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Bipolar electro-coagulation with cortextomy in the treatment of insular and insulo-opercular epilepsy explored by stereoelectro-encephalography

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ABSTRACT

Objective: The diagnosis and treatment of insular and insulo-opercular epilepsy remain underexplored because the insula is covered by the insulo-opercular and a dense vascular curtain. Stereoelectro-encephalography (SEEG) is a reliable and recommended technique for locating the epileptic zone, especially in insular and insulo-opercular regions (Isnard et al., 2000, 2004). Bipolar electro-coagulation with cortextomy is an alternative therapy for treating drug-resistant epilepsy and is more convenient and less likely to cause adverse complications. We report 20 patients with insular and insulo-opercular epilepsy diagnosed through SEEG who underwent surgical treatment via bipolar electro-coagulation with cortextomy. The outcomes and findings are presented as a retrospective analysis (Cui et al., 2012; Zhai et al., 2015).
Method: We performed a retrospective analysis of 20 insular and insulo-opercular epilepsy patients. All patients involved in the analysis had undergone a comprehensive presurgical evaluation, including video electro-encephalographic recordings (at least 1 insultus), SEEG (at least 3 electrodes placed at insular depth), magnetic resonance imaging, positron emission tomography, and magneto-encephalography. All patients underwent bipolar electro-coagulation with cortextomy surgery. The follow-up time was over 24 months.
Result: After bipolar electro-coagulation with cortextomy surgical treatment, 16 of the 20 patients (80.0%) were seizure free (Engel class I), and all patients achieved satisfactory seizure control (Engel class I–III) with a mean follow-up of 29.6 months (range, 24–39 months). Histopathological findings demonstrated focal cortical dysplasia in 14 patients (70.0%), neuro-damage in 3 patients (15.0%), ganglioglioma in 2 patients (10.0%), and gliosis in 1 patient (5.0%). Sixteen of the 20 patients reported no complications (80.0%), 3 exhibited temporary complications that recovered within 3 months (15.0%), and 1 patient experienced permanent complications (5.0%).
Significance: Bipolar electro-coagulation with cortextomy of the insular and insulo-opercular cortex explored by SEEG findings can be performed safely and resulted in satisfactory seizure control.

1. Introduction

In the surgical treatment of medically refractory epilepsy, it is difficult to treat the epileptogenic zone (EZ), which is located in the insular and insulo-opercular cortex. The insula is covered by the insulo-opercular region and is buried deep in the sylvian fissure. It has close connections with temporo-mesial structures, the frontal/central cortex and the prefrontal cortex (Ture et al., 1999). As epileptic discharges always spread to the temporal lobe, the frontal lobe and the partial lobe, and surface EEG and subdural EEG are imprecise for evaluating insular cortex epilepsy (Isnard et al., 2004). Due to the progress made in image techniques and stereoelectro-encephalography (SEEG) in the past decades, it is now possible to accurately identify the epileptogenic zone of insular and insulo-opercular epilepsy. These techniques pave the way for developing cures for insular and insulo-opercular medically refractory epilepsy through surgical treatment (Isnard et al., 2000; Kori et al., 2013; Liew et al., 2009; Dylgjeri et al., 2014). Although complete resection of the epileptogenic zone is the main procedure in epilepsy

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surgery, the dense vascular curtain above the insular cortex can hinder cortextomy of the insula. In addition, the insular and insulo-opercular cortex is adjacent to the eloquent area. Surgical treatment can potentially lead to unacceptable neurological complications or unsatisfactory outcomes. Thus, surgical treatment of insular and insulo-opercular medically refractory epilepsy has been rarely reported.

Bipolar electro-coagulation of functional cortex (BCFC), which was developed and applied by Luan et al. (Luan et al., 2001), is a new method for treating epilepsy of the eloquent area. This method is easy to implement and highly practical. Combined with foci resection, BCFC can greatly improve the outcomes of surgery and effectively decrease unacceptable neurological complications. This treatment has recently been extensively applied during epilepsy surgery in China, especially in cases that involve eloquent areas. However, BCFC has not yet been used in insular and insulo-opercular medically refractory epilepsy.

This retrospective study reports our experience in treating a group of patients suffering from insular and insulo-opercular medically refractory epilepsy by means of bipolar electro-coagulation combined with cortextomy after SEEG evaluation.

2. Methods

SEEG has been used in our center since 2012 to accurately identify the epileptogenic zone of medically refractory epilepsy, which represents the first application of SEEG in China. In this report, we focus on patients with insular and insulo-opercular medically refractory epilepsy who underwent bipolar electro-coagulation combined with cortextomy.

2.1. Patients

Patient files were extracted from the database of the Epilepsy Centre of Beijing Sanbo Brain Hospital between January, 2012, and September, 2015. Among 2074 epilepsy patients and 226 SEEG studies, 20 patients fulfilled the following criteria: (1) parts of the insular and insulo-opercular cortex were within the epileptogenic zone confirmed by SEEG; and (2) the patient underwent bipolar electro-coagulation with cortextomy including parts of the insular cortex. The mean age of these patients was 19.4 years (range 4–37 years). The demographic and imaging data of the patients are summarized in Table 1.

2.2. Preoperative evaluation and surgical planning

Preoperative evaluation was precisely and thoroughly performed in all patients, including semeiology monitoring, 1.5-T magnetic resonance imaging (MRI), magneto-encephalography (MEG), neuropsychological assessment, fluorodeoxyglucose positron emission tomography (PET), and video-electroencephalography monitoring (VEEG). In the summary of the clinical data below, we presume an ictal epileptogenic zone. If part of the insular and insulo-opercular cortex was within the presumed epileptogenic zone, the SEEG study was performed. Our electrode implantation strategy is designed to accurately identify the onset zone and the epileptogenic zone. At least 3 electrodes were implanted in the insular and insulo-opercular area. Each electrode implantation plan was developed individually so that it was suitable to each patient. At least 3 seizures were captured during EEG monitoring to obtain subjective sensations of seizure and ictal clinical signs. In addition, electrical stimulation (1 Hz and 50 Hz) was performed to recall the aura or the seizure in each patient. Thus, functional mapping of the insular and insulo-opercular cortex could be established at the individual level. The clinical history, semeiology and VEEG data of patients are summarized in Table 2. The SEEG analysis and surgical plan data of patients are summarized in Table 3.

The preoperative plan was to synthesize all the imaging and electro-anatomical data, individually map the functional area and identify the onset zone and the epileptogenic zone. Then, to eliminate the epileptogenic zone and protect the functional area, the bipolar electro-coagulation area and the cortextomy area were planned (see Fig. 1 for details).

2.3. Surgery

All patients were operated by one senior surgeon, Pro. Luan Guoming. All patients were treated with a transsylvian approach by opening the sylvian fissure. Obeying surgical plans and using neuro-navigation, the insulo-opercular cortex was removed, and bipolar electro-coagulation was applied to the insular cortex. The output power of the bipolar electro-coagulation was 5–7 W. The brain surface was kept clean and moist with saline gauze. There was a 45° angle between the forceps axis and the brain surface. The direction of electro-coagulation was perpendicular to the long axis of the brain gyrus. The tip diameter of the bipolar forceps was 2 mm, and stimulation was applied with 1 s duration. The brain surface was immediately washed with saline to lower the brain temperature, which became elevated by the heat of electro-coagulation. To limit blood vessel damage, the coagulation of large arteries was avoided (Fig. 2).

2.4. Follow-up

A strict follow-up procedure was implemented. Out-patient follow-ups were performed at 3 months, 6 months and 12 months after surgery and included 2 h of EEG and MRI. Another in-patient follow-up was performed 24 months after surgery and included 16 h of VEEG, MRI and neurological examinations. The outcome of seizures (Engel class) and the neurological deficit were the variables of interest.

3. Results

The range of cortextomy and bipolar electro-coagulation area, histopathological findings, seizure outcome, complications and follow-up data are summarized in Table 4.

3.1. Patients

The mean age of patients at the time of operation was 19.4 years (range 4–37); 7 were female (35.0%), and 13 were male (65.0%). The epileptogenic zone of 10 patients was located in the right hemisphere (50.0%), and the epileptogenic zone of 10 patients was located in the left hemisphere (50.0%). All patients were right handed. The mean time of follow-up was 29.6 months (range, 24–39 months). Four patients (No. 8, 10, 17, and 19) had previously undergone surgery. Five patients exhibited neuropsychological development delay (25.0%). The neurological examinations of all patients was normal.

3.2. Morphological and functional neuro-images

All patients underwent 1.5-T MRI and MEG, and most underwent fluorodeoxyglucose PET. The preoperative MRI was normal in 7 patients (35.0%). Focal cortical dysplasia was observed in 7 patients (35.0%), postoperation scar in 4 patients (20.0%) and low-grade glioma in 2 patients (10.0%). The preoperative MEG showed a diffuse perisylvian distribution in the same hemisphere in 9 patients and an insular dipole cluster in 11 patients. Sixteen patients underwent PET tests (except cases 2, 8, 10 and 15). The PET evaluation was normal in 2 patients, hypermetabolism of the left perisylvian region was observed in 6 patients, and hypermetabolism of the right perisylvian region was observed in 8 patients. All the hypermetabolism regions were confirmed by SEEG.

3.3. Semeiology and surface video-electroencephalography

Surface VEEG monitoring revealed the seizure region in the frontal