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Recent advances in the presurgical evaluations in epilepsy surgery

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Epilepsy surgery has been regarded as one of the most effective treatment approaches in the selected patients with intractable epilepsy. Recent advances in clinical electrophysiology and brain functional imaging have led to less invasive, more accurate presurgical evaluation, but essentially it should delineate an epileptogenic zone and define the eloquent cortices at or close to the epileptogenic zone before surgery. Epilepsy surgery is considered to the patients with intractable epilepsy when seizures disable them very much in daily life, and when seizures also progressively lead to neurological deterioration. It improves their quality of daily life, the functional state and its prognosis, and risk of accidents caused by seizures. Therefore, it is very essential to select the patients for surgery most reliably and most effectively, and less invasive evaluation is also very important to avoid any unnecessary risk with invasive methods.

From the view of presurgical evaluation, the current era is regarded as the crossover between the old and new stages; the former with well-established, either gold standard or almost reliable methods such as invasive EEG recording, intraoperative ECoG and conventional image techniques (CT, MRI, SPECT, etc.), and the latter with newly developed and rapidly introduced, less invasive techniques such as magnetoencephalography (MEG), functional MRI (fMRI), near-infrared spectroscopy (NIRS), FDG-PET and SPECT by using newly introduced ligands (flumazenil, iomazenil, etc.).

This paper introduces the three recent topics of presurgical evaluation in epilepsy surgery that could improve the current problems or concerns.

Is the core epileptogenicity well delineated? Is cortico-cortical connection investigated before surgery? Ictal DC shifts and cortico-cortical evoked potentials

In patients with neocortical epilepsy like frontal lobe epilepsy, even implanted subdural electrode grids at times show widely distributed, ill demarcated ictal onset activity, and thus it is very difficult to define the core epileptogenicity, if present, by means of conventional EEG recording. Ictal DC shift was recorded with the setting of long time constant of EEG amplifier such as 10 sec and more, and can reflect sustained paroxysmal depolarization shifts (PDSs). It also represents the degree of passive depolarization of glial cells which surround the seizing neurons as a syncitium connected by gap junctions. Recently, it is pointed out that astrocytes at the cortical dysplasia made experimentally demonstrated the abnormal potassium buffer function in the extracellular space.[1] It potentially augements the degree of ictal DC shifts with the abnormal glial cells. Usually epileptogenic zone in so-called " symptomatic" epilepsy is invariably accompanied by gliosis, and thus glia seems to plays an important role for modulating the degree of epileptogenicity.[2] We have shown that ictal DC shifts recorded from the subdural electrodes in patients mainly with neocortical epilepsy was recorded from the 1 or 2 selected electrodes among ones showing conventional ictal EEG patterns, and it often preceded the conventional ictal EEG onset by several sec or more.[3,4] It is most likely that ictal DC shifs complement the conventional ictal EEG recording, by reflecting the PDS and abnormality of glial activity.

Cortico-cortical evoked potentials (CCEPs) are elicited by single pulse electric cortical stimulation of the cortex in human epilepsy, and this transient potentials were recorded not only at the adjacent electrodes to but also at the distant one from the stimulus site with the latency of several to tens of msec. The latter was demonstrated as the evoked potentials at the posterior language area in response to the stimulation at the frontal language area 5. This technique can aid in clarifying the functional connectivity within or between lobes, and can aid in clarifying the mechanism of seizure propagation.

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Is less invasive and precise mapping possible? Bereitschaftspotentials or readiness potentials for motor mapping

Functional mapping by electric cortical stimulation is a well established reliable method as a gold standard in functional neurosurgery since 1950s of Penfiled's era, and it has been developed with chronically implanted electrodes as well as awake surgery.[6,7] Recent advances in neuroimaging studies enable us to complete functional mapping noninvasively before surgery by means of fMRI, but it still needs to investigate the degree of specificity and the sensitivity. In the present time, it can aids in planning the placement of subdural electrode implantation, and aids in stimulation during awake surgery. MEG also could delineate the epileptic sources and functional landmarks by means of various kinds of exogenous evoked magnetic fields (somatosensory-, auditory-, and visual evoked fields, etc.) and endogenous magnetic fields (event-related fields, etc.).

Among endogenous potentials, Bereitschafts-potentials (BPs) are defined as slow potentials occurring before voluntary movement onset by 1 to 2 sec, and they are generated from the primary- and non-primary motor cortices such as lateral premotor area, supplementary motor area proper and pre-supplementary motor area.[8,9,10] At least for motor mapping, BPs provide complementary information to cortical stimulation because (1) BP can be investigated in voluntary movements of any body parts, and (2) no risk of seizure or afterdischarge induction as compared with cortical electric stimulation. At the same time, it needs several concerns as follows; repeated trials of voluntary movements are needed for obtaining the averaged wave forms, and thus patient's cooperation is also needed.

Does verbal memory decline inevitably by left hippocampal resection? Basal temporal language area and left temporal stem disconnection by transsylvian approach

In mesial temporal lobe epilepsy, hippocampal sclerosis/ atrophy is well delineated by MRI, and FDG-PET can further delineate the epileptogenic zone, and thus, invasive ictal EEG records are less needed. However, verbal memory decline after mesial temporal resection on the dominant hemisphere seems to impede the surgical treatment in patients especially with normal cognitive function. Long term-follow up of patients witl left temporal lobe resection resulted in progressive decline of verbal memory in more than 10 years after surgery, that was more than that of patients without surgery.[11] Even selective hippocam-pectomy resulted in significant verbal memory decline after surgery, to a lesser degree than the case of temporal lobectomy.[12] Resection of hippocampus of the dominant hemisphere may inevitably result in verbal memory decline. However, two concerns are raised in this regard. (1) Basal temporal language area is often found in the fusiform gyrus, and it carries the language process of Kanji- and Kana- letters each selectively or in combination.[13] Postsurgical anomia was demonstrated with significant correlation between hippocampus and fusiform resection.[14] Therefore, preserving the function of the basal temporal language area would lessen this concern.[15] (2) In transsylvian approach in selective amygdalohipocampectomy, projection fibers of cholinergic system arising from the nucleus basalis of Meynet[16] into the temporal lobe seems to be disconnected at the temporal stem, and one into the parietal lobe through the external capsule seems to be located close to this surgical approach route. The former would result in a net effect of cholinergic disconnection more or less similar to standard temporal lobectomy.

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