Journal of Clinical Neuroscience xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Tools and techniques

Intraoperative definition of bottom-of-sulcus dysplasia using intraoperative ultrasound and single depth electrode recording – A technical note

Dorothea Miller [a,g,*], Patrick Carney [b,d,f], John S. Archer [b,e,f], Gregory J. Fitt [c], Graeme D. Jackson [b,f], Kristian J. Bulluss [a]

[a] Department of Neurosurgery, Austin Health, Heidelberg, Victoria, Australia
[b] Department of Neurology, Austin Health, Heidelberg, Victoria, Australia
[c] Department of Radiology, Austin Health, Heidelberg, Victoria, Australia
[d] Eastern Health Clinical School, Faculty of Medicine, Nursing and Health Sciences, Monash University, Box Hill, Victoria, Australia
[e] University of Melbourne, Austin Health, Heidelberg, Victoria, Australia
[f] The Florey Institute of Neuroscience and Mental Health, Melbourne Brain Centre, Heidelberg, Victoria, Australia
[g] Department of Neurosurgery, Essen University Hospital, Essen, Nordrhein-Westfalen, Germany

ARTICLE INFO

Article history:
Received 3 July 2017
Accepted 10 October 2017
Available online xxxx

Keywords:
Focal cortical dysplasia
Bottom-of-sulcus dysplasia
Intraoperative ultrasound
Electrocorticography
Depth electrodes

ABSTRACT

Bottom of sulcus dysplasias (BOSDs) are localized focal cortical dysplasias (FCDs) centred on the bottom of a sulcus that can be highly epileptogenic, but difficult to delineate intraoperatively. We report on a patient with refractory epilepsy due to a BOSD, successfully resected with the aid of a multimodal surgical approach using neuronavigation based on MRI and PET, intraoperative ultrasound (iUS) and electrocorticography (ECoG) using depth electrodes. The lesion could be visualized on iUS showing an increase in echogenicity at the grey-white matter junction. IUS demonstrated the position of the depth electrode in relation to the lesion. Depth electrode recording showed almost continuous spiking. Thus, intraoperative imaging and electrophysiology helped confirm the exact location of the lesion. Post-resection ultrasound demonstrated the extent of the resection and depth electrode recording did not show any epileptiform activity. Thus, both techniques helped assess completeness of resection. The patient has been seizure free since surgery. Using a multimodal approach including iUS and ECoG is a helpful adjunct in surgery for BOSD and may improve seizure outcome.

1. Introduction

Bottom of sulcus dysplasias (BOSD) are a recently recognised cause of medication resistant epilepsy. These small focal cortical dysplasias can be difficult to visualize on standard magnetic resonance imaging (MRI), with many patient's previously considered 'lesion-negative'. Locating the lesion and its boundaries intraoperatively can be challenging. In this technical note, we present a multimodal surgical approach using neuronavigation based on MRI and PET, intraoperative ultrasound and electrocorticography (ECoG) using depth electrodes during resection of the lesion.

2. Illustrative case and description of technique

A 25 year-old right-handed man presented to our comprehensive epilepsy programme with a 20-year history of drug resistant epilepsy. Routine electroencephalogram (EEG) showed focal epileptiform discharges arising from the right medial centroparietal region. Previous MRI had been reported as normal.

2.1. Pre-operative investigations

Video-EEG-monitoring (VEM), revealed frequent low amplitude interictal spike and wave discharges focally over Cz-Pz, with variable low amplitude fast activity at P4 preceding the spike component of discharges. Seizure semiology was supportive of a right-sided origin. However, localizing features were not persuasive and muscle artefacts obscured EEG.

An epilepsy-directed MRI scan at 3 Tesla (T) (protocol as described elsewhere [6]) demonstrated a subtle BOSD in the right

* Corresponding author at: Department of Neurosurgery, Austin Health, 145 Studley Road, Heidelberg 3084, Victoria, Australia.
E-mail address: dorotheamiller@web.de (D. Miller).

https://doi.org/10.1016/j.jocn.2017.10.045
0967-5868/

precuneus with poor grey-white matter differentiation in the depths of a slightly abnormal sulcus and a hyperintense band extending to the posterior body of the right lateral ventricle (Fig. 1a and b). Positron emission tomography (PET) of the brain using 228 MBq F-18 fludeoxyglucose (FDG) confirmed hypometabolism in the right mesial parietal region.

2.2. Pre-surgical planning

A volumetric MRI (T1 with contrast, T2, FLAIR) was performed prior to surgery. MRI sequences and the PET were loaded onto the neuronavigation platform (StealthStation®, Medtronic, Fridley, US). A trajectory for the placement of a depth electrode was preplanned (Fig. 2) with the target in the pathology on FLAIR and PET imaging. The entry point was planned taking into account the vascular anatomy, which could be visualized on T1 weighted sequences with contrast-enhancement and T2 images as well as 3D surface rendering.

2.3. Operation

After induction of general anaesthesia according to our neuroanaesthetic protocol (midazolam and propofol on induction, remifentanil and low dose isoflurane thereafter), the patient was placed in a left lateral position with the head turned to the left and fixed in the Mayfield head clamp, patient-to-image registration was performed in the usual fashion, and a sterile stereotactic arm was attached to the Mayfield clamp (Vertek®, Medtronic). Image-guided craniotomy was accomplished, exposing the superior sagittal sinus. Before the dura was opened, a transdural ultrasound was performed using the FlexFocus system (BK Ultrasound, Peabody, US) with a specialized craniotomy transducer. This curved multifrequency transducer has a small footprint, high resolution and a frequency range of 3.8–10 MHz. An imaging depth of 6.4 cm was chosen to allow imaging of the pathology and surrounding anatomical landmarks. All ultrasound imaging and interpretation was performed by the first author, a neurosurgeon trained in neurosurgical ultrasound. Ultrasound imaging visualized the subtle BOSD as a well visible increase in echogenicity involving grey matter and the grey-white matter junction at the bottom of the sulcus (Fig. 1c) while neighbouring sulci did not show any increase in echogenicity. After opening of the dura, the depth electrode was inserted using the stereotactic arm and the pre-planned trajectory as guidance. A transcortical ultrasound scan was performed, visualizing the position of the depth electrode with respect to the BOSD (Fig. 3). Electrode contact 1 was positioned in a depth of approximately 40 mm, distal to the lesion while contacts 2 and 3 were likely within the lesion and contact 4 was proximal (Fig. 3a). The ECoG showed almost continuous spiking and bursts of fast activity in all electrodes. Maximal activity was seen in contact 3, consistent with the lesion location (Fig. 3b). The electrode was pulled back 5 mm prior to further recording (Fig. 3c). On this occasion maximal activity was seen at electrode 2 (Fig. 3d). Thus, intraoperative imaging and electrophysiology helped confirm the exact location of the lesion. The electrode was left in position during piecemeal resection. Once the resection was complete recordings were taken from the anterior, posterior and lateral surfaces of the resection cavity. No spiking was seen in these locations post-resection. Post-resection ultrasound (Fig. 4c) demonstrated minor blood products as high echogenicity making assessment of residual dysplasia difficult. But correlation between pre- and post-resection appearances suggested complete resection. Size and exact location of the hyperechogenicity on pre-resection scans were compared to size and location of the resection cavity. Thus, intraoperative imaging in combination with electrophysiology helped tailor the resection and assess completeness of the resection with good confidence. Haemostasis and closure was achieved in a usual manner. Anaesthetic time, including positioning of the patient and preparation for neuronavigation was recorded as 207 min. Surgery including intraoperative ultrasound and ECoG lasted 140 min.

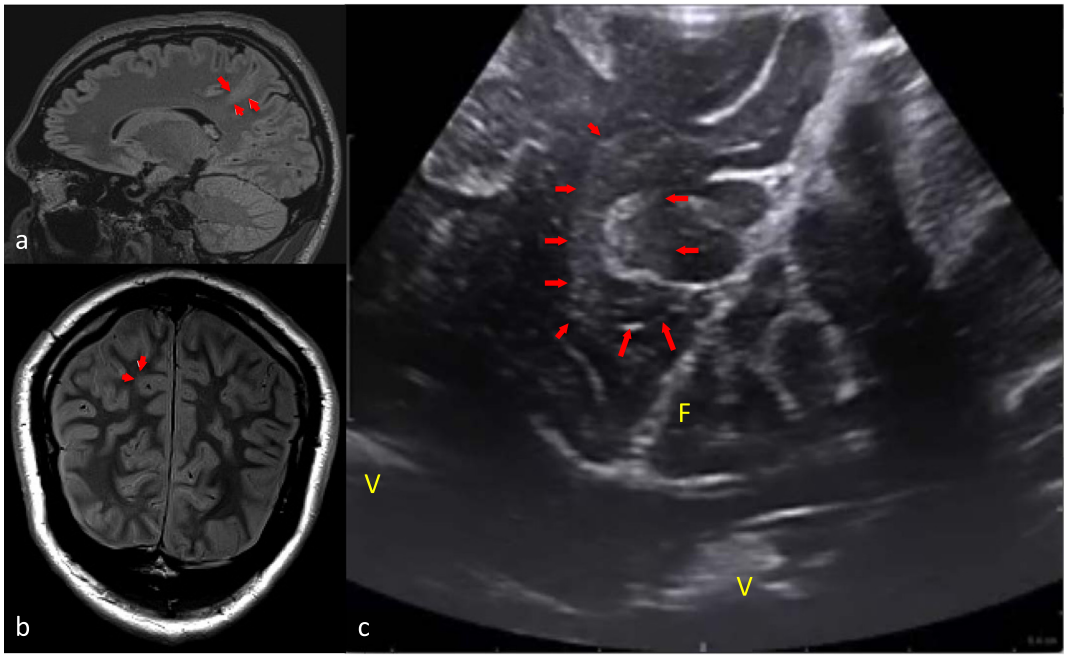

Fig. 1. (a–b) Preoperative MRI showing the mesial parietal BOSD with a slight increase in signal at the bottom of the sulcus and blurring of the grey-white matter junction. (c) Intraoperative ultrasound image showing an increase in echogenicity at the bottom of a sulcus arising from the mesial surface of the parietal lobe. F falx, V ventricle, red arrows: lesion margin.

Please cite this article in press as: Miller D et al. Intraoperative definition of bottom-of-sulcus dysplasia using intraoperative ultrasound and single depth electrode recording – A technical note. J Clin Neurosci (2017), https://doi.org/10.1016/j.jocn.2017.10.045