

MD-1. Bleeding Risk of Deep Brain Stimulation Pertaining to the Targets: Subthalamic Nucleus Versus Globus Pallidus

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Objective: Intracranial hemorrhage is a rare complication of deep brain stimulation (DBS) but it is catastrophic disaster which could result in mortality or neurological sequela. The authors analyzed the bleeding risk associated with the targets of DBS: subthalamic nucleus (STN) and globus pallidus interna (GPi).

Methods: A total of 316 DBS procedures were performed on 172 patients with idiopathic Parkinson's disease (IPD) or dystonia at a single institution between March 2002 and February 2015. Immediate after the surgery, all patients had conducted computed tomography or magnetic resonance imaging. We analyzed immediate postoperative intracranial hemorrhage and compared the ratio according to the DBS targets.

Results: All of 316 DBS procedures included 279 procedures diagnosed with IPD and 37 with dystonia. According to the targets, STN was applied in 232 and GPi in 84. There was no stastically significant difference of UPDRS improvement between two groups. Nine hemorrhages (3 major hemorrhages and 6 minor hemorrhages) were occurred and the incidence of hemorrhage per procedure was 2.85%. All of 9 hemorrhages occurred in STN group, whereas there was no hemorrhage in GPi group ($p=0.119$).

Conclusions: In IPD, the functional outcomes are similar in STN and GPi DBS group and in dystonia, GPi is the only target. However, according to our study, STN targeting for DBS revealed significantly high risk of bleeding compared to GPi targeting. Therefore, we should consider this aspects for DBS operation.

MEMO



MD-2. Long-term Results of Transaxillary Subpectoral Implantation of Implantable Pulse Generators for Deep Brain Stimulation

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Objectives: We introduced a technique of transaxillary subpectoral implantation of implantable pulse generator (IPG) for deep brain stimulation (DBS) in 2012, and investigated problems related to replacement of IPGs following transaxillary subpectoral IPG implantation and long-term results of transaxillary subpectoral IPG implantation.

Methods: 25 patients who underwent bilateral IPG replacement following transaxillary subpectoral IPG replacement and 45 patients who underwent transaxillary subpectoral IPG implantation were investigated for IPG site problem.

Results: No erosion and primary infection originating from the IPG implantation site were observed. There was no difficulty in replacement of subpectoral IPG through transaxillary route. One case of IPG migration into axilla occurred. Three cases of transient paresthesia in upper arm due to irritation of the intercostobrachial nerve were observed.

Conclusions: These results demonstrated that transaxillary subpectoral IPG implantation can provide better cosmetic satisfaction, with less discomfort and morbidity related to erosion and infection. No difficulty was found related to replacement of IPG following transaxillary subpectoral implantation.

MEMO



MD-3. Pallidal Deep-Brain Stimulation Improves Memory in Cervical Dystonia Patients

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Objectives: Medically refractory cervical dystonia may be treated with surgery such as deep brain stimulation. Recently, the nucleus basalis of Meynert has been suggested as a potential target for memory impairment. As the globus pallidus internus, which is the optimal target for cervical dystonia, is anatomically close to the nucleus basalis of Meynert, stimulation for the therapeutic purpose of cervical dystonia potentially affects that.

Methods: The neuropsychological examinations, which were conducted pre- and postoperatively, of nine patients with cervical dystonia were retrospectively analyzed. Before performing the neuropsychological tests, the location of the active contact was plotted on the Schaltenbrand-Wahren atlas, and the patients were separated into two groups according to whether the active contact was adjacent to the nucleus basalis of Meynert.

Results: Analysis of the neuropsychological examinations showed that delayed recall, as shown by verbal learning tests, was significantly improved after deep-brain stimulation (mean baseline score of 5.9 ± 2.0 and mean postoperative score of 7.0 ± 2.1 , $p=0.041$). Five of the nine patients had active contacts adjacent to the nucleus basalis of Meynert, and this group presented with higher memory improvement rates (median 37.5%, range of 0-100%) than the other group (median 0%, range of 0-20%, $p=0.096$).

Conclusion: The patients with cervical dystonia who underwent pallidal deep-brain stimulation showed significant improvement in verbal memory delayed recall. This positive effect on memory function likely correlated with unintended stimulatory effects on the nucleus basalis of Meynert, which is known to play an important role in modulating human cognitive function.

MEMO



MD-4. Vim and PSA Stimulation in Holmes' Tremor Secondary to ICH

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Holmes' tremor, first described by Gordon Holmes in 1904, is a rare condition characterized by symptomatic low frequency resting tremor, usually less than 4.5 Hz, which is enhanced by posture, even more aggravated with action, disappears during sleep, and is generally unilateral. This tremor, also known as rubral, midbrain, or myorhythmia, typically involves the proximal regions of the limbs and occurs as a delayed manifestation of lesions involving the upper brain stem, areas adjacent to the red nucleus, substantia, and the nigrostriatal tract. Only a few case reports have described effective management involving medical treatment. Because of the low success rate of medical treatment, some patients are referred for surgery. The ventralis intermedius nucleus (Vim) of the thalamus is the commonly chosen target for deep brain stimulation (DBS) to alleviate essential and parkinsonian tremor. Thalamic DBS has therefore often been applied for the surgical treatment of Holmes' tremor. However, the outcomes of surgical treatment for Holmes' tremor have often been disappointing. We report clinical follow-up for a fifty six year-old man who underwent Vim and posterior subthalamic area (PSA) DBS for diagnosed Holmes' tremor.

A 56-year-old man with severe tremor affecting predominantly the right upper limbs and head was referred to our department of Neurosurgery. Fifteen months ago, he had developed suddenly right hemiparesis and dysarthria. Computed tomography (CT) showed an acute hemorrhage from the brachium pontis through the dorsal midbrain on the left side. At 11 months from the initial hemorrhage, the patient developed tremor of the head and right arm, which worsened progressively in the following days. He had low amplitude, irregular, coarse tremor of the right upper extremity at rest and posture that was further accentuated by action and did not occur during sleep. He received various treatments including propranolol, carbidopa, clonazepam and baclofen in adequate dosage for reasonable periods of time, but these drugs were ineffective. Because of insufficient medication response, he was evaluated for DBS and was treated with left Vim and PSA DBS in 2014. Surgery was performed following established DBS procedures. Clinical rating scale for tremor (CRST) was assessed before surgery and was repeated at 1 month and 3 months after DBS surgery. At a postoperative period of 3 months,



part A of the CRST was remarkably improved from 16 to 4 with Vim and PSA DBS. In the 3-month postoperative period, part B of the CRST was also improved from 31 to 25, and part C was improved from 30 to 21. In conclusion, Vim and PSA DBS can be an effective and safe treatment for medically refractory Holmes' tremor.

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MD-5. Electrode Reposition in Deep Brain Stimulation for Parkinson's Disease

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Objectives: Review causes, target changes and clinical characteristics of lead reposition cases in DBS.

Methods: Among 60 patients treated by deep brain stimulation from 2013 to 2015 in the Asan medical center by one neurosurgeon (J.K. Lee), six lead reposition cases were collected. Four patients were referred and three patients were reoperated.

Results: Leads were repositioned in seven patients of 11 electrodes. Intervals between the initial lead insertions and revisions ranged from 1 to 157 months (median: 15 months). In three patients, unilateral revisions were done and bilateral revisions were done in four patients. These patients were dopa-responsive and partially responsive to deep brain stimulation before revision. In all patients deep brain stimulation effects were ineffective or suboptimal. In two patients, freezing of gait was unresolvable. In one patients, dysarthria was severe. In one other patient, dyskinesia was severe. In one patient, foot dystonia was uncontrolled by deep brain stimulation. In post-revision patients, UPDRS III scores was improved 16-70% when deep brain stimulation was turned on. Some focal symptoms were also improved. Freezing of gaits were improved in two patients. One lead was changed from globus pallidus interna to subthalamic nucleus in one of these patients. Dyskinesia and dysarthria were also improved. In one patient with dystonia, unilateral deep brain stimulation ineffectiveness was not resolved after revision from globus pallidus interna to subthalamic nucleus. In one patient with abulia and tremor, subthalamic nucleus target was changed to posterior subthalamic nucleus and symptoms were improved. In all other eight lead revisions, subthalamic nucleus was the target in the initial operations and revisions. When subthalamic nucleus targets were maintained, electrodes moved median 2.8 mm (1.4-5.9 mm). When pre-revision and post-revision MRIs were compared, 6 leads moved closer to ideal MRI direct target. 2 leads moved farther from the ideal MRI targets.

Conclusion: Our result shows that lead reposition can be considered in suboptimal or ineffective outcome deep brain stimulations with suboptimally placed leads. Target change from globus pallidus interna to subthalamic nucleus or subthalamic nucleus to posterior subthalamic area can be effective in some cases.



MD-6. Comparison of 1 Year Result in Variable Treatment Modalities for Essential Tremor

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Objectives: Various modalities for essential tremor (ET) have had emerged and disappeared during past 10 years. Though lesioning of ventralis intermedius (Vim) nucleus of thalamus (thalamotomy) is now rarely applied to patients, it was popularized and regarded to be equally effective as deep brain stimulation (DBS) for essential tremor. Nowadays magnetic resonance-guided focused ultrasonic surgery (MRgFUS) is on its clinical trials and early application to patients. We retrospectively analyzed the effectiveness and adverse effects by comparing thalamotomy, DBS, and MRgFUS at the time of 1 year after surgery.

Methods: Twenty-seven patients who had undergone thalamotomy, 13 for DBS, 17 for MRgFUS had unilateral procedure to the severe tremor side were included. Assessments were performed preoperatively, and 3, 6, 9, and 12 months after surgery mainly with 'Korean version of clinical rating scale for tremor' based on Fahn S (1988).

Results: For unilateral thalamotomy group, 25 directed to left, and 2 to the right Vim and their mean age were 61.6 ranging 26 to 77, whose follow up periods were 27 months ranging 15-57. For unilateral DBS group, all 13 patients had Lt posterior subthalamic area (PSA), whose mean age was 64.2, ranging 51 to 79 with mean follow up period was 24 months. MRgFUS group whose mean age was 63.2, ranging 46-78, had undergone procedure at left Vim in all 17 patients with 12 months follow up. Excellent and good outcome were 88.9% in thalamotomy group, 92.3% in DBS, and 76.5% in MRgFUS group. Treatment related complication was 44.4% (n=12) in thalamotomy, 15.3% (n=2) in DBS, and 11.7% (n=2) in MRgFUS. MRgFUS related side effects were sensory change on tongue and disequilibrium which was disappeared within 6 months after surgery.

Conclusion: Unilateral Vim thalamotomy, PSA DBS, and MRgFUS have similar effectiveness at the time of 1 year after surgery, although treatment-related complication seems to be less in DBS and MRgFUS group. Further investigation and long term follow up is essential for comparing these modalities especially in DBS and MRgFUS.



MD-7. Temporal Patterns of Pallidal Deep-Brain Stimulation Parameters in Cervical Dystonia

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Objectives: Medically intractable cervical dystonia should be managed with surgical modalities, including deep-brain stimulation (DBS) within the ventral portion of the globus pallidus internus (GPi) or selective peripheral denervation. The purpose of this study was to identify temporal patterns in stimulation parameter settings using a predetermined parameter adjustment algorithm.

Methods: Nineteen patients with medically refractory idiopathic cervical dystonia who underwent GPi DBS were enrolled. The algorithm of stimulation parameter adjustment included a test stimulation, initial adjustments, and follow-up adjustments. Baseline and follow-up parameters were analyzed according to their dependence on time after DBS. The changing pattern in the stimulation parameter with respect to time, the differences across the four active contacts, and the relationship between the stimulation parameters and clinical benefits were evaluated.

Results: The mean age and the duration of the disease were 50.9 years and 54.7 months, respectively. Significant increases in the amplitude and the frequency were found within three months of the operation. The intensities of the parameters were higher in the bipolar mode and in the upper active contacts. Other than the stimulation parameters, the only factor associated with improved clinical benefits was time.

Conclusion: High intensities in the pulse width are not recommended. Although, sufficiently high intensities in the amplitude and frequency may be needed to achieve improvements in GPi DBS in patients with cervical dystonia, increasing intensities in the amplitude and the frequency are not determinants of clinical benefit. Rather, clinical benefits increase over time, independent of other factors.

MEMO



MD-8. Selective Peripheral Denervation in the Treatment of Spasmodic Torticollis: Outcomes in 65 Patients

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Objectives: This study was carried out to analyze the treatment results and prognostic factors in patients with spasmodic torticollis who underwent selective peripheral denervation.

Methods: 65 patients with follow-up of more than 6 months were retrospectively analyzed. The mean follow-up period was 22 months (range, 6-84). The mean age at time of surgery was 46 (range, 16-74). The mean duration of disease was 34 months (range 4-247). 49 patients had a rotational type, 9 had laterocollis, 7 combined type (3 reterorotation, 3 laterorotation, and 1 retrolateral type). Selective peripheral denervation of the spinal accessory nerve and extraspinal posterior rami of the cervical spine nerves postramisectomy C1-C6 with/or the C3 and C4 anterior rami to the levator scapulae muscle were performed. Patients were assessed with clinical severity scale, Bertrand's criteria, and preoperative parameters between excellent/good and fair/poor group.

Results: We obtained excellent result in 21.5% of the cases, good in 55.4%, fair in 13.8%, and poor in 9.2% at the last follow up after surgery. The mean age in excellent/good (n=35) and fair/poor (n=13) group at operation was 43.2 and 53.5, respectively. The pattern of head movement in excellent/good and fair/poor group was tonic in 84.7% (50/59) and phasic in 83.3% (5/6) in cases, respectively. These factors affected the prognosis statistically ($p=0.024$ (age), $p=0.005$ (pattern)). The excellent group did not differ significantly from the poor group in sex ($p=0.78$), symptom duration ($p=0.147$), and preoperative clinical severity scale ($p=0.329$). 50 percent (3/6) of combined type had a poor result. Almost patient had tolerable numbness in the C2 dermatome except for 3 patients (4.6%) who suffered from annoying dysesthesia or pain on the occipital area.

Conclusion: Selective peripheral denervation can offer significant improvement without severe side effects in the treatment of selected patients with simple rotatory and lateral type of spasmodic torticollis.

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