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Review

Seizure outcome following primary motor cortex-sparing resective surgery for perirolandic focal cortical dysplasia

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HIGHLIGHTS

- Perirolandic focal cortical dysplasia can be resected with good outcomes.
- Outcome studies addressing the extent of surgical resection are lacking in this refractory epilepsy syndrome.
- Multimodal mapping of the seizure focus & functional cortex helps achieve seizure freedom with normal motor function.

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ABSTRACT

Objectives: We present a case series of patients who underwent perirolandic resection for medically refractory focal epilepsy due to focal cortical dysplasia (FCD). Our aim was to specifically evaluate the outcome of a surgical strategy intended for seizure freedom while preserving primary motor cortex function.

Materials and methods: Thirteen patients undergoing perirolandic resection for pharmacoresistant focal epilepsy between 2010 and 2015 who demonstrated histological evidence of FCD were selected from a prospectively maintained database. Presurgical evaluation included video EEG telemetry and 3T MRI brain for all patients. Eight patients underwent interictal FDG PET scan. Intracranial EEG monitoring was done for 8 patients – six by conventional subdural grid and depth electrodes and two by Stereo EEG. Additional techniques included extraoperative cortical stimulation mapping, intraoperative electrocorticography (ECoG), intraoperative motor cortex mapping and awake surgery in various combinations. In all cases (lesional and nonlesional), resection was intentionally limited for anatomic preservation of the primary motor cortex.

Results: Amongst the thirteen patients with age ranging 14–44 years (mean 26.8 ± 9.2) 62% of them had daily seizures. MRI abnormalities were identified in 8 patients (62%), PET showed concordant findings in 7 patients (88%). When utilized, the mean duration of intracranial EEG recordings was 8.0 ± 7.2 days (range 2–23 days). All patients underwent a primary motor cortex-sparing resection of the suspected epileptogenic cortex. The mean postoperative follow up period was 23 months (range 7.5–62 months). Twelve out of 13 (92%) were seizure free (Engel 1) outcome at the last follow-up assessment; one patient had Engel 2a outcome at 28 months. Six patients (46%) had immediate new focal neurological deficits, however all six patients had recovered completely within three months.

Abbreviations: ETLE, extratemporal lobe epilepsy; M1, primary motor cortex; MST, multiple subpial transection; ECoG, electrocorticography; ICEEG, intracranial EEG; MEG, magnetoencephalography; FCD, focal cortical dysplasia; SEEG, stereo-electroencephalography; EOR, extent of resection; HFO, high frequency oscillation; SISCOM, Subtraction Ictal Single photon emission computed tomography (SPECT) Co-registered to Magnetic resonance imaging (MRI); EZ, epileptogenic zone.

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Conclusion: The surgical strategy of a primary motor cortex-sparing resective surgery for perirolandic FCD is associated with an excellent early seizure-freedom rate and no permanent neurological deficits. Since the ultimate goal of resective epilepsy surgery is seizure freedom with simultaneous functional preservation, similar long term outcome studies should ultimately guide the resection strategy.

1. Introduction

In epilepsy surgery centers worldwide, approximately 20% of the patients with focal epilepsy have extratemporal lobe epilepsy (ETLE) – most commonly from frontal and central regions [1–3]. The challenges in the surgical management of these patients include the difficulties in localization of the epileptogenic zone using imaging alone and the higher risk of neurological deficits due to damage to adjacent functional cortex. In spite of significant advances in neuroimaging, the yield of lesion by MRI in perirolandic focal epilepsy is still low [4–7]. Even in lesional cases, neurological deficits following surgery for perirolandic epilepsies are as high as 50% [4,7–9]. Cortical dysplasia is the most frequent etiology of pediatric epilepsy surgery (33%) and the third major etiology in adult epilepsy surgery patients (13%) [6].

The dilemma often arises as to whether long term motor function should be compromised in the interest of seizure freedom when the epileptogenic zone is perceived to involve the primary motor cortex (M1). Multiple subpial transections (MST), once developed primarily for this situation have become less popular for FCDs that overlap into the primary motor cortex following previous experience [4,7–9]. Remaining options include pure lesionectomy when visible on MRI, resection tailored to interictal studies including magnetoencephalography (MEG) or acute intraoperative electrocorticography (ECoG), and finally chronic intracranial EEG (ICEEG) ictal recording to map the ictal onset zone and functional cortex followed by tailored resection. The latter method is generally considered essential when MRI fails to reveal the lesion. Using pure ICEEG criteria such as high frequency oscillation patterns to delineate the epileptogenic zone or network and subsequent extent of resection, the M1 cortex may also fall into the planned resection zone.

During the past two decades, the emergence of more sophisticated imaging and mapping techniques have allowed more precise localization of both the epileptogenic focus and adjacent functional cortex. This leads to the option of more focused resection with functional preservation. Outcome studies are therefore necessary to validate these techniques. Clinical series describing outcomes for surgery for pharmacoresistant focal rolandic epilepsy in the present era, though few, report Engel Class I or II outcomes in the range of 40–77% [4,5,7,8,10]. Clearly better rates of seizure freedom will be attained with wider resections [6,8,11]. However, the functional cost of wider resections in the perirolandic region is obviously high; hence, outcomes specific to motor-sparing resections are of importance. Previous data mostly combine outcomes from resection of different pathologic substrates, however a more focused analysis based on pathology is also needed. Here we describe the outcome of surgery in thirteen cases of pharmacoresistant epilepsy due to perirolandic focal cortical dysplasias specifically using a motor-function sparing surgical approach.

2. Materials and methods

2.1. Study group

Patients undergoing perirolandic resections for pharmacoresistant focal epilepsy who demonstrated histological evidence of focal cortical dysplasia (Blumcke et al., 2011) [12] were selected from the prospective database maintained at our epilepsy center and retrospectively reviewed. We defined *perirolandic* as reaching the precentral or post-central sulci with or without involvement of the adjacent pre- & post-central gyrus cortex [4,5,10]. Patients with perirolandic lesions other than FCDs or other types of epilepsy surgery (eg. disconnective surgery) were excluded from the analysis. Thus, a total of thirteen patients out of 166 epilepsy surgeries performed between January, 2010 and February, 2015 were identified and reviewed.

2.2. Presurgical evaluation

Patients with pharmacoresistant epilepsy based on the ILAE two-drug criteria [13,14] underwent video-EEG telemetry using a modified 10–20 international system of electrodes including the T1/2 (surface electrodes Sp1/2), F9/10, T9/10 and P9/10 electrodes from the 10-10 system. All the patients underwent 3 T MRI [Siemens Magnetom Verio system (5 cases) or GE Discovery MR 750 W system (8 cases)]. Imaging included high resolution axial and coronal FSE T2 weighted sequences, Coronal FLAIR, coronal 3D volumetric spoiled GRE and sagittal thin 3D double IR sequences. In one case MRI was done using surface coil after doing routine study. fMRI studies were not undertaken since all patients underwent extraoperative and/or intraoperative electrocortical stimulation mapping. Interictal ^{18}F FDG PET/CT was done using a standard protocol (GE Discovery PET 8 slice CT scanner). PET images were reconstructed by iterative reconstruction and evaluated separately as well as after image fusion. The FDG-PET images were interpreted visually for focal areas of hypometabolism by at least two nuclear medicine physicians in consensus. PET data sets were also reviewed after fusion with brain MRI in some cases. All images were reviewed in comprehensive epilepsy presurgical group meetings.

2.3. Surgical details

2.3.1. Resection following phase 1 evaluation

Five patients with perirolandic lesions identified on MRI underwent craniotomy and image-guided focal resection of the depth of sulcus dysplasias following intraoperative ECoG (Fig. 1).

2.3.2. Resection following phase 2 evaluation

All nonlesional cases and lesional cases with phase 1 noninvasive evaluation discordance underwent invasive monitoring. These phase 2 evaluations included PET/MR image-guided placement of subdural grids centered over the suspected perirolandic focus (precentral in three, post-central in one, and combined in one) along with interhemispheric subdural strip electrodes in all cases. Temporal subdural strips and depth electrodes were inserted whenever presurgical electroclinical suspicion of temporal involvement in the epileptogenic network existed (Fig. 2).

As practice patterns at our center changed since June, 2014, SEEG was used instead of subdural electrode recordings in two patients. SEEG implantations were performed using orthogonal