Epilepsy Research 127 (2016) 331–338

Contents lists available at www.sciencedirect.com

Epilepsy Research

journal homepage: www.elsevier.com/locate/epilepsyres

Preoperative prediction of temporal lobe epilepsy surgery outcome

Daniel M. Goldenholz (MD, Ph.D.)[a,*], Alexander Jow[a], Omar I. Khan (MD)[a,c], Anto Bagić (MD, Ph.D.)[a,1], Susumu Sato (MD)[b], Sungyoung Auh (Ph.D.)[d], Conrad Kufta (MD)[e], Sara Inati (MD)[b], William H. Theodore (MD)[a]

[a] Clinical Epilepsy Section, NINDS, NIH, United States
[b] Electroencephalography Section, NINDS, NIH, United States
[c] Office of the Clinical Director, NINDS, NIH, United States
[d] Clinical Neurosciences Program, NINDS, NIH, United States
[e] Neurosurgical Biology and Therapeutics Section, NINDS, NIH, United States

ARTICLE INFO

Article history:
Received 29 March 2016
Received in revised form 29 August 2016
Accepted 17 September 2016
Available online 22 September 2016

Keywords:
Epilepsy
Surgery
Outcomes
MRI
Video EEG
Long term monitoring

ABSTRACT

Purpose: There is controversy about relative contributions of ictal scalp video EEG recording (vEEG), routine scalp outpatient interictal EEG (rEEG), intracranial EEG (iEEG) and MRI for predicting seizure-free outcomes after temporal lobectomy. We reviewed NIH experience to determine contributions at specific time points as well as long-term predictive value of standard pre-surgical investigations.
Methods: Raw data was obtained via retrospective chart review of 151 patients. After exclusions, 118 remained (median 5 years follow-up). MRI-proven mesial temporal sclerosis (MTSr) was considered a separate category for analysis. Logistic regression estimated odds ratios at 6-months, 1-year, and 2 years; proportional hazard models estimated long-term comparisons. Subset analysis of the proportional hazard model was performed including only patients with commonly encountered situations in each of the modalities, to maximize statistical inference.
Results: Any MRI finding, MRI proven MTS, rEEG, vEEG and iEEG did not predict two-year seizure-free outcome. MTSr was predictive at six months (OR = 2.894, p = 0. 0466), as were MRI and MTSr at one year (OR = 10.4231, p = 0. 0144 and OR = 3.576, p = 0. 0091). Correcting for rEEG and MRI, vEEG failed to predict outcome at 6 months, 1 year and 2 years. Proportional hazard analysis including all available follow-up failed to achieve significance for any modality. In the subset analysis of 83 patients with commonly encountered results, vEEG modestly predicted long-term seizure-free outcomes with a proportional hazard ratio of 1.936 (p = 0.0304).
Conclusions: In this study, presurgical tools did not provide unambiguous long-term outcome predictions. Multicenter prospective studies are needed to determine optimal presurgical epilepsy evaluation.

Published by Elsevier B.V.

1. Introduction

Approximately 30% of patients with epilepsy have seizures that remain uncontrolled by medications (Kwan and Brodie, 2000). Surgery can be an effective option, leading to long-term seizure-freedom in 38–85% of patients (De Tisi et al., 2011; Engel et al., 2012; Jeha et al., 2006; Kelley and Theodore, 2005; Wiebe et al., 2001). The largest prospective randomized study (Wiebe et al., 2001) found 38% of temporal lobe epilepsy patients achieving 1-year postoperative complete seizure-freedom, versus 3% in the medical therapy group. A more recent smaller randomized study (Engel et al., 2012) reported 85% versus 0% 2-year complete seizure-freedom in surgical and medical groups respectively. Due to methodological differences (such as the timing of randomization), these two studies may not be directly comparable. Several studies emphasize the importance of a seizure-free outcome in order for patients to report significant improvements in quality of life after surgery (Birbeck et al., 2002; Leidy et al., 1999; Modi et al., 2009). Although surgery is often the best option to achieve seizure-freedom, surgery does

Abbreviations: EEG, electroencephalogram; vEEG, inpatient scalp video-electroencephalogram; rEEG, routine scalp outpatient electroencephalogram; MRI, magnetic resonance imaging; MTS, mesial temporal sclerosis.

* Corresponding author at: National Institutes of Health, NINDS Clinical Epilepsy Section, CNP, DIR 10 Center Drive, 10-CRC, Room 5S-209, MSC 1408, Bethesda, MD 20892, United States.
E-mail address: daniel.goldenholz@nih.gov (D.M. Goldenholz).
[1] Present address: Comprehensive Epilepsy Center, University of Pittsburgh.

http://dx.doi.org/10.1016/j.eplepsyres.2016.09.015
0920-1211/Published by Elsevier B.V.

carry some degree of morbidity. This emphasizes the importance of seizure outcome prediction in presurgical decision-making.

It is widely recognized that video-EEG is the bedrock of epilepsy diagnosis (Ghougassian et al., 2004; Jin et al., 2014; Perry et al., 1983; Theodore et al., 1983). It is a test with rare but measurable risks. An international survey from 147 inpatient EEG monitoring centers reported 49 deaths over 3008 patient-years (Ryvlin et al., 2013). Additional risks include status epilepticus, cardiac complications, dislocations and vertebral fractures (Noe and Drazkowski, 2009). Aside from its role in diagnosis, ictal scalp video-EEG (vEEG) has also been considered a useful predictor of surgical outcome (Armon et al., 1996; Holmes et al., 2000; Tatum et al., 2008; Uijl et al., 2008a). However, a recent study discriminated the lowest surgical success group (48% seizure-free) from the highest (72% seizure-free) without including the results of vEEG (Garcia Gracia et al., 2015). Perhaps modern imaging has outpaced vEEG in identifying markers of surgical success, given that many studies have found valuable prognostic value from imaging, while fewer consistently find prognostic value from vEEG (Zhang et al., 2013). Even in the case of MRI imaging, it has been difficult to show a consistent unequivocal predictive value, possibly due to the lack of objective analytic techniques (Bernhardt et al., 2015).

Given the safety concerns and conflicting data, we reviewed the experience of the National Institutes of Health over a 28-year period. Our objective was to examine the prognostic value of preoperative localizing procedures for temporal lobectomy outcome.

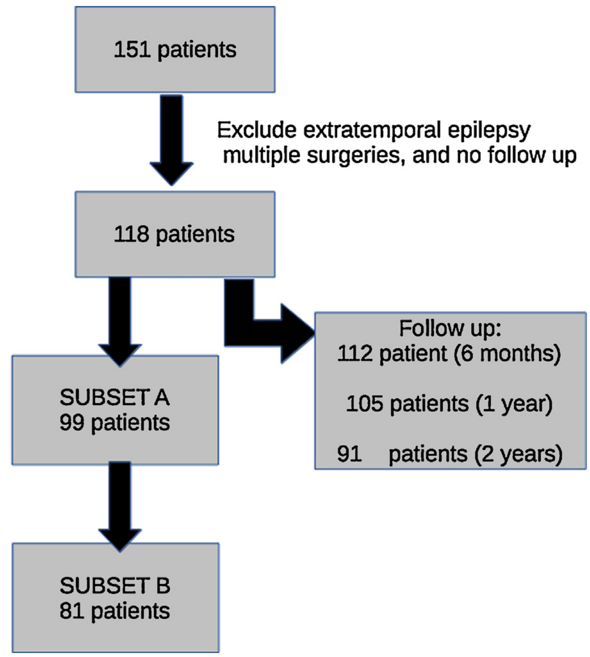

Fig. 1. Patient allocation. Patients were drawn from consecutive epilepsy resection surgeries from Jan 1, 1984 to Jan 1, 2012. Subset A refers to patients that have rEEG codes "concordant" or "partially concordant" as well as vEEG codes "concordant" or "partially concordant". Subset B are patients in subset A that also have MRI codes of either "concordant" or "normal/diffuse/no data". The subsets were chosen because they represent the most commonly encountered codings.

2. Methods

A retrospective review was performed of the 151 consecutive, resective epilepsy surgical cases at the National Institutes of Health between January 1, 1984 and January 1, 2012. All subjects were enrolled in research protocols in accordance with our institutional review board. Each underwent presurgical evaluation, including 1.5 T or 3.0 T magnetic resonance imaging (MRI), interictal routine scalp electroencephalography (rEEG), and vEEG. The available interictal video EEG data was included, however in many cases data was no longer available for review. Dr. Sato, Dr. Theodore or Dr. Inati performed all primary EEG interpretation at NIH during the study period. Data from FDG-PET scans were excluded because not all patients in the sample had the test. After surgery, patients were followed in clinic for a median of 5.0 years, (range 0–23.2 years). Seizure-freedom outcome data was obtained via in-person clinic follow-up at the NIH Clinical Epilepsy Section. Data were corroborated with EEG clinical histories and nursing notes when possible. Of note, because of the retrospective nature of this study, there was no standard clinic follow up interval – each patient was somewhat different. When less than 2 years of clinical follow-up outcome data was unavailable, telephone or mail contact was used to obtain more updated outcome information.

For this study, patients who had extratemporal operations, repeat surgeries, or no follow-up were excluded. Temporal lobectomies were mostly standard anterior temporal lobectomies with the exception of 6 that included temporal lesionectomies. All the surgeries (except 6 cases) were performed at NIH. The included 118 patients (Fig. 1) had each of the presurgical modalities coded as either "fully concordant," "partially concordant," "discordant," or "normal/diffuse/no data." The coding reflects the seizure focus localization by the modality compared to the location of surgical resection. Specifically, intracranial EEG (iEEG) coding represented the operative interictal localization, vEEG represented the ictal localization, the rEEG represented the interictal localization based on the most clear focal finding (epileptiform discharges when present, focal slowing when discharges were absent), and the MRI coding represented the location of the lesion if present. In cases where a modality was employed more than once, the composite of all exams was coded. Thus, when multiple routine EEGs were obtained, for example, if all of them identified the same region that was ultimately resected, then rEEG was coded "concordant". On the other hand, if 2 routine EEGs were "concordant" and 1 was "discordant," then rEEG would be coded "partially concordant". Furthermore, if at least 1 was "concordant," and others were "normal," this was coded as "concordant" as well. Of note, MRI codes accounted for the sum of the final impression from the radiology report and the consensus opinion of the multidisciplinary surgical review conference findings – any focal findings from either would be included when coding. If multiple localizations were present, all of them were accounted for when coding concordance with surgical resection. Additional codes for presence or absence of mesial temporal sclerosis (by consensus of radiologist and epileptologists) on the MRI scan (MTSr) were also included. When the localization included multiple areas (e.g. bitemporal spikes on rEEG, or multifocal hyperintensities on MRI etc.), then when the surgical resection included part of the localization, these were coded as "partially concordant". When localization did not include the resection volume (such as contralateral hippocampal changes) then "discordant" was coded. Original clinical imaging, EEG and pathological reports were used, and the studies were not reinterpreted.

To address the possibility that changing MRI technology played a role in MRI predictive capability, we also divided the MRIs into subcategories based on the year of the most recent presurgical MRI available, using ranges of 1984–1990, 1990–2000, and 2000–2011 as categories. Unfortunately, the actual magnet strength and full descriptions of pulse sequences were often not documented in the available reports, therefore we used year of scan as a surrogate for technological improvement.

Two additional subsets of patients were evaluated for the proportional hazard analysis in an effort to decrease the heterogeneity of the population and thereby improve the statistical inference. In