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Review Article

Spectrum of neurosurgeon's role in epilepsy surgery

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ABSTRACT

It is well known that there is high quality evidence of epilepsy surgery as an effective and safe option for patients with drug refractory epilepsy by advanced imaging technology and computerized electrophysiological facilities during recent three decades. However, it still remains debate regarding necessities of epilepsy surgery in terms of less satisfactory surgical outcome, especially in non-lesional neocortical epilepsies. This review is for the role of epileptic neurosurgeon rather than the role of epilepsy surgery, namely, the necessity of neurosurgeon's positive participation starting from the first visit of epilepsy patients followed by pertaining process by stages and its degree of contribution. All experienced epilepsy centers also need innovative or challenging trial absolutely through this kind of standpoint, because all of the present protocols and techniques are coming from the past. In any event, the interdepartmental and interpersonal cooperation is inevitable especially for improving patient's quality of life. Serious neurosurgical considerations are needed for patients with intractable epilepsies, especially in referred cases from other center for the purpose of double check, and incongruent cases with contrary opinions by epileptologist.

It is well-known that epilepsy surgery is a reasonable therapeutic option for patients suffering from recurrent epileptic attacks despite the best medical treatment [1,2], since Sir Victor Horsley first conducted a first surgical resection of a cortical scar in a patient with recurrent Jacksonian seizures. Great contributions of Penfield and Jasper at the Montreal Neurological Institute firmly established basic epilepsy surgery techniques became an important historical landmark [3–6].

George Ojemann at University of Washington Medical Center developed the practical intraoperative functional brain mapping especially cortical language localization [7] with modern sophisticated EEG techniques and neuroimaging, which improved the surgical outcome further and the number

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of epileptic patients having surgery has increased significantly [8]. Nowadays, there is high quality evidence that epilepsy surgery became an effective and safe option for patients with drug-refractory epilepsy.

However, most surgeons are generally interested in and trained themselves in surgical techniques itself, namely, 'Hammerman'. Moreover, in terms of practical situation of epilepsy surgery, epilepsy surgeon is usually concerned only about the surgical procedures of candidate who was already decided and referred by epileptologists. For this reason, this review is focusing on the 'role of neurosurgeon' as an introductory remark along with the subject of the procedural issues of epilepsy, stepping aside from surgical point of view.

Baseline protocol for presurgical evaluation

Patients are considered for the epilepsy surgery if they have medically intractable epilepsy that interferes with quality of life significantly. Our sequential protocol for presurgical evaluation consists of a battery of tests designed to both lateralize and localize the epileptogenic region. Intractable patients with incidental small lesions on high-resolution MRI could also enter into this protocol to identify adjacent and/or remote epileptogenic areas [9].

Presurgical evaluation

Phase I (non-invasive studies); All patients evaluated for surgery undergo complete clinical history and detailed semiology, electrophysiologic (scalp EEG and 24-h video-EEG monitoring) and neuroimaging (CT, MRI, SPECT, PET) studies, and neuropsychological studies [10,11] with intracarotid amobarbital procedure (IAP). Data from the noninvasive evaluation are analyzed in an attempt to localize the area of brain responsible for initiation of the patient's habitual seizures. It suggests a localized area responsible for the seizures, surgery is recommended.

Phase II (invasive monitoring); Intracranial recordings are performed in patients who may be good candidates for surgery but who do not meet criteria for surgery based on noninvasive evaluation. Multiple types of implanted electrodes, such as subdural strip, grid and/or depth electrodes may be used. The type and location of electrodes are carefully determined to prevent sampling error.

Intraoperative evaluations: Tailored resection for minimalism by intraoperative acute recording (Electrocorticography; ECoG) and functional brain mapping with the electrical stimulation techniques [12,13] to identify the epileptic and/or essential areas related to language or sensorimotor are usually performed under local and intravenous Propofol anesthesia [14].

Procedural issues to decide candidate of epilepsy surgery

This review is for the role of epileptic neurosurgeon rather than the role of epilepsy surgery, namely, the necessity of neurosurgeon's positive participation starting from the first visit of epilepsy patients followed by pertaining process by stages and its degree of contribution. Therefore, we, epileptologists including epileptic neurosurgeon, would be better to change our attitude and mind as caring the patient's individual medical diversity instead of caring epilepsy itself, for the purpose of improving patient's quality of life [11].

Table 1 – Confirmatory procedural issues to select the candidate of epilepsy surgery.

1. Basic confirmatory diagnosis & cause of epilepsy
2. Consideration of additional medical therapy
3. Participation to surgical conference in epilepsy monitoring unit
4. Contribution to decide intracranial recording
5. Intraoperative functional mapping under awake
6. Modification of surgical strategies

The procedural issues to decide the surgical candidates [Table 1] are designed and proposed based on personal experience to search the practical situations regarding how much of this role we have been playing for surgical decisions on the subject of process of management by stages.

Basic confirmatory diagnosis & cause of epilepsy

In case, a patient was referred as a candidate of epilepsy surgery from outside, what is going to do as a neurosurgeon? Do we need re-evaluation for basic confirmatory diagnosis with neuroimaging and EEG and verification of cause of epilepsy? Otherwise, do we need re-refer to epileptologist or EEGgrapher specialist or recommend admission directly to epilepsy monitoring unit for presurgical evaluations?

Although it depends on patient's condition with the medical and neuroimaging information brought by the patient, double check for confirmation of diagnosis and cause of epilepsy is inevitable in terms of surgical decision, such as, the patient is truly epilepsy, really non-lesional epilepsy or really medically intractable. Moreover, in extraordinary case referred as inoperable epilepsy with epilepsia partialis continua (EPC), serious consideration is needed whether it is really inoperable lesion.

For this reason, we, neurosurgeon, need further knowledge of basic work-up with EEG, including ictal-EEG and intraoperative electrocorticogram (ECoG) as well as neuroimaging studies for cooperative understanding and decision of surgical candidates.

Consideration of additional medical therapy

In case, a patient is referred as a candidate of epilepsy surgery, it is very important to make sure whether the patient is really medically intractable or not. In this standpoint, do we, neurosurgeon need more experiences to consider additional appropriate medical therapy, regarding appropriate add-on combination of recent antiepileptic drugs (AEDs) such as AMPA antagonist or potassium channel modulator and/or adjunct trial of alternative AEDs?

Benzodiazepines, for example, are rarely used as long term therapy for patients with epilepsy, however, once traditional antiepileptic drugs have failed, an adjunct trial may be justified to reduce seizure frequency. Sugai [15] reported the excellent efficacy of clobazam and excellent and prolonged

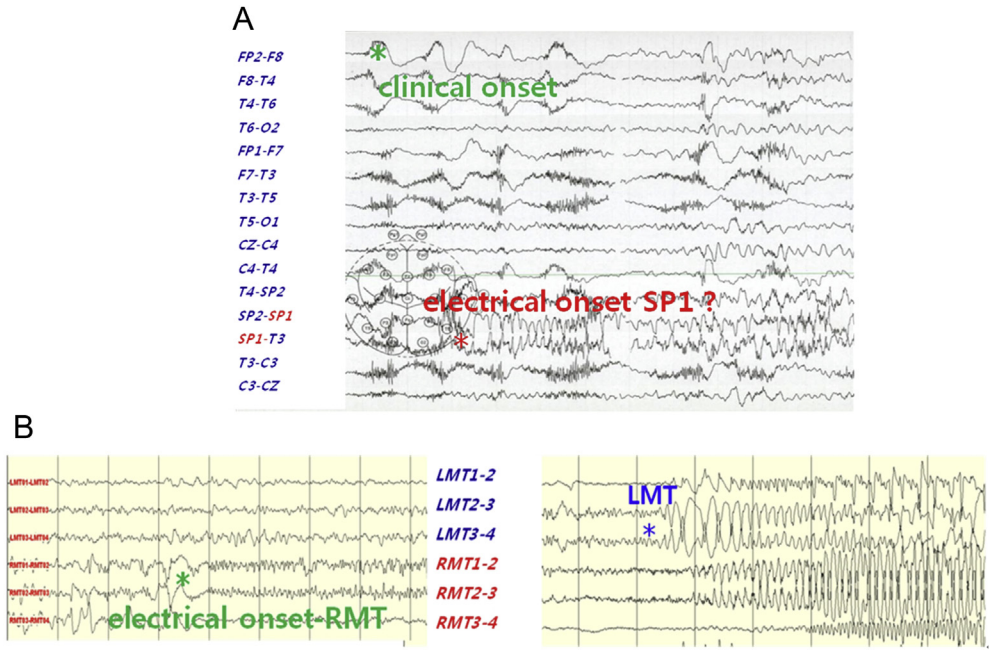

Fig. 1 – A. Ictal scalp electroencephalogram (EEG) shows suggestive electrical onset on left sphenoid electrode (SP1). B. Intracranial recordings with bi-temporal strip electrodes, verified as the definite initiation of the electrical onset on right medial temporal (RMT) electrodes 13 s before left medial temporal (LMT).

efficacy of clorazepate for refractory epilepsies. Abdelmoity et al. [16] also reported a significant reduction in seizure frequency in all patients started on Tranxene SD (a sustained release preparation of clorazepate), in a retrospective study of 'Efficacy of Tranxene SD in Patients with Refractory Epilepsy'.

Active participation to surgical conference in epilepsy monitoring unit

In case contrary opinions with epileptologist by incongruent results, how do we proceed next step regarding intracranial

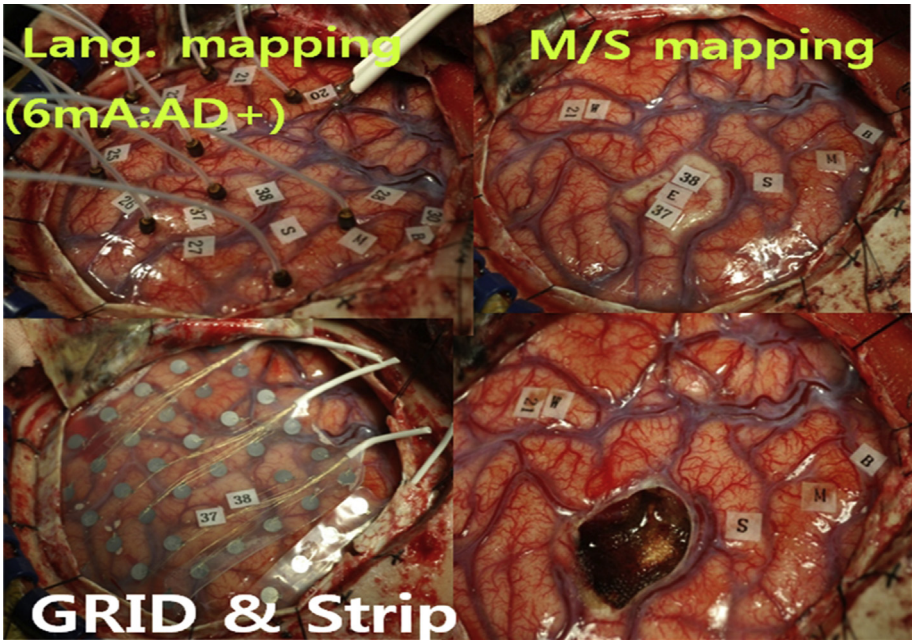

Fig. 2 – Left posterior perisylvian and central area was covered with subdural grids and strips in a patient of 38 year-old male with intractable epilepsy, which was verified as small localized epileptic area (E 37, 38) and performed small corticectomy on Lt. inferior parietal lobule, just posterior sensory cortex (S) and near Wernike's sensory language area (W21) confirmed by intraoperative language and sensorimotor (M/S) mapping with electrical stimulation under awake and Propofol anesthesia. B: Broca's language area.

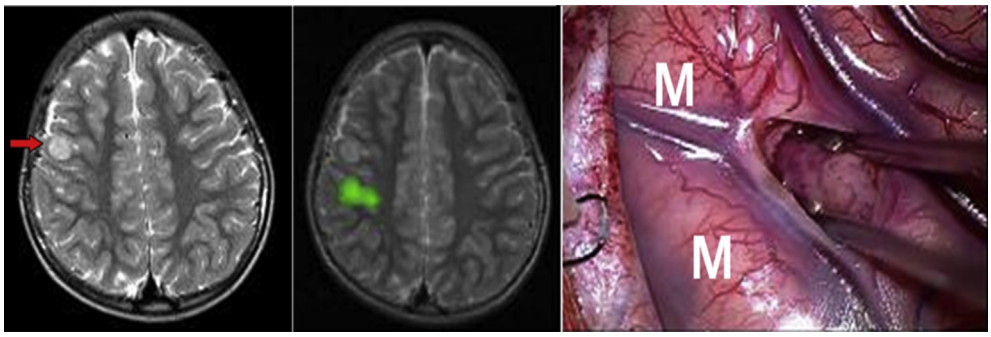

Fig. 3 – 7 year-old boy with small round mass in MRI was referred for surgery due to frequent brief motor seizure, which was removed successfully adjacent right motor area by intraoperative stimulation mapping to confirm motor area (M) under awake. Green dot: motor area in functional MRI.

recording and how much do we participate the case conference actively to decide the location and extent of surgical resection? For example, if we, neurosurgeon grab the hammer, who is in charge of decision making for the location and number of nail?

As an illustrative case, the laterality of operation was changed after intracranial recording, who was 34 year-old male with intractable temporal lobe epilepsy (TLE) resulted successful surgical outcome. Initially, the epileptologist recommend the left temporal surgery [Fig. 1A], based on possible ictal onset on left sphenoid EEG (SP1) and diffuse atrophy on left temporo-parietal area caused by childhood meningitis. However, suspicious delayed ictal EEG onset rather than clinical onset urged to perform the intracranial recording with bi-temporal strip electrodes, verified as the definite initiation of the electrical onset on right medial electrodes [Fig. 1B], which became seizure free postoperatively after right temporal surgery.

Contribution to decide intracranial recording

Regarding the contribution of neurosurgeon in terms of intracranial recording for surgical candidates especially for localization or lateralization of epileptic area, it absolutely depends on who is in charge of decision-making for, such as indication, location and numbers of intracranial electrodes as well as the extent of coverage and selection of type of intracranial electrodes.

As a unique illustrative case, 38 year-old male with intractable epilepsy showed non-lesional MRI and non-regional EEG findings unfortunately. During surgical case conference with serious consideration of inoperable or possible option, we finally decided to perform the challenging trial of intracranial subdural grids only based on not so definitive semiology of brief sensory seizure on right hand followed by brief speech arrest. Left posterior perisylvian and central area was covered with subdural grids and strips, which was verified as small localized epileptic area on Lt. inferior parietal lobule, just posterior sensory cortex and near Wernike's sensory language area confirmed by intraoperative language and sensorimotor mapping with electrical stimulation under awake and Propofol anesthesia [Fig. 2]. The patient became seizure free after small corticectomy only.

Intraoperative functional mapping under awake

In case, a patient with small indolent mass in MRI was referred for possibility of operation from other center due to its location in motor area, the techniques of awake surgery and intraoperative functional mappings are obligatory in terms of neurosurgeon's role?

As a pediatric illustrative case, 7 year-old boy with small indolent mass in central area was referred for surgery due to epilepsia partialis continua (EPC), which was removed successfully adjacent right motor area by intraoperative stimulation mapping to confirm motor area (M) under awake [Fig. 3].

Modification of surgical strategies

In most cases of medically refractory partial epilepsy, the first choice of treatment is resective surgery if the seizure focus can be definitively localized and if surgery can be safely performed without causing intolerable neurologic deficits.

However the modification of surgical strategies such as major stream or even minor surgical techniques of various options is needed for better surgical outcome based on initial experiences. Son et al. concluded that surgical outcome of epilepsy surgery has improved over time and it has shown to

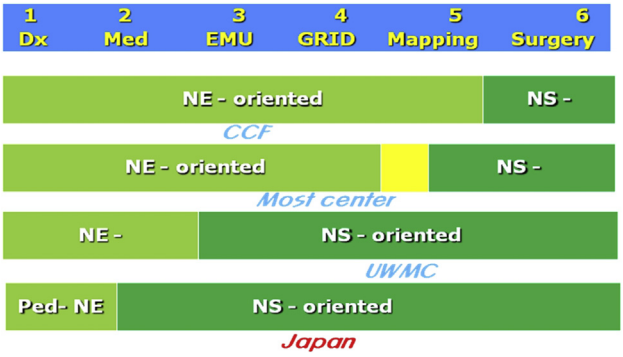

Fig. 4 – Degree of contribution and the role of neurosurgeon according to procedural issues differ in each Epilepsy Center, even in different country. Abbreviations used: Dx: diagnosis, Med: medication, EMU: EEG monitoring units, NE: neurology, NS: neurosurgery, Ped: pediatrics, CCF: Cleveland Clinic Foundation, UWMC: University of Washington Medical Center.

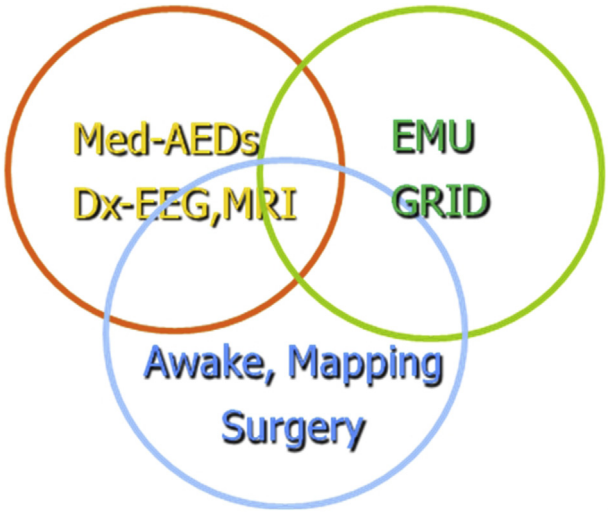

Fig. 5 – Overlapped diagram of interdepartmental collaborations for surgical candidates of intractable epilepsies. Med: medication, Dx: diagnosis, EMU: EEG monitoring units.

be efficient to control medically intractable epilepsy with appropriate patient selection, comprehensive preoperative assessments and more extensive resection resulted good postoperative outcome [17,18].

Patients with medically refractory epilepsy who are not candidates for potentially curative surgery may benefit from the implantation of a neuromodulation device, such as vagus nerve stimulation (VNS), deep brain stimulation (DBS), responsive neurostimulation (RNS), trigeminal nerve stimulation (TNS). Furthermore, the efficacy of these devices continues to improve over years. There are currently no head-to-head trials comparing the different neuromodulation devices but efficacy appears to be roughly similar [19,20]. Studying the prognostic factors and the evolution of surgical strategies for surgically remediable epilepsy can surely lead to better surgical outcomes. In summary, all the procedural issues and strategies could be modified depends on neurosurgeon's ability and experiences.

Actually, the role of neurosurgeon differs in each Epilepsy Center, even in different country [Fig. 4]. However the reason for making the extent of role is naturally the necessity of neurosurgeons' adequate degree of contribution endowed with professional knowledge which enables them to cope with every step of process and procedures is on the rise.

Conclusion

Based on the review of the procedural issues, it is worthwhile to expand the role and responsibility of epileptic neurosurgeons for decision making to proceed the next step for sophisticated extensive evaluation or giving up surgery for patients with medically refractory epilepsies, regarding the debating procedural issues. Double check of differential diagnosis and medical intractability are needed in referred cases from other center, and serious neurosurgical considerations are inevitable especially in incongruent cases with contrary opinions by epileptologist in surgical candidate for intractable epilepsies. In any circumstances, interpersonal and interdepartmental collaborations [Fig. 5] are very important especially for improving patient's quality of life.

Conflicts of interest

The authors have no financial conflicts of interest.

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