Inspecting Resecting: Examining 20-Year Trends in Epilepsy Surgery

The Evolution of Epilepsy Surgery Between 1991 and 2011 in Nine Major Epilepsy Centers Across the United States, Germany, and Australia.

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OBJECTIVE: Epilepsy surgery is the most effective treatment for select patients with drug-resistant epilepsy. In this article, we aim to provide an accurate understanding of the current epidemiologic characteristics of this intervention, as this knowledge is critical for guiding educational, academic, and resource priorities. **METHODS:** We profile the practice of epilepsy surgery between 1991 and 2011 in nine major epilepsy surgery centers in the United States, Germany, and Australia. Clinical, imaging, surgical, and histopathologic data were derived from the surgical databases at various centers. **RESULTS:** Although five of the centers performed their highest number of surgeries for mesial temporal sclerosis (MTS) in 1991, and three had their highest number of MTS surgeries in 2001, only one center achieved its peak number of MTS surgeries in 2011. The most productive year for MTS surgeries varied then by center; overall, the nine centers surveyed performed 48% (95% confidence interval [CI] –27.3% to –67.4%) fewer such surgeries in 2011 compared to either 1991 or 2001, whichever was higher. There was a parallel increase in the performance of surgery for nonlesional epilepsy. Further analysis of 5/9 centers showed a yearly increase of $0.6 \pm 0.07\%$ in the performance of invasive electroencephalography (EEG) without subsequent resections. Overall, although MTS was the main surgical substrate in 1991 and 2001 (proportion of total surgeries in study centers ranging from 33.3% to 70.2%); it occupied only 33.6% of all resections in 2011 in the context of an overall stable total surgical volume. **SIGNIFICANCE:** These findings highlight the major aspects of the evolution of epilepsy surgery across the past two decades in a sample of well-established epilepsy surgery centers, and the critical current challenges of this treatment option in addressing complex epilepsy cases requiring detailed evaluations. Possible causes and implications of these findings are discussed.

Commentary

In 1886, there were three recorded epilepsy surgeries, all performed by Sir Victor Horsley (1). His patients had their heads shaved and soaked in carbolic acid for 12 hours. They were administered purgatives the night before surgery and enemas on the morning of surgery, and then were given morphine and chloroform before craniotomy, of which it was noted “our present means of removing the bone [making trephine-holes and cutting with a Hey’s saw] are open to considerable improvement.” All surgeries were extratemporal procedures, with seizures localized by focal skull fractures in two cases of post-traumatic epilepsy and by semiology (focal motor symptoms at onset in a patient of Hughlings Jackson) in a third. All had less than 4 months of follow-up at the time of his report, but this was a proof-of-concept rather than efficacy report.

Since that landmark year, there have been many efforts to track trends in epilepsy surgery.

One hundred years later (1986), the first international conference on the surgical treatment of epilepsy was held in Palm Desert, California (2). Reports were collected from 44 centers, thought to represent nearly all worldwide epilepsy surgical programs. Six years later, a second Palm Desert meeting documented remarkable growth: The number of surgical centers in the United States had more than doubled, and the annual number of epilepsy surgical procedures had tripled (3). The most common surgical procedure was anterior temporal lobectomy for mesial temporal lobe epilepsy. It was estimated that this increased pace of surgery was still inadequate to address the pool of untreated surgical candidates. Expected to further drive demand were the positive findings of a randomized clinical trial of epilepsy surgery in 2001 and subsequent 2003 AAN guidelines that strongly supported early referral of patients with poorly controlled epilepsy to epilepsy surgery centers (4, 5). Did this anticipated increase in epilepsy surgery materialize?

Data are not readily accessible in the United States, which lacks a national healthcare system. Nonetheless, several approaches to this question were undertaken. Englot et al. examined data from a large nationwide sample of nonfederal

U.S. hospitals spanning the period 1990 to 2008 (6). Over this period, they noted a marked increase in the annual rates of hospital admissions for refractory epilepsy—but not a corresponding increase in the rate of epilepsy surgeries, which remained relatively unchanged. The administrative data used in this study provided rough overall estimates but were unable to distinguish changes in rates of specific surgeries, such as the proportion of temporal and extratemporal cases. They noted a trend toward distribution of admissions across a larger number of hospitals; admissions to the 20 largest volume centers actually declined over the study period. The authors speculated that this shift away from major surgical centers might partly explain the dissociation between increased admissions and unchanged surgery rates. A community-based sample in the United States from 1993 to 2009 not only showed no growth but, in fact, a significant decline in surgery rates; however, the decline did not appear to be attributable simply to a change in referral patterns (7).

Perhaps most similar to the Palm Desert surveys was the recent work of Kaiboriboon et al. examining the surveys of the U.S. National Association of Epilepsy Centers over the period 2003 to 2012 (8). At the start of the period, 37 member centers reported surgical data, but by the end of the period, the ranks had swelled to 189. Again, a marked increase in epilepsy monitoring unit admissions was documented—including a doubling from 2008 to 2012—but this was accompanied by a 65% decrease in temporal lobectomy for hippocampal sclerosis over the 4-year period from 2006 to 2010, despite the increase in EMU admissions. In contrast, extratemporal surgeries showed growth; extratemporal procedures doubled over the last 5 years of the surveys, and beyond 2008, there were more extratemporal than temporal lobe surgeries.

Outside of the United States, reports from Germany (1989–2009) showed a similar increase in the number of patients evaluated for epilepsy surgery matched by an increase in number of patients who were not suitable candidates for surgery, and stable rates of surgery (9). Another report from three German centers specifically examined temporal lobe epilepsy surgery over a similar time period (1988–2008) and found an early increase in surgical volume over the first 4 years of the study period, followed by stable rates over the subsequent 16 years (10). Surgical candidates near the end of the study period were older and had epilepsy for longer durations, a finding that the authors suggested might indicate decreasing incidence of hippocampal sclerosis. Similar trends of decreasing epilepsy surgery were reported in the U.K. and Sweden (11, 12).

While each of these reports may be prone to bias or sampling error, they point to an undeniable trend toward increased evaluations of patients with refractory epilepsy without a corresponding increase in surgical procedures, as well as a decline rather than increase in what was once the most common epilepsy surgery: anterior temporal lobectomy for hippocampal sclerosis.

It is in this context that the welcome new report from 10 leading worldwide (United States, Germany, Australia) epilepsy centers appears. This report, tapping into the detailed surgical databases of these high-volume epilepsy surgery centers has the potential to provide a much more detailed picture of trends in epilepsy surgery than can be extracted from large

administrative databases. All participating centers reported data at three key time points—1991, 2001, and 2011—and data from six centers were detailed enough to examine annual trends over the two decades.

Over the span of the study, the number of epileptologists employed at these centers grew by 123%, while the number of surgeons increased by only 19%. Despite staffing increases (and presumably an increase in number of presurgical evaluations [not reported]), there was a trend toward fewer epilepsy surgeries over time, a finding most pronounced in temporal lobe resections for patients with mesial temporal sclerosis (MTS). The peak number of surgeries for MTS at most centers occurred in 1991, with only one center reporting peak MTS surgical volume in 2011. Overall, 48% fewer surgeries were done for MTS in 2011 compared with the previous peak year at each center, and there was a nonsignificant trend of a 25% decrease in total surgeries, though there was considerable heterogeneity among centers. Even in the context of declining overall surgery rates, MTS as a proportion of total surgeries shrunk from 42.6% (1991) to 36.5% (2001) to 30.5% (2011), while nonlesional surgeries increased from 22% (1991) to 33% (2011), accompanied by a threefold increase in intracranial evaluations not resulting in resection.

This valuable contribution to the conversation about trends in epilepsy surgery has its own limitations. Most prominent is the focus on large high-volume epilepsy centers, which may fail to capture important changes resulting from the rapid growth of lower volume centers.

Additionally, we should not forget the world outside of high-income countries. A recent study from India—a country of 1.2 billion people—reported a threefold increase in epilepsy surgeries from the period 1995 to 2000 to the period 2007 to 2012, three-quarters of which were temporal lobe surgeries (13). Reports from China signaled similar trends reminiscent of the growth seen in the U.S. reports from the early 1990s (14).

Jehi and coauthors grappled with the import of their study findings and offered several hypotheses to explain the decline of MTS-related surgery, the increase in extratemporal—especially nonlesional—epilepsy surgery, and the increased pursuit of intracranial evaluations that do not lead to resection.

Like most worthwhile research, this report raises as many questions as it answers. If the opportunities to perform highly successful mesial temporal surgeries are declining, how aggressively should we redeploy epilepsy surgery center resources to extratemporal and nonlesional cases that have relatively poorer outcomes and sometimes higher risk? How should we weigh and integrate complex factors such as patient wishes, likelihood of seizure freedom, risk of operative morbidity, risk of SUDEP without surgery, the irreversible nature of surgical treatment, and the likelihood of major medical or device advances in the intermediate future to guide patient decision making? Where is the borderland beyond which surgery should not be offered? If there is an acceptable rate of negative laparotomy or negative appendectomy, what is the acceptable rate of intracranial EEG monitoring without resection?

Sir Victor Horsley opened a new frontier in 1886, the boundaries of which continue to be mapped.

by David Spencer, MD

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