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EDITORIAL

Pediatric epilepsy surgery

Toward increased utilization and reduced invasiveness

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Approximately 25% to 35% of patients with epilepsy continue to have seizures even with appropriate drug treatment, a proportion that has remained relatively unchanged for the last 3 decades despite the introduction of several new antiseizure medications.[1,2] Epilepsy surgery offers a better likelihood of seizure freedom in properly selected patients with such drug-resistant epilepsy (DRE). This is particularly important for childhood-onset DRE, which is often associated with adverse long-term developmental and cognitive consequences.[3] Evaluation of patients for epilepsy surgery is a stepwise process and requires intracranial EEG monitoring (IEM) in many patients, particularly in those where MRI of the brain does not show a lesion specific enough to guide neurosurgical decisions (MRI-negative).[4,5] The goal of extraoperative IEM is to accurately define the seizure-onset zone, and its anatomical relationships with "eloquent" functional cortical areas.[4] Although IEM provides crucial information for epilepsy surgery, it is associated with risks of infection, intracranial hemorrhage, and elevated intracranial pressure.[6] These adverse events are not trivial and have required an additional surgical procedure(s) in up to 3.5% of patients.[6] Over time, recognition of these adverse events, understanding their mechanisms, and improvements in surgical technique have resulted in increased safety and use of IEM.[6,7] Nevertheless, key questions remain regarding the long-term trends in the utilization of IEM and whether increased use of IEM has resulted in improved safety and efficacy of epilepsy surgery in pediatric DRE.

In this issue of *Neurology*®, Wang et al.[8] have reviewed data about patients with DRE, aged 18 years and younger, from the Healthcare Cost and Utilization Project Kids' Inpatient Database (HCUP-KID) (which includes approximately 80% of the discharges from about 4,100 hospitals), from 2000 to 2012, to obtain proportions and determinants of patients undergoing IEM, associated adverse events, and resective epilepsy surgery. The authors report that while admissions for DRE evaluations nearly tripled from 2000 (n = 5,287) to 2012 (n = 14,949), the numbers of patients undergoing IEM did not increase proportionately (301 in 2000 to 393 in 2012). This represents a substantial decrease in the percentage of patients undergoing IEM. However, among those who underwent IEM, a higher proportion eventually had resective epilepsy surgery. Furthermore, over the same time frame, there was an increase in partial lobectomies compared to more aggressive surgical procedures. The authors also report differences in utilization of epilepsy surgery based on geographic region, race/ethnicity, and insurance payer. Although IEM was associated with complications including subdural hematoma (1.1%), meningitis (2.4%), and soft tissue infections (3.7%), the mortality rate for patients who underwent epilepsy surgery (whether with or without IEM) was lower than in patients with DRE who did not undergo surgery.

The trend for increased DRE admissions observed in this study is interesting. According to the authors, it may partially be attributable to the changes in billing codes. However, it is probably multifactorial and may also reflect improved referral of patients with DRE. The discrepancy between increased DRE admissions and lower IEM could potentially reflect increased 1-step resections from improved noninvasive localization. However, data from this study showed declining rates of upfront resective surgery.[8] An important confounder is that some of these admissions could have included patients without DRE. The increased propensity for IEM-

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guided smaller resections probably reflects improved confidence in surgical decision-making insofar as to resect/disconnect the minimum cortex sufficient to optimize the likelihood of seizure-free outcome vis-à-vis risks of postoperative deficits. In addition, it echoes a conceptual paradigm where destruction or isolation of the epileptogenic zone may not be desirable; instead, a critical interruption of the core seizure-generating network may be similarly effective and safer.

This study demonstrates that IEM helps surgical decision-making and likely improves seizure outcomes in patients who are MRI negative or have multilesion DRE.[5,8,9] However, in patients with a single potentially epileptogenic MRI lesion, sometimes the criterion for epilepsy surgery is stretched, and not all such patients may indeed have DRE. While this study confirms clinical impressions, it has certain limitations. First, HCUP-KID provides weights to extrapolate numbers from actual discharges using an obscure process that lacks information about unique patients who underwent IEM or epilepsy surgery. This can potentially inflate the numbers where for example, a postresection electrocorticograph may have been coded as a separate procedure-related discharge. Also, regarding the covariates for the number of DRE admissions, or the proportions of IEM or resective surgery, fitting a multilevel model with discharge identifier as a random effect and the data points at different times as repeated measures, could have been better. However, such mathematical models may not be intuitive to most clinicians, and may not add value for clinical decision-making, although they can highlight subtle patterns in the data. Finally, the adverse events reported in this study likely represent only those for IEM with subdural electrodes. These are consistent with a meta-analysis including 2,542 patients that reported neurologic infections (2.3%), superficial infections (3.0%), intracranial hemorrhage (4.0%), and elevated intracranial pressure (2.4%).[6] A similar meta-analysis for stereo-EEG monitoring showed lower frequency of overall (1.3%), hemorrhagic (1.0%), and infectious (0.8%) complications.[10] As stereo-EEG becomes increasingly utilized for IEM, it will be interesting to analyze similar trends in the future about access, efficacy, and safety of stereo-EEG–driven epilepsy surgery.

Author contributions

R.A.: study concept, data extraction, data interpretation, first draft, and revision of the manuscript for intellectual content. J. T.R.: data interpretation, and revision of the manuscript for intellectual content. Both authors approved the final submitted version.

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