Somatotopy in the GPi: Analysis of Motor Side Effects during Intraoperative Assessment in a Parkinsonian

Jerome Coste, Simone Hemm, Miguel Ulla, Philippe Derost, François Caire, Franck Durif, Jean-Jacques Lemaire

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INTRODUCTION

A somatotopie inside the human globus pallidus (GP), based on intra operative microelectrode-recordings during passive or active movement and on clinical results of deep brain stimulation (DBS) in movement disorders, has been described in the literature (7,8). We aimed at reporting a GP somatotopie, observed in one parkinsonian patient by dystonic motor side effect assessment during acute stimulation, and to MRI anatomy.

MATERIAL AND METHODS

History

A 65 year old right-handed woman suffered from Parkinson's disease for 16 years, initially affecting the right upper limb with tremor. Before surgery, dyskinesia was encountered for the upper and the lower limbs, for the trunk with alternatively, severe blocking episodes. Moreover, an important bradykinesia was observed with chin and upper limb tremor.

Surgical technique

Stereotactic MRI. On the first day, the stereotaxic Leksell G frame (Elekta, Sweden) was placed with its repositioning kit (Leksell repositioning kit, Elekta, Sweden) under local anaesthesia. A stereotactic MRI was performed (Sonoda I.S Tesla, Siemens, Germany) in three orthogonal planes (axial, coronal and sagittal). The voxel size was 0.52 × 0.52 × 2.0 mm. Three scans (270 × 270 × 270 mm3, each 2048 × 2048 × 2048 µm) of a Turbo Spin Echo (TSE)-sequence were used for the axial and the sagittal planes; 18 × 3000 mm, 10 × 15 mm, 24 slices. A White matter Adiabatic Inversion Recovery (WAIR) sequence was used for the coronal plane; 18 × 3000 mm, 10 × 15 mm, 15 × 15 mm, 21 × 15 images (15mm distance). The frame was removed.

Planning: Direct targeting of GP was performed using a stereotactic software (plan. BrainLab, Germany). We identified all the segments of the Globus Pallidum (GP). GP is commonly divided in two parts (17), the lateral and the medial segments, respectively named external GP (GPe) and internal GP (GPi). An anatomical soma or soma paradoxa incisura, in a basal and posterior position, partially separates the GP into a lateral (GPi) and a medial (GPe) substructures (4.6.6.4). With the help of probe view reconstructions, we determined a trajectory, with a double oblique, avoiding the main vessels, going strictly through the paracentyma and with an ambition located at the lower boundary of the structure; we schematically placed the end point at the junction between the 3rd and the 4th of GP according to its main anterior-posterior axis (17). We planned three parallel tracts, a central one centered on the best anatomical target, a 2mm-lateral one and a 2mm-medial one on the left hemisphere, a central one, a 2mm-anterior one and a 2mm-lateral one on the right hemisphere.

Implantation surgery. The following day, the stereotaxic frame was repositioned. Under local anaesthesia, after recording of neuronal activity, an acute stimulation (pointby-point, intermediate current, TSE/PHASE-sensitive FLASH) was performed using unshielded tungsten microelectrodes (modified, 0.1 mm, 100 µm, 300 µm, 400 µm) with a microguide system (Alpha Omega, Israel). This allowed exploring the clinical effects every 1 to 2 mm (up to 50 mm) along the distal 10mm on the 3 parallel tracts on each side. Contralateral dystonic movements were noted (mean current = 0.05±0.002 mA). On the 3 tracks, the GP checkpoints, involved body parts (face, upper and lower limbs) were matched with the anatomic structures. Then a quadripolar electrode (DBS Medtronic, USA) was placed on the selected tract (the central one for both with one or two contacts in the clinically most efficient area. Peroperative tactile radiographs X-rays controls and postoperative non-stereotactic conical TSE MRI acquisitions were performed to control the electrode positioning.

Postoperatively, chronic DBS dramatically improved dyskinesia (electrodes implanted on the central tracks).

A SOMATOTOPIE OF DYSTONIC MOTOR SIDE EFFECTS WAS ENCOUNTERED INSIDE EACH PALLIDAL STRUCTURE

GPe, GPi lateral and GPi medial (GPMi) seemed to be characterized by a segregated body map.

Controlateral dystonic movements were noted during acute intraoperative stimulation and represented as pigtails along the distal 10mm on 3 parallel tracts on each side using probe views. Central (C), anterior (A) and lateral (L) tracts are explored on the Right pallidum and central (C), medial (M) and lateral (L) trajectories on the Left one. A scale represents the 10mm course of the stimulation exploration. (figures 1b and 1e)

Axial slices with surrounded structures are illustrated for the position -8mm, -4mm then 0mm on the central tracts (figures 1a and 1d).

We found inside each structure (GPe, GPi and GPMi) a rostro-caudal somatotopie organisation

- face  
  - superior part
  - upper limb  
  - intermediate part
  - lower limb  
  - inferior part

DISCUSSION

The somatotopopie organization analysis is an interesting spin-off of intra operative motor side effect analysis. The GP somatotopie related to these clinical conditions has to be confirmed. Studies have reported a somatotopie of clinical effect (dystonia (9), dyskinesia (12)) or a spatial organization of kinesthetic cells in Parkinsonian GP (7). Techniques of localization of clinical effects or anatomical structures should influence the results and have to be refined as proposed with our patent based approach.

References:
3. Carpenter’s Human Neuroanatomy
10. References

Sources:
4. Carpenter’s Human Neuroanatomy