficits and changes in potentials," Raudzens said. However, another conference participant, Stephen Jones of the National Hospital for Nervous Diseases in London, reported that it might be possible to use SEP monitoring during surgery to correct scoliosis, an abnormal curvature of the spine. He described one case (out of a total of 67 who underwent the monitoring) in which an abrupt loss of SEP's caused the surgeon to alter his course and may have prevented paralysis of the patient.

More work will be required to establish the validity of evoked potential monitoring during surgery. One obvious problem is that the drugs and anesthetics required for surgery can alter nerve impulse conduction. Still, as Jones points out, "a general view amongst orthopedic surgeons is that any reasonable straightforward safety measure is worthwhile." Neurosurgeons undoubtedly concur.

Testing Babies for Neurological Problems

"One of the values of evoked potentials in research," says Oliver Braddick of the University of Cambridge, England, "is to look at young infants who can't give any other kind of response." Results of such studies, described at the conference by Braddick and by Diane Kurtzberg of Albert Einstein College of Medicine in New York, suggest that the measurements may help to identify strabismus (failure of the eyes to work together) and other neurological problems at a very early age, when the conditions are most correctable.

Braddick and Janet Atkinson, also of Cambridge, have been using a technique devised by Bela Julesz and Walter Kropfl of Bell Laboratories, Murray Hill, New Jersey, to study the development of binocular vision in infants. As Braddick describes it, the technique involves "a large-screen video display that is like a snowstorm of colored dots." The dots form a pulsating pattern that can be detected only if the subject has binocular vision; then the pattern elicits a VEP.

The 26 infants who were tested in the first phase of the study, in the laboratory of Ivan Bodis-Wollner at Albert Einstein, were all healthy and ranged in age from 1 to 8 months. According to Braddick, "The data give some suggestion that binocularity is reliably present in infants over 3 months," but not in younger ones.

Currently, Braddick and Atkinson are concentrating on the youngest infants in their work at Cambridge. The data thus far, he says, "tend to support the view that the younger ones may not have binocular vision."

Braddick and Atkinson have tested only one strabismic infant thus far. As expected, the child, who was 4 months old and should have produced a VEP, failed to do so. Early detection of strabismus is important. Infants who have the condition see with only one eye and are in danger of suffering permanent loss of vision in the other eye if the condition is not corrected in time. Ultimately, the VEP method may aid in diagnosing these infants.

Premature infants are especially prone to neurological problems, including hearing and vision deficiencies. Kurtzberg and Herbert Vaughan, also of Albert Einstein, are trying to determine whether evoked potential measurements can pick up these problems. They measured both visual and auditory potentials in a group of 79 high-risk infants, all of whom weighed 1500 grams or less at birth. About half of the infants, who were first studied 40 weeks after their conception (the earliest age at which a control group of normal infants could be found), had abnormal VEP's and about 10 percent had abnormal auditory evoked potentials.

After 1 year of follow-up, the VEP's of 97 percent of the premature infants who had tested normally the first time

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were still normal. Depending on the stimulus, the VEP's of 50 to 75 percent of those in the abnormal group remained defective. Kurtzberg says, "It is still too early to tell whether they have a problem with the visual system or whether they have more subtle brain damage." But she hopes that evoked potentials will permit early identification of babies who are suffering harmful neurological consequences of their premature births.

BEAM Sheds Light on Brain Disorders

Although evoked potentials are widely used in clinical practice, especially for the diagnosis of multiple sclerosis and of hearing and vision disorders, they have not always lived up to their promise. "At one time I would have predicted that evoked potentials would attain widespread use and displace EEG's," says Frank Duffy of Children's Hospital Medical Center in Boston, "but that has not happened. . . . The problem is that evoked potentials may have too much information, not too little."

To extract the information and display it in a more readily interpretable format, Duffy and his colleagues have devised a computer method for topographic mapping of evoked potentials. In the method, which they call BEAM for brain electrical activity mapping, at least 20 electrodes are distributed over the surface of the head to record the potentials evoked by a light flash. The computer converts the potentials, which are recorded at 4-millisecond intervals for a total of 512 milliseconds, into a series of color-coded maps of the brain that show areas of positive and negative potentials. "In this way," Duffy explains, "you can see waves of positivity or negativity moving across the brain. It is very useful from the clinical point of view. If there is a lesion anywhere, such as a tumor, the wave is blocked, or it may be too large or too small."

The Children's Hospital workers have detected brain tumors and infarcts (areas of dead tissue that may be caused by strokes) in BEAM images. Since these anatomical abnormalities can usually be picked up by computed tomography (CT) scans, Duffy suggests that "the greatest utility of BEAM images is in the analysis of functional lesions where the CT scan may be normal."

For example, Duffy can identify areas of hyperexcitability—the hallmark of epilepsy—in BEAM images of the brains of patients with the condition. Even dyslexia, a learning disorder of unknown cause that is characterized by reading difficulties, may be amenable to diagnosis by a modification of BEAM called significance probability mapping (SPM). In SPM, the computer compares the test subject's BEAM image with that of a normal population and produces a color-coded map showing where they differ significantly. Although the CT scans of the brains of dyslexic individuals appear normal, the SPM images show changes in the speech areas of the brain cortex and in the frontal lobe, according to Duffy.

Question Marks for SIDS Test

A test to identify babies at high risk for sudden infant death syndrome (SIDS), which claims up to 10,000 lives every year in the United States, has long been sought. For a time it looked as if BAEP measurements might provide one. Results presented at the New York Academy meeting by James Stockard of the University of California Medical Center in San Diego throws that in doubt, however.

Many investigators now believe that babies who die of SIDS or who have "near misses," but are found in time and resuscitated, have some subtle defect in the brain centers that control respiration. These are located in the brainstem near the auditory pathways that produce the BAEP's, which suggested that an abnormality in the respiratory centers might extend to the auditory pathways and be reflected in atypical BAEP's.

According to James Orlowski, Richard Nodar, and Derrick Lonsdale of the Cleveland Clinic, all of the 15 near-miss SIDS infants that they originally examined had abnormal BAEP's by at least two of the seven criteria they used to evaluate the potentials. In contrast, Stockard did not detect significant irregularities in the BAEP's of any of seven SIDS or near-miss SIDS infants. In fact, one of these babies had a normal BAEP when it was evaluated shortly after birth and had once been included in Stockard's control group. Then, at the age of 17 weeks, the infant had a near miss. The BAEP determination was redone and again found to be normal. Two weeks later the infant died suddenly. "Here was an infant," Stockard says, "who had normal BAEP's for his age, yet died of SIDS." Another group of investigators, including Leslie Dorfman and Christian Guilleminault of Stanford University Medical Center, also failed to find abnormal BAEP's in nine near-miss SIDS babies.

Orlowski responds that the Cleveland group has now studied 80 near-miss SIDS and 100 normal infants. They have found that the BAEP's of normal males differ from those of normal females. This difference may affect the ability to detect abnormals and may account for the failure of the other groups to find aberrant BAEP's in the near-miss babies, he suggests. "We have studied more near-miss SIDS infants than anyone and still feel that we can distinguish normal and abnormal in 80 to 85 percent of the cases," Orlowski concludes.

Stockard, in turn, questions the validity and objectiveness of the Cleveland group's criteria. "When we applied the Cleveland criteria to 78 age-matched normals," he says, "71 percent turned out to be abnormal."

Even though the BAEP's of the individual near-miss SIDS babies studied by Stockard fell within the norms for their age group, the group as a whole appeared abnormal with regard to one of the BAEP characteristics. If they are, he suggests, this might be secondary to the oxygen deprivation caused by the abnormally long breathing cessations characteristic of near-miss babies, and not an indication of some primary brainstem defect. A group of infants who suffered from oxygen deprivation because they have congenital heart disease were abnormal in the same way.

The Cleveland results are again diametrically opposed; the workers there did not find abnormal BAEP's in infants with congenital heart disease. So, while Stockard concludes that BAEP's are of no value in identifying infants at risk for SIDS, Orlowski and his colleagues think otherwise.

—Jean L. Marx—