Editorial

Stereoelectroencephalography using computerized tomography– or magnetic resonance imaging–guided electrode implantation

NICHOLAS M. BARBARO, M.D.

Department of Neurological Surgery, University of California, San Francisco, California

De Almeida, et al., report on their experience with the use of stereotactic depth electrodes (DEs) in a large series of patients at the Montreal Neurological Institute (MNI) for medically refractory epilepsy. Their study represents one of the largest reported series and is useful in helping to define the overall risk and success of this method of seizure localization. The surgeon who performed these procedures, Dr. André Olivier is among the most experienced practitioners of stereotactic techniques in the world. The authors used stereotactic techniques and implanted electrodes developed at their site rather than those commercially available to most centers. When counseling patients, personnel at each center should quote morbidity rates based on the procedures performed at that particular institution. Centers with less experience in performing certain procedures may have slightly higher complication rates than those reported here.

Even when used by the most experienced surgeons, there is a small but significant risk of clinically relevant hemorrhage when multiple DEs are implanted, especially in the frontal lobes. If the risk is 3% per frontal lobe with multiple electrodes, then the risk of hemorrhage approaches 6% in the more complex cases involving a frontal lobe in which bilateral implantations are needed. These risks should be weighed against the relative increase in the information provided by DEs compared with subdural surface electrodes.

Although the use of DEs has been standard in the evaluation of patients with temporal lobe epilepsy, this practice has been based on the relative difficulty of recording from medial structures using scalp or even surface subdural electrodes. The rapidity with which electrical impulses can travel between medial temporal lobes can further complicate the analysis when surface electrodes are used. The fact that surface recordings have been shown to mislateralize in patients with normal findings on magnetic resonance (MR) imaging adds to the concern in the evaluation of temporal lobe epilepsy. Depth electrodes provide localized recordings from a region very near each electrode. When a single structure such as the amygdala or hippocampus is suspected of containing the epileptic focus, this degree of specificity is an advantage. When a relatively large region is in question, as is often the case in frontal lobe epilepsy without specific MR imaging data or other abnormalities, DEs will not allow precise localization unless multiple electrodes are used, as was done in the authors’ series. Clinical information such as seizure symptoms, scalp electroencephalography (EEG) recordings, or, more recently, subtraction single-photon emission computerized tomography or magnetoencephalography data can help to delimit the region from which recordings are needed. Nonetheless, relatively numerous electrodes are required to cover one or both frontal lobes when there are few radiological or clinical hints about the site of seizure onset. Personnel at most epilepsy surgery programs would use surface grids with numerous electrodes in these cases, especially if clinical data allow for the localization of seizure onset. Multiple stereotactically implanted DEs rather than a large surface recording grid provides a more or less three-dimensional recording volume as electrodes span from the surface to the depths of the frontal lobes. The associated risk of hemorrhage must be taken into account given this added information. Furthermore, surface electrode grids offer the additional advantage of allowing extraoperative mapping of functional areas, something rarely accomplished with multiple DEs.

As the authors of this series imply, the use of implanted EEG recording electrodes, which declined in the 1980s following the advent of MR imaging and other imaging modalities, has recently been increasing. This trend represents an understanding of the limitations of imaging in predicting electrophysiological events and less reluctance on the part of epilepsy surgery centers to treat more complex cases.

Although hemorrhage is the most feared and potentially morbid side effect of surgically implanted electrodes, other complications are important to consider, for example, infection, including meningitis and abscess. These complications were extremely infrequent in the series under discussion even though prophylactic antibiotic agents were not used. Contemporary data suggest that the use of perioperative antibiotics reduces the risk of postsurgical infection, espe-
cially if foreign material is implanted. The current series reinforces that the best way to avoid infections—and all complications, for that matter—is the use of an impeccable sterile surgical technique. Perhaps the complication rate could be reduced even further if antibiotics were used. Although the authors imply that relatively small amounts of leaking cerebrospinal fluid (CSF) are common during or following invasive electrode use, it should be noted that continuous CSF leakage is associated with an increased risk of infection; thus, efforts should be made, including tunneling of electrodes and suturing of leakage sites, to stop CSF leaks relatively quickly to reduce the morbidity of this technique. Note that the statement that CSF leakage may be a cause of postoperative headache is puzzling. Many centers use dexamethasone for a short time following electrode implantation in an effort to reduce the side effects associated with CSF inflammation. One should remember that this drug can raise the seizure threshold temporarily and must be tapered rapidly.

Finally, numerous advances in the understanding of brain function have been achieved by using intracranial electrodes to study brain function while simultaneously recording seizures. Although ethical considerations preclude the placement of electrodes in regions not supposed to be part of a seizure focus, electrodes are placed throughout much of the brain in patients with epilepsy, making this a fertile field for research.

References


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applied, and the choice of technique will be based on the experience and preferences of the assistant neurophysiologists and neurosurgeons involved. In this respect, knowing the associated morbidity and efficacy of the different procedures is essential in the decision-making process. Our experience shows that SEEG is safe (the complication rates were very low) and can yield reliable data for or against surgery in most patients (96%). Dr. Barbaro has stated that our results should not be extrapolated because our data reflect the morbidity in one group and the work with a technique that has constantly evolved over the last 30 years using a device developed at the MNI. However, the morbidity in our series is comparable with that at other centers using different brands of depth electrodes, and lower if compared with grids using grid electrodes. The incidence of subdural hematoma using grid and strip electrodes has varied from 7.8 to 16% in recent series. The highest risk of bleeding in our series was approximately 3% in a frontal lobe implanted with four or more electrodes. Furthermore, concerning the risk of hemorrhage in frontal lobe explorations, it is important to mention that all patients with a hematoma had significant brain atrophy. We think that the site rather than the presence of atrophy is the significant risk factor. With the technique used, all electrodes were inserted through an avascular corridor established with the trajectory made by the navigation system.

Cerebrospinal fluid leaks are a common event after implantation of both DEs and grids and, likewise, the incidence of infection seems comparable among techniques, varying from 2.2 to 8.5% (the rate of infection in our study was 3.5%). We think that the headaches were associated with CSF leaks, which we now try to avoid systematically. We do not believe that the use of antibiotics would further decrease the rate of infection, although at present this is a matter of opinion, as only a double-blind study would be able to prove our hypothesis. From our point of view, the lower rate of complications in SEEG should be imputed to the technique itself, because it does not require craniotomy and manipulates the skin only minimally.

Regarding efficacy, DEs correctly identify and lateralize seizures arising in the mesial structures of the temporal lobe more consistently than subdural electrodes. Moreover, although there seems to be a consensus regarding the indications for DEs in bitemporal lobe epilepsy, it is important to note that in well-lateralized nonlesional temporal lobe epilepsy, SEEG can be used to detect the site of seizure onset with electrodes placed within the temporal pole, insula, amygdala, and hippocampus as well as over the neocortex. Other advantages of SEEG include its safety in sampling large areas of the brain, including both hemispheres, and in prolonging the duration of implantation without a significant increase in morbidity (electrodes remained implanted in the patients in our series for approximately 17 days). On the other hand, SEEG is not as effective as grids in mapping circumscribed cortical areas, as a huge number of electrodes placed in a small area would be necessary. However, if cortical mapping is necessary, patients may undergo surgery while awake; this technique is very effective and carries less risk than grid implantation.

Weighing against SEEG is the fact that the work required by neurophysiologists in planning electrode numbers and positions is extensive. Furthermore, analysis of findings is also demanding and requires a professional experienced with the technique.

Finally, we thank Dr. Barbaro for his very pertinent opinions and point out that such discussion emphasizes the need for an in-depth electrophysiological study in patients with surgically remediable epilepsy to further our understanding and improve treatment of this devastating condition.

ANTONIO NOGUEIRA DE ALMEIDA, M.D., PH.D.
Instituto Neurológico de São Paulo
São Paulo, Brazil
ANDRÉ OLIVIER, M.D., PH.D.
Montreal Neurological Institute
Montreal, Canada

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