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Original Article

Neurophysiological comparisons of subthalamic deep-brain stimulation for Parkinson's disease between patients receiving general and local anesthesia

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ABSTRACT

Objectives: Subthalamic nucleus deep-brain stimulation (STN-DBS) is suggested as a standard treatment for patients with Parkinson's disease (PD) and drug-related side effects. Most centers perform the operation under local anesthesia (LA) to ensure better microelectrode recording (MER). Given the advances in imaging and MER, general anesthesia (GA) is perceived as an alternative choice for PD patients undergoing STN-DBS. However, the outcomes in terms of clinical symptoms and MER after GA have rarely been reported. In this report, we compared the outcomes after STN-DBS for PD between patients receiving LA and GA.

Materials and Methods: We included 16 patients with comparable severity of PD undergoing either GA ($n = 8$) or LA ($n = 8$) for STN-DBS. MER was performed in all patients for STN localization, and surgical outcomes were evaluated using the Unified PD Rating Scales, and Mini-mental status examination. All adverse effects were documented.

Results: Both groups (GA and LA) acquired similar benefits from STN-DBS, and there were no significant differences in neuropsychiatric outcome analysis between groups. There were no significant differences in stimulation parameters and adverse effects from STN-DBS between groups. The GA group had a trend toward a lower frequency rate of STN firing on MER.

Conclusion: Although the GA group has a lower neuronal firing frequency in the STN during surgery, STN-DBS under GA showed comparable and non-inferior outcomes as compared with STN-DBS under LA.

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1. Introduction

The efficacy of subthalamic nucleus deep-brain stimulation (STN-DBS) for Parkinson's disease (PD) has been well documented in long-term follow-up studies. It offers patients with medication-related side effects a better quality of life as compared with using medication alone [1,2]. Given the imperative role of the electrode position within the target nucleus for DBS, delineation of the "intraventricular" nuclei with imaging and

detailed electrophysiological mapping with microelectrode recording (MER) are the most powerful tools available to improve surgical outcomes [3]. Adverse effects from STN-DBS are rare and most can be improved with adjustment of the DBS parameters.

DBS for neuropsychiatric diseases is usually performed in awake patients under local anesthesia (LA) to provide the most accurate neural characteristics of the target nucleus. However, intra-operative safety risks and postoperative psychosis, although rare, increase in awake patients undergoing long cranial surgeries [4]. It is still debated whether neuromodulation surgery with intra-operative electrophysiological localization could be performed under general anesthesia (GA). There is a paucity of reports directly comparing PD symptoms after STN-DBS between patients who had GA or LA.

Conflicts of interest: none.

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Previous reports demonstrated that intravenous sedation with propofol led to significant damping of MER during STN-DBS for PD [5]. In our previous study, we showed that inhalation anesthetics could ensure adequate recording of neural firing during STN-DBS. We therefore analyzed clinical and electrophysiological outcomes between PD patients who had GA or LA [6].

2. Materials and methods

2.1. Patient selection

From January 2010 to December 2014, 16 PD patients who underwent bilateral STN-DBS at Tzu Chi General Hospital, Hualien, Taiwan were enrolled in this comparison study. Eight were assigned to the GA group and received desflurane GA with endotracheal intubation during bilateral STN-electrode implantation, and eight patients were assigned to the LA group and received regional anesthesia in the scalp. The type of anesthesia was determined by patient preference after comprehensive explanation of the pros and cons of different anesthetic strategies. Considerations in choosing the anesthetic method generally included ability of the patient to stay alert and cooperate during the entire DBS procedure and risks of GA in terms of medical status. The inclusion criteria for PD patients included: (1) significant positive response on a levodopa test [Unified PD Rating Scale (UPDRS) part III > 30% improvement in score]; (2) preoperative brain magnetic resonance imaging (MRI) ruling out structural abnormalities (i.e., stroke, traumatic brain injury, encephalopathy, etc.) and showing cerebral vasculature; and (3) no active psychiatric or severe medical diseases. This study was approved by the Institutional Review Board of Tzu Chi General Hospital (No. 103-09-B).

2.2. Preoperative imaging planning

Before the date of operation, cranial images were obtained with a 1.5-tesla magnetic resonance (MR) unit (General Electric, Rahway, NJ, USA). The standard settings comprised T1-weighted axial images at 0.75-mm thickness, T2-weighted axial images at 2-mm thickness, and T1-weighted images with contrast (delineation of vasculature in cases of inadvertent injury). Each of these sequences was performed in contiguous axial slices. The images were transferred to the Stealth neuronavigation workstation (Medtronic, Minneapolis, MN, USA). The image fusion software fused all three sets of MR images. The tentative surgical target coordinates for the tip of the permanent implantable electrode were set at the central lowest border of the STN by direct visualization from brain MRI (direct targeting) and adjusted according to the relative position of the anterior commissure–posterior commissure (AC-PC) line and red nucleus (indirect targeting).

2.3. Stereotactic and anesthetic procedure

On the morning of the operation, a Leksell G-frame (Elekta Instrument Inc., Norcross, GA, USA) was applied under LA with the patient sitting in a chair. Both groups of patients (GA and LA) were then given computed tomography (CT) examinations. The CT images were fused on preoperative MRI to determine target coordinates. Patients in the LA group were placed in the supine position with the head of the bed elevated at 30°. GA was induced in the other group of patients by administration of regular narcotic agents and a muscle relaxant. After intubation, patients were maintained by desflurane inhalation during the entire surgical course. The depth of anesthesia was maintained at 0.5–1.0 minimal alveolar concentration, so the patient would not experience a

Table 1

Pre-operative status between GA and LA.

Clinical demographics	GA (n = 8)	LA (n = 8)
Age of onset, y	49.6 ± 7.1	41.1 ± 10.2
Disease duration, y	9.3 ± 2.4	12.4 ± 9.2
Pre-op Levodopa response (%)		
Part I	39.9 ± 27.7	30.0 ± 13.9
Part II	54.3 ± 30.1	49.0 ± 27.1
Part III	41.7 ± 29.4	39.9 ± 16.3
Brady	41.5 ± 21.0	32.3 ± 17.3
Tremor	33.8 ± 67.4	39.3 ± 44.4
Rigidity	49.2 ± 43.3	54.3 ± 23.4
Posture & Gait	41.9 ± 29.4	43.1 ± 27
Axial	35.7 ± 25.6	34.4 ± 22.3
Total	41.1 ± 25.9	35.2 ± 13.2
Part IV score	6.1 ± 3.1	4.6 ± 3.5
H&Y stage ^a	3.0 ± 0.5	2.9 ± 0.6
SEADL score ^a (%)	68.8 ± 18.9	66.3 ± 17.7

Data are presented as mean ± standard deviation.

GA = general anesthesia; H&Y = Hohen and Yahr; LA = local anesthesia; SEADL = Schwab and England activity of daily living score; STN-DBS = subthalamic nucleus deep-brain stimulation; UPDRS = unified Parkinson's Disease rating scale.

^a H&Y stage and SEADL were expressed in Med off status.

cough reflex or any change in heart rate or blood pressure during the MER procedure [6].

2.4. MER procedure

Neural firings obtained from the tip of the microelectrode (FHC, Bowdoin, ME, USA) were sent to the intraoperative MER system (Leadpoint; Medtronic) where they were magnified and displayed. The sampling rate was 24 kHz. For both groups of patients, passive movement of the contralateral limb was tested during MER in the STN to observe whether there were any movement-related neuronal firing changes. The selection of the final trajectory for electrode implantation depended on adequate length of STN hyperactivity neuronal firing and the presence of movement-related firing-pattern changes. In the LA group, stimulation of up to ~4–5 V was done to test for adverse effects and the immediate effectiveness of each individual electrode. We did not perform any intraoperative test stimulation in the GA group.

Table 2

STN-DBS effectiveness (%) between preoperative and postoperative status in both groups.

	GA	<i>p</i> ^a	LA	<i>p</i> ^a
Part I	36.2 ± 31.7	0.0127 *	35.7 ± 15.9	0.0053 **
Part II	41.8 ± 51.0	0.0102 *	49.2 ± 26.6	0.0028 **
Part III	41.5 ± 35.8	0.0008 **	45.8 ± 26.2	0.0003 **
Brady	31.0 ± 10.1	0.0013 **	33.5 ± 25.8	0.0016 **
Tremor	69.8 ± 38.5	0.0082 **	76.2 ± 38.1	0.0085 **
Rigidity	59.0 ± 1.9	0.0028 **	61.3 ± 38.2	0.0056 **
Posture & Gait	29.7 ± 32.8	0.0080 **	33.3 ± 33.2	0.0199 *
Axial	34.0 ± 35.0	0.0109 *	31.9 ± 40.3	0.0094 **
Part IV	43.3 ± 0.6	0.0050 **	39.5 ± 4.9	0.0100 *
Total	38.5 ± 41.7	0.0013 **	46.0 ± 30.9	0.0006 **
Hoehn & Yahr Stage	28.1 ± 23.7	0.0050 **	32.2 ± 20.2	0.0479 *
SEADL Score	73.8 ± 11.9	0.0038 **	86.3 ± 10.6	0.0035 **

Data are presented as mean ± standard deviation.

* *p* < 0.05.

** *p* < 0.01.

GA = general anesthesia; H&Y = Hohen and Yahr; LA = local anesthesia; SEADL = Schwab and England activity of daily living score; STN-DBS = subthalamic nucleus deep-brain stimulation.

^a The *p*-value represents a comparison to preoperative status.

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