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Review

A modern epilepsy surgery treatment algorithm: Incorporating traditional and emerging technologies

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ABSTRACT

Epilepsy surgery has seen numerous technological advances in both diagnostic and therapeutic procedures in recent years. This has increased the number of patients who may be candidates for intervention and potential improvement in quality of life. However, the expansion of the field also necessitates a broader understanding of how to incorporate both traditional and emerging technologies into the care provided at comprehensive epilepsy centers. This review summarizes both old and new surgical procedures in epilepsy using an example algorithm. While treatment algorithms are inherently oversimplified, incomplete, and reflect personal bias, they provide a general framework that can be customized to each center and each patient, incorporating differences in provider opinion, patient preference, and the institutional availability of technologies. For instance, the use of minimally invasive stereotactic electroencephalography (SEEG) has increased dramatically over the past decade, but many cases still benefit from invasive recordings using subdural grids. Furthermore, although surgical resection remains the gold-standard treatment for focal mesial temporal or neocortical epilepsy, ablative procedures such as laser interstitial thermal therapy (LITT) or stereotactic radiosurgery (SRS) may be appropriate and avoid craniotomy in many cases. Furthermore, while palliative surgical procedures were once limited to disconnection surgeries, several neurostimulation treatments are now available to treat eloquent cortical, bitemporal, and even multifocal or generalized epilepsy syndromes. An updated perspective in epilepsy surgery will help guide surgical decision making and lay the groundwork for data collection needed in future studies and trials.

1. Introduction

Epilepsy surgery has seen numerous changes in recent years, necessitating continued updates to the treatment algorithms for this disorder. This field has achieved technological advances in both diagnostic and therapeutic procedures, and previously unavailable treatment options have been introduced. The core strategy in the evaluation of drug-resistant epilepsy remains relatively consistent: noninvasive presurgical evaluation, with or without invasive intracranial monitoring, followed by a therapeutic intervention [1]. However, many of our diagnostic capabilities have improved, and surgical options now extend beyond subdural electrodes (SDE) and resection or disconnection. These changes in the new era of epilepsy surgery hinge primarily on the improvement or development of minimally invasive diagnostic and ablative procedures, as well as the introduction of nondestructive neurostimulation techniques. In addition to subdural grid and strip electrodes, wider use and refinement of stereotactic electroencephalography (SEEG) have permitted invasive electrographic monitoring while avoiding a craniotomy. Beyond lobar or multilobar resection or disconnection, newer ablation procedures include laser interstitial thermal therapy (LITT) guided by magnetic resonance imaging (MRI) and stereotactic radiosurgery (SRS), while neuromodulation techniques now comprise closed-loop responsive neurostimulation (RNS) and open-loop deep brain stimulation (DBS), as well as open- or closed-loop vagus nerve stimulation (VNS). While the expanding armamentarium of surgical interventions in this field is certainly welcomed, it also introduces new challenges in selecting which diagnostic or therapeutic strategy is best for each individual patient.

The goal of this paper is to review both novel and traditional interventions in epilepsy surgery, and discuss one possible treatment algorithm for epilepsy surgery in the modern era (Fig. 1). With this

Abbreviations: AED, antiepileptic drug; ATL, anterior temporal lobectomy; EEG, electroencephalography; EZ, epileptogenic zone; fMRI, functional magnetic resonance imaging; LITT, laser interstitial thermal therapy; MEG, magnetoencephalography; MRI, magnetic resonance imaging; MST, multiple subpial transections; PET, position emission tomography; RNS, responsive neurostimulation; SAH, selective amygdalohippocampectomy; SDE, subdural electrodes; SEEG, stereotactic electroencephalography; SPECT, single-photon emission computed tomography; SRS, stereotactic radiosurgery.

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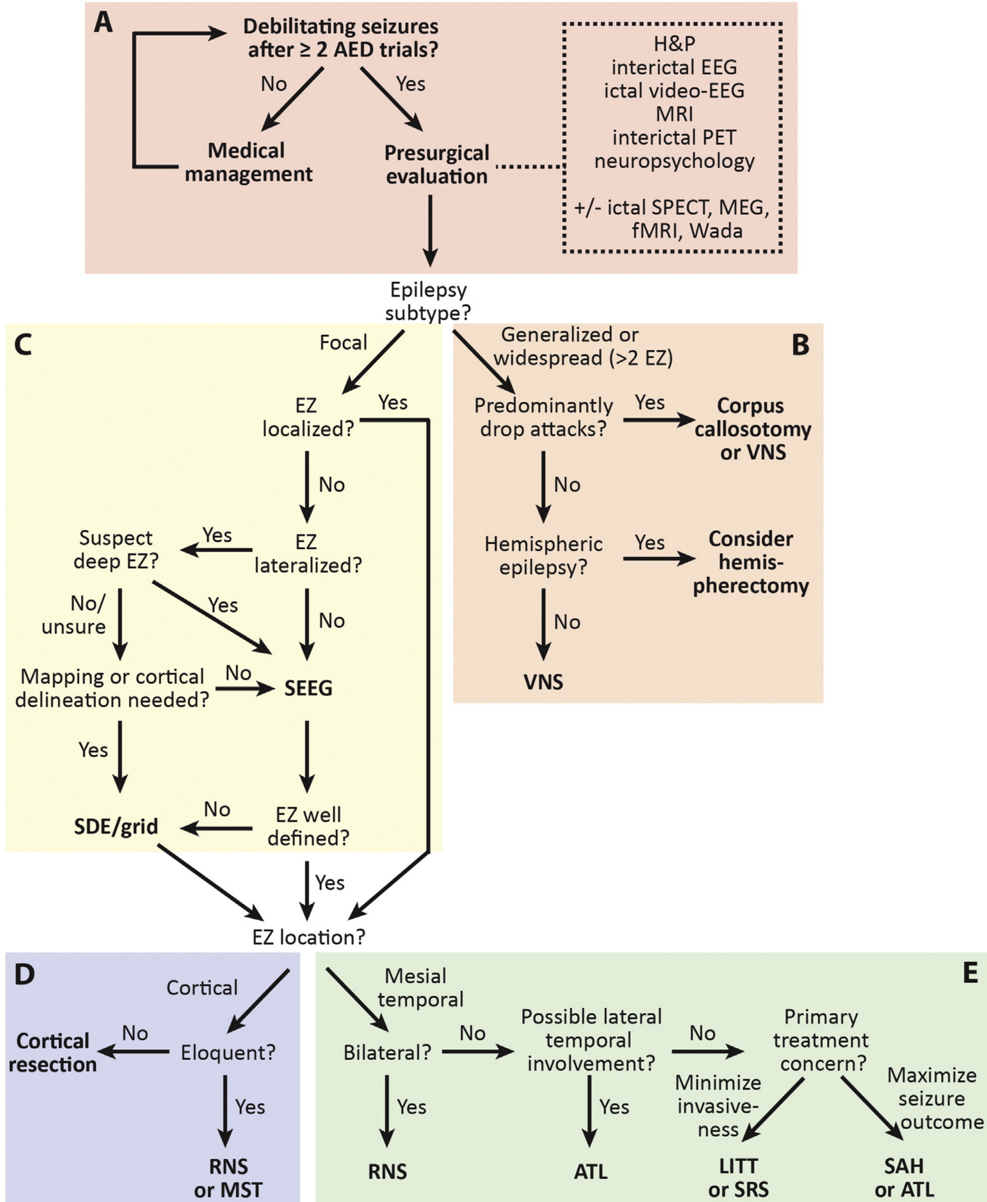

Fig. 1. A modern epilepsy surgery treatment algorithm. The algorithm begins with noninvasive surgical evaluation (A), and includes treatment of generalized or multifocal epilepsy (B), invasive monitoring decisions (C), and treatment of neocortical (D) or mesial temporal lobe (E) epilepsy. AED: antiepileptic drug; ATL: anterior temporal lobectomy; EEG: electroencephalography; EZ: epileptogenic zone; fMRI: functional magnetic resonance imaging; LITT: laser interstitial thermal therapy; MEG: magnetoencephalography; MRI: magnetic resonance imaging; MST: multiple subpial transections; PET: position emission tomography; RNS: responsive neurostimulation; SAH: selective amygdalohippocampectomy; SDE: subdural electrodes; SEEG: stereotactic electroencephalography; SPECT: single-photon emission computed tomography; SRS: stereotactic radiosurgery.

goal in mind, several disclaimers are in order. The present algorithm reflects the author's individual opinions and personal biases, and therefore, should not be viewed as a definitive clinical guide. Furthermore, no single treatment algorithm is appropriate for every epilepsy center or every patient, as clinical decisions are influenced by institutional availability of technologies and provider opinion and experiences. Also, there are often specific nuances related to individual cases that cannot be captured in a flowchart. While not quite simple, this algorithm is a simplified summary that excludes several clinical scenarios, for the sake of conciseness. Finally, just as quickly as the field of epilepsy surgery has changed in recent decades, we may expect a continued rapid evolution going forward. As such, continued modification and modernization will be required, as has been the case with previous algorithms. The value of this approach, however, is to encourage examination of both old and new surgical options side-by-side, through a critical review of the relevant literature. The timeliness of this topic rests in the fact that despite the introduction of several new antiepileptic drugs (AEDs) over the past two decades, the proportion of drug resistance among patients with epilepsy remains at approximately 30–40%, and high rates of morbidity and mortality persist [2]. Furthermore, despite class I evidence and consensus guidelines establishing the efficacy of epilepsy surgery, surgical interventions remain dramatically underutilized in this disorder, with fewer than 1% of eligible candidates referred for surgical evaluation [2,3]. Our goal is that an improved understanding of therapeutic options in drug-resistant epilepsy may lead to improved access, utilization, and treatment success.

2. Presurgical epilepsy evaluation (Fig. 1A)

Patients with epilepsy who continue to have seizures despite treatment trials with two well-tolerated AEDs or drug combinations should be referred to a comprehensive epilepsy center for noninvasive