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

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 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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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

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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...