Contribution of local field potential to subthalamic nucleus deep brain stimulation in Parkinson’s disease
Jerome Coste, Philippe P Derost, Aurelien Mulliez, Jean Gabrillargues, Bruno Pereira, Jean-Jacques Lemaire

To cite this version:
Jerome Coste, Philippe P Derost, Aurelien Mulliez, Jean Gabrillargues, Bruno Pereira, et al.. Contribution of local field potential to subthalamic nucleus deep brain stimulation in Parkinson’s disease. 1st International Symposium on Deep Brain Connectomics, Sep 2012, Clermont-Ferrand, France. hal-01871528

HAL Id: hal-01871528
https://uca.hal.science/hal-01871528
Submitted on 11 Sep 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Contribution of local field potential to subthalamic nucleus deep brain stimulation in Parkinson’s disease

J Coste(1,2); P Derost(3); A Mulliez(4); J Gabrillargues(1,5); B Pereira(1,4); JJ Lemaire(1,2)

(1) Image-Guided Clinical Neuroanatomists and Neurologists, IGCNC, EA 7295, Université d’Auvergne, Clermont-Ferrand, France
(2) Service de Neurochirurgie A, CHU de Clermont Ferrand, Clermont-Ferrand, France
(3) Service de Neurologie, CHU de Clermont Ferrand, Clermont-Ferrand, France
(4) Direction de la Recherche Clinique, CHU de Clermont Ferrand, Clermont-Ferrand, France
(5) Service de Radiologie A, Unité de Neuroradiologie, CHU de Clermont Ferrand, Clermont-Ferrand, France

INTRODUCTION

The subthalamic nucleus (STN) is the main target for deep brain stimulation (DBS) in Parkinson’s disease. We analysed the relationships between magnetic resonance imaging (MRI) anatomy and electrophysiology done during surgery. In addition to extracellular recording of spontaneous neuronal activity (carried out conventionally in our Hospital), we performed simultaneous recordings of local field potential (LFP), i.e. deep EEG activity. We hypothesized that the contribution of LFP to neuronal firing rate with detailed MRI anatomy should allow to explore finely anatomic-electrophysiological relationships and also to determine precisely functional surgical targets.

PATIENTS, MATERIAL AND METHODS

Patients

10 patients with Parkinson’s disease (9F – 1M; mean 62±4 years old; 11±3 years disease duration) underwent bilateral STN DBS surgical procedure.

Surgical technique

Stereotactic MRI. On the first day, the stereotactic Leksell G frame (Elekta, Sweden) was placed with its repositioning kit (Leksell repositioning kit, Elekta, Sweden) under local anesthesia. A stereotactic MRI was performed (1.5 Tesla, Siemens, Germany) with notably a White matter Altered Tissue Invasion Recovery (WART) sequence on the coronal plane: TR = 4000 msec; TE = 10 msec; TI = 1000 msec; 1.5 x 1.5 mm3 (iso-cube volume). The frame was removed.

Planning: Direct targeting of STN region was performed using a stereotactic software (Brainlab, Germany). We identified all the nuclei of the subthalamic region. With the help of probe view reconstructions, we determined a trajectory, with a double obliquity, avoiding the main vessels, going strictly through the parenchyma and with an endpoint located in the STN. We planned two parallel tracks, a central one centered on the best anatomical target, a 2mm distant one.

Implantation surgery: The following day, the stereotactic frame was repositioned. Under local anesthesia after repositioning of neuronal activity and LFP an acute stimulation (Paracelsus, negative current, Frequency 10 Hz, iso-cube width 0.5 x 0.5 x 0.5 mm) was performed using unshielded tungsten microelectrodes (Integra 602, length 1.2 mm, diameter 10 μm). MRI a MEGA-pulse py system (Alpha Omega, Israel). We evaluated the clinical effects every 0.5mm (jump up to 3 mm) along the tip of the parallel blocks. Then a quadrupolar electrode (DBS 3337, Medtronic, US) was placed on the selected track with one or two contacts in the most efficient area. Perioperative radiographic X-rays controls and postoperative CT scanner acquisitions were performed to control the electrode positioning.

Postoperative clinical assessments (6 months) showed a mean improvement of 58±9 (14±9; ranging from 30.0 to 75.5) in motor control (part II of UPDRS).

Electrophysiology

- 715 unitary electrophysiological recordings of spontaneous extracellular neuronal activity (calculating the mean frequency of neuronal activity, and the occurrence of burst activity)
- 651 LFP recordings; Power spectral densities (0-50Hz), 100 Hz frequency vectors. Normalization: percent of LFP PSD. Calculations for a STN (K = 47%, 22.2 ± 9.6), a Thalamus (K = 28%, 6.4±1), and 20±100% (frequency range).

In MRI outlined anatomical structures (Thalamus (Tha), Zona Incerta (ZI), Forel Field (Forel) and STN) were analyzed.

RESULTS

Electrophysiological recordings of spontaneous unitary extracellular neuronal activity

1. In this study, the mean frequency failed to discriminate between the structures of the region of interest (non-parametric Kruskal-Wallis ANOVA; p = 0.13).
2. The frequency of burst activity was significantly different between structures (K-W: p = 0.01). Burst activity in thalamus was statistically higher than in the STN (pairwise comparisons: p = 0.002).

Local field potential power spectral density analysis

3. Delta band power spectral density (PSD) of LFP was significantly different between structures (K-W: p = 0.0003). Post hoc tests showed differences between Thalamus and Forel Field (p = 0.0001), between Forel Field and STN (p = 0.003) and between Thalamus and Zona Incerta (p = 0.008).
4. Theta band PSD was significantly different between structures (K-W: p = 0.02). Thalamus had higher θ band activity than Forel Field (p = 0.001). Alpha and 50-100Hz bands showed the same statistically different pattern between Thalamus and Forel Field.
5. Gamma band activity was significantly different between structures (K-W: p = 0.0003). Thalamus γ activity differed from all other structures (Thalamus-ZI: p = 0.00004; Thalamus-STN: p = 0.0001; Thalamus-Forel: p = 0.0002).

CONCLUSION

- This study suggests the interest of LFP, which is at least as effective as extracellular neuronal activity (Coste et al., EJN, 2009), to discriminate between structures in the subthalamic region using exploration electrode with patient at rest during DBS surgery. Contrary to previous studies reporting an increase in δ band when entering the STN (Chen et al., Exp Neurol, 2006), no significant difference was shown between structures concerning the δ band.
- Another part of this study will consist in correlating extracellular neuronal activity and LFP, and analyzing modulations on LFP during voluntary movements of the patients.

Grant: Fondation de l’Avenir | Projet ETT-455 « Développement d’outils d’électrophysiologie pour aider à la localisation et à la compréhension des mécanismes physiopathologiques durant l’implantation d’électrodes de stimulation stéréotaxique»

jcoste@chu-clermontferrand.fr