Insulectomy for Insular and Peri-insular Seizures. Critical Review and Anatomical Landmarks

ABSTRACT

Insulectomy is an established microsurgical technique for treatment of insular epilepsy refractory to clinical management. The insular origin of epilepsy is unusual. However with depth investigation through hybrid electrodes, it is becoming possible to improve its diagnosis. The authors emphasize the insular functions as well as the anatomical landmarks for surgery. The main complications and physiological basis are discussed.

Key words: Insula; Insulectomy; Temporal lobe epilepsy; Hybrid electrodes

INTRODUCTION

The insula is the only cortical part of the brain which could not be visible on the surface of the hemisphere. It is totally covered by the frontoparietal and temporal opercula.

Many patients with temporal epilepsy could not be cured by surgery due to their insular component, therefore insular exploration is mandatory. In order to minimize the risks intra-operative direct cerebral stimulation and precise anatomical knowledge helps the surgeon to guide the extent of resection and to avoid structural damage when operating within the insula.

The role of the insula in some epilepsies was recently investigated by means of depth electrode recordings made following Talairach’s stereoelectroencephalography (SEEG) methodology.

Ictal signs associated with insular discharge are very similar to those usually attributed to mesial temporal lobe seizures.

Ictal symptoms associated with insular discharges are characterized by visceral symptoms (abdominal or chest constrictions), respiratory rhythm changings, or orolimentary automatisms (swallowing or chewing) seizures. Seizures arising from the temporal lobe may invade the insular region in the majority of the patients, but in approximately 10% of cases, the seizures may be originated in the insular cortex itself.
Electrophysiological Investigation

The role of the insular lobe in temporal lobe epilepsy (TLE) has often been suggested but never directly demonstrated. The observation of this clinical sequence at the onset of seizures on video-EEG recordings of patients with TLE showed important questionings about where the seizure begins. Many electrophysiological records showed that the results strongly suggest that the seizure onset zone is located not in the temporal lobe but in the insular region. Recording directly from the insular cortex through multiple hybrid electrodes should be performed before making any decision regarding epilepsy surgery. Therefore, an isolated temporal lobectomy was a higher risk of residual epileptogenic foci and the surgical approach may be reconsidered.

Penfield and Jasper, in 1954, were the first ones to use intraoperative interictal stimulation of hidden surfaces under the frontal and parietal opercula as well as recording the insula activity after temporal lobectomy.

Isnard et al. (2000, 2004) were the first to publish intracerebral recordings of insular seizures using depth electrodes inserted orthogonally (i.e., along a horizontal axis) through the opercula with a Talairach type of stereotactic frame.

Afif et al. (2008) advocated a frame-based stereotactic depth implantation along an oblique axis through the frontal and the parietal lobes, for that an conventional angiography is extremely useful in order to avoid vascular injury. Those two techniques of stereotactic depth implantation of electrodes are minimally invasive and show a low complication rate.

The insular seizure when suspected may be investigated by means of hybrid depth and superficial electrodes or by means of parasagittal transinsula electrodes for stereo-EEG in temporal and insular lobe epilepsies using StealthStation with an entry point in the parieto-occipital junction. The senior author published before about combined depth and subdural electrode scan that may be used safely to investigate complex insular/perisylvian refractory epilepsy. However, a choice of implantation scheme should be individualized according to pre-surgical data and functional localization.

Anatomy of Insula

The insula is physiologically correlated to emotional and autonomic activities, therefore crises that has it origin within the insula are very specific characterized by changes in blood pressure, cardiac frequency, anxiety, as well as in visceromotor and sensitive control and function. There is considerable evidence for the involvement of the insula as a somesthetic area, including a major role in the processing of nociceptive inputs. The insula has a triangular shape, and is separated from the opercula by the anterior, superior, and inferior peri-insular sulci. The insula is composed of two portions, one anterior and other posterior. The anterior is connected with frontal lobe and the posterior is connected with the parietal and temporal. The insula is a paralimbic structure, which constitutes the invaginated portion of cerebral cortex. The opercula covers and encloses the surface of insula. The peri-insular sulci (anterior, superior, and inferior) defines the limits of the frontobasal, frontoparietal, and temporal opercula. The anterobasal portion of insula, in the depth of Sylvian fissure is the limen of insula.

Also, the insula is composed by a central sulci, three short gyri (anterior, middle and posterior) as well as long insular giri. The posterior portion of insula is composed of two long gyrus of insula, and the postcentral insular sulcus which separates them. This should be considered when planning a surgical approach through it (Figure 1a). The orbital gyrus of frontal lobe has direct correlation with anterior portion of insula. The vascular supply of the insula (Figure 1b) in general is provided by the M2 segments of the middle cerebral artery. One important point is that in the majority of the cases the insular arteries primarily supply the insular cortex, extreme capsule, and, occasionally, the claustrum and external capsule, but not the putamen, globus pallidus, or internal capsule, which are vascularized by the lateral lenticulostriate arteries (LLAs), although some thicker branches from M2 may anastomose with the LAAs. Figures 1c and 1d display the topographic anatomy of the insula.
Surgical Technique

Insulectomy is a relatively new procedure, and it can be done partially and totally, guided by neuronavigation. Resection of the epileptogenic insular cortex is surgically challenging. Other methods as radiosurgery has been attempted with same purposes revealing promissor results. Wide-opening of the Sylvian fissure is mandatory in order to identify M2 branches and insular anatomical landmarks. A few millimeters of the apex cortex is suctioned, keeping the integrity of the arteries in insular sulci. Resection is carried out from anterior to posterior, from the short gyrus to the long gyrus.

Ischemic images in the depth may be observed until the putamen, in postoperative MRI, since M2 perforators must be sacrificed during the resection of the insular cortex. This should not be problematic for the global result, differently if any of the M1 perforators (proximal to the limen insula) suffers any injury.

The bifurcation M1/M2 can be located near by the limen insula in the majority of the cases showing the importance of this anatomical landmark (Figures 1 and 2).

The resection must be employed with suction and bipolar, with meticulous hemostasis. Some times complete hemostasis can be accomplished with a hemostatic matrix, Floseal® (Baxter, USA).

Complication and Outcome

Minor transient hemiparesis may be observed in the patients in postoperative period, and the majority of patients achieve Engel I after the surgery, as Malak et al. (2009) demonstrated in 6 of 7 patients submitted to insulectomy with 0% of mortality according to the Montreal University experience at this time. Currently, there is unpublished data of 34 cases operated by the main author (AB) showing low morbidity and also 0% of mortality.
REFERENCES


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