Editorial

Invasive monitoring

JEFFREY G. OJEMANN, M.D.

Department of Neurological Surgery, Seattle Children’s Hospital, Seattle, Washington

In their important report, Dr. Pestana Knight and colleagues carefully reviewed their experience with children who underwent subdural electrode implantation but did not subsequently undergo resection. In a 7-year period, 66 implantations were performed, and 9 of the patients (over 13%) had electrodes removed without a resection. The reasons for not performing a resection were a combination of multifocality and/or nonlocalizing seizures and proximity to eloquent cortex with a family reluctance to accept a high risk of deficit.

An invasive study that does not lead to resection is not necessarily a failure. Invasive monitoring may be the best, or perhaps the only, way to define the relationship of critical function to focal onset in a given patient. It is important for the surgical approach to allow careful consideration of the appropriateness of a resection so that a regretted decision is not made hastily. However, subdural electrodes carry known morbidity and their use would not be pursued without some hope of offering benefit from a resection. Thus, a rate of 13% of patients having no resection seems higher than would have been expected and is perhaps more than desirable. Unfortunately, it is difficult to generalize the results of this report to other centers, as many subjective factors influence the decision-making and thus the outcome.

Any epilepsy surgery requires a medically intractable disease, focal seizures, and proposed resection in a safe area. Any of these factors has an element of subjectivity, and a nonlesional, dominant frontal lobe investigation may be very appropriate in a child with daily impairing seizures in a way that may not make sense for a child with persistent, but mostly controlled, events.

The distinction between multifocality and nonlocalizing studies is problematic. Subdural electrodes, even in large numbers, still vastly undersample the cortex and have a field of view superior to depth electrodes although still limited to probably just a few mm. Other (for example, deeper) sources can spread unpredictably and perhaps inconsistently, giving the appearance of multifocality. In some cases, a mixture of grid and depth electrodes is appropriate for targeting areas with possible deep sulcal pathology. Given the sampling characteristics inherent to invasive monitoring, it is unusual to achieve specificity in seizure localization better than the lobar or sublobar level. Each lobe will have specific critical functions that typically limit resection, and these functions can usually be defined using a combination of preoperative and extraoperative (grid mapping) techniques. Functional MR imaging is increasingly used in the pediatric population, often to the age of 5 years. This modality combined with detailed neuropsychological screening can greatly improve the ability to anticipate that the seizure focus and eloquent cortex may overlap. It is hoped that these advances will make less common the dilemma of encountering critical function unexpectedly close to the zone of seizure onset.

In the report by Dr. Pestana Knight et al., Todd’s paralysis in the dominant hand was more common in the no-resection group, indicating that a focus that impacts function is more likely to be near eloquent cortex. Should surgery even be considered in such a patient? It depends on the severity of the seizures and the preoperative (including before the invasive monitoring operation) discussion with the family about the possibility of a focus near eloquent cortex. The other statistically significant difference between the groups was the fact that the no-resection group had more electrodes placed than did the resection group, probably because their seizures were more difficult to localize. This does not mean that patients with Todd’s paralysis should not undergo surgery. Neither does it mean that using a certain number of electrodes may be futile, but rather that we must redouble our efforts to understand function and seizure localization in children with severe intractable epilepsy.

Another surgical option in critical areas is the use of multiple subpial transections. In motor or language areas, this approach has good published results, especially when used in combination with resection. This procedure should not be systematically ignored. Plasticity of the language and, to a lesser extent, the motor cortex is also a rationale for considering more aggressive resections in the younger group.

The authors emphasize that the parents often decided not to accept the risk of deficit, and thus a resection was not performed. Preresection consultation is a time-sensitive discussion that stands in contrast to the often-prolonged decision-making that leads up to the pursuit of epilepsy surgery. Presumably, the risk of deficit became
more clearly greater to the family only after the invasive monitoring study, and defining functional relationships to ictal onset is certainly a highly valuable use for invasive studies. However, it is equally important to discuss potential scenarios with families even before the initial implantation. Although the importance of a team approach at any medical center cannot be underestimated, the pediatric epilepsy surgeon surely knows that establishing a relationship with the family well in advance of elective surgery and addressing common scenarios beforehand can lead to clearer decision-making. And the pediatric epilepsy surgeon is ultimately responsible for making sure that these things happen, even if the family is traveling from afar or has sought out destination care specifically for surgery.

In summary, the authors’ report gives us important guidance as to what issues may lead to invasive studies that do not proceed to resection. It is hoped that thorough preoperative evaluations and consultations can make such scenarios uncommon without denying aggressive surgical care to appropriate children, who may share some of the characteristics as in those who did not undergo resection in this series.

Disclosure

The author reports no conflict of interest.

References


Response

Ajay Gupta, M.D.,1 Elia M. Pestana Knight, M.D.,2 and William Bingaman, M.D.1

1Epilepsy and Pediatric Neurology Center, Neuroscience Institute, Cleveland Clinic Foundation; and 2Department of Pediatrics, Division of Epilepsy, Rainbow Babies and Children’s Hospital, Cleveland, Ohio

We thank Dr. Ojemann for his valuable comments. A decision to implant long-term intracranial grid and depth electrodes for epilepsy surgery in a child requires a hypothesis-driven surgical strategy with clear objectives. A careful review of noninvasive data by a multidisciplinary team in a management conference facilitates this plan. Despite this process, however, 10%–25% of children with implanted electrodes do not undergo resection according to reported series, and our study was an attempt to learn from such cases at our center. Dr. Ojemann’s observations as well as our findings suggest that what-if scenarios should be an important part of informed consent and decision-making prior to implantation. If the preimplantation hypothesis involves a host of possible resection scenarios and the potential for new permanent postoperative neurological deficits, running what-if scenarios during informed-consent discussions can help the family and caregivers to visualize outcomes and make appropriate decisions. In selected cases, a bioethics specialist could help to facilitate and validate discussions as well as the informed consent process prior to surgery.

Given the inherent subjectivity involved at every step of the presurgical evaluation, divergent opinions exist among various centers with regard to the indications for and the frequency of intracranial implantation for epilepsy surgery in children. We believe that in children with MR imaging lesion-based epilepsy surgery, the indications for the implantation of subdural grid and depth electrodes are few, and we usually limit their use in children with normal examinations in which electroencephalography (EEG) and MR imaging show resection at or near the primary motor, sensory, and language regions. In such cases, creating a detailed motor sensory homunculus and/or language map coregistered with the anatomical and electrophysiological boundaries of the lesion could provide the best opportunity for complete resection. Most children undergoing resection of an epileptogenic MR imaging lesion at our center undergo anatomically guided resection with or without the use of intraoperative electrocorticography (ECoG) and, when appropriate, central sulcus and motor mapping in the operating room. Hence, children who undergo grid and depth electrode placement at our center tend to have little in the way of anatomical brain MR imaging abnormalities, and the slightly higher percentage of children who did not undergo any resection after grid implantation in our study was no surprise. On the contrary, experience at our center has shown that children with intractable epilepsy due to congenital and early-acquired lesions can demonstrate a clinical and EEG picture of widespread and diffuse static or progressive epileptic encephalopathy (generalized interictal spikes and nonlocalized or generalized ictal onset).2,4 One would hope that the use of depth and subdural grids covering the lesion in such children might help to prove the epileptogenic potential of the lesion and surrounding areas. However, in few children in this cohort who underwent subdural grid implantation for long-term or intraoperative ECoG, we found that the epileptogenicity was widely distributed in the brain covered by intracranial electrodes and that the use of subdural grids did not refine or change the surgical strategy. Regardless of the degree and extent of confusing or contradictory EEG findings in this cohort, anatomically guided resection after a careful review of all data led to seizure freedom or significant improvement on par with that in children who had exclusive focal EEG findings.2,4 Furthermore, postoperative EEG in the seizure-free children in this cohort tended to normalize with resolution of the epileptic encephalopathy picture, suggesting that the development of diffuse or widespread epileptogenicity is likely to be a secondary phenomenon in some children that cannot be solved presurgically by existing EEG techniques, whether with scalp or intracranial implantations.

In patients with an MR imaging lesion, there is a lack
of evidence suggesting that the use of long-term intracranial EEG produces superior seizure outcome. As experience with noninvasive imaging techniques in children is growing, techniques, such as functional MR imaging, diffusion tensor imaging, and tractography, may become reliable enough for us to be even more selective in the use of subdural grids and depth electrodes in older and cognitively normal children. In young and cognitively impaired children, challenges will remain, forcing us to customize our strategy.

In children with intractable epilepsy with nonlesional MR imaging, we still rely on intracranial implantation to help clarify the area of brain involved in the generation of seizures. Driven by hypotheses generated from data gathered during noninvasive evaluation, intracranial implantation in a nonlesional brain MR imaging case is likely to involve a larger surface and a higher number of implanted electrodes, as shown in our study. Even then, tunnel vision can occur by looking only at select regions of the brain under the grid or in contact with the depth electrodes, resulting in an inability to isolate the location and extent of the epileptogenic zone. Unfortunately, in our study, we did not find any reliable presurgical predictors in the no-resection versus the resection group. The only significant predictor was the existence of Todd palsy in the no-resection group. Note that the pathophysiology of Todd palsy is not clearly understood. And while Todd palsy is a reliable lateralizing sign, it may not be a specific indicator of seizures originating from or near the primary motor cortex. Overall, long-term seizure outcome in nonlesional epilepsy surgery guided by intracranial implantation remains less than satisfactory.1,3

We are aware that some epilepsy centers consider multiple subpial resections as a reasonable option in children who are not candidates for resection because of the involvement of eloquent brain regions. The safety and efficacy of this procedure remains to be clearly established and is largely an experience-driven technique practiced at some centers.

Ultimately, the risk of perioperative complications, additional equipment, hospital and personnel costs, and patient discomfort are important factors that should be weighed against the potential benefits before deciding on intracranial implantation in every child. Approximately, 1 in 10 children undergoing intracranial implantation may have no resection after the procedure given a lack of confidence in delivering a good seizure outcome and/or the high risk of new unacceptable neurological deficits. We agree with Dr. Ojemann that such cases may not be considered as surgical failures, and improving our criteria for selecting children for intracranial implantation will continue to be a challenging work in progress. Our study is a step in that direction, and we hope it will aid in the presurgical counseling of families. (DOI: 10.3171/2011.6.PEDS11131)

References