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RESEARCH ARTICLE

Parkinson's disease and selected reuse of Stereotactic surgery

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Abstract

Parkinson's disease is a common progressive, degenerative disease whose victims experience the symptoms of bradykinesia, tremor and rigidity. Leva dopa therapy was assumed to be a break through in the treatment of Parkinson's disease. But with time it was seen that the effect decreased with each passing day of treatment. With advanced brain-mapping technology, surgical techniques have developed significantly, and considerable interest has been generated in the current role of stereotactic surgery. The use of highly advanced computers to locate and create a three-dimensional image of a tumor is called stereotaxy. When used during surgery, this technique is called stereotactic surgery. The aim of this article is to emphasize the role of this type of surgery and its moderately beneficial effects on the patients' life style. The goal of all stereotactic procedures is to provide accurate navigation to a point or region in space. These methods provide guidance techniques to access deep structures within the brain without the necessity of direct visualization. The development of a stereotactic frame for human use required detailed maps of the human brain in standard and reproducible orientations .Further developments included frame-based, image-guided neurosurgical procedures for the biopsy and treatment of lesions using primarily computed tomography (CT) or magnetic resonance imaging as well as the advent of frameless stereotaxis, which provides accurate localization based on various forms of three-dimensional digitization of the skull and brain.

Introduction

After more than 20 years of experience with levodopa therapy, it became clear that some people respond poorly, and that in others treatment is limited by the development of drug-induced side effects or by benefits becoming unpredictable. (People with early-onset PD have a very strong possibility of developing complications within a very short time.) Initially, symptoms can be controlled with L-Dopa, but eventually, side effects of the medication preclude further dose increase. The patient develops periods of painful spasms, "freezing" of movements and abnormal involuntary movements which can involve one or both sides of the body.

Minimally invasive stereotactic surgery and implantation of deep brain stimulators (similar to pace-makers) into various parts of the brain are new modes of therapy for patients with advanced Parkinson's disease. Neurosurgeons specially trained in these techniques provide surgical expertise and use special recording devices during the operation to ensure correct placement of the electrode stimulators (wires). The major part of the procedure is carried out under local anesthesia. After each operation, programming of the stimulators is carried out to turn on the stimulators and determine the best settings that will alleviate the symptoms of Parkinson's disease.

The main aim of the study is to highlight the important advantages which stereotactic surgery confers in some cases.

Methodology:
Comparing the data from different sources and generalizing the data to lead to simpler conclusions was adapted. Primary modalities of stereotactic surgery have also been described in relation to different parts of brain as far as their significance is concerned. A brief mention of complications as well as contraindications is also mentioned and in no way should a generalization be made about treatment of Parkinsonian symptoms but a more specific approach should be adopted.

Discussion:

Stereotactic Surgeries for Parkinsons Disease have surgical targets in the Central Nervous System
Surgical Targets:
1 **Thalamus:** for tremor
2 **Globus pallidus**: for rigidity, bradykinesia, dyskinesia, dystonia
3 **Subthalamic Nucleus**: for rigidity, bradykinesia, dyskinesia, tremor, postural instability

Several types of surgery are accepted in the treatment of Parkinson's disease. The most important are deep brain stimulation, pallidotomy and thalamotomy. These are all "stereotactic" surgeries, which mean that a special frame is attached to the head for the operation. This frame has calibration marks that enable the surgeon to position instruments very precisely within the brain. Magnetic Resonance (MR) images are taken after the frame is put in place, and these images are used to find the correct target sites in the brain for the surgery.

Stereotactic surgery requires only a small incision and a hole less than 1/2 inch in diameter to be made in the skull. This is usually done under local anesthesia. Because stereotactic brain surgery is "minimally invasive" many stereotactic surgeries can be performed on an outpatient basis.

Stereotactic surgery is an approach to treatment that makes use of a system of three-dimensional coordinates to locate a site (most commonly within the brain) as precisely as possible for biopsy or surgery. Stereotactic surgery can be used to treat movement disorders as well as brain tumors. In fact, the first clinical application of stereotactic systems in human medicine was in the treatment of schizophrenia in the late 1940s, followed by the use of stereotactic surgery to treat Parkinson's disease and chronic pain in the 1950s. As of the early 2000s, stereotactic surgery is used to treat such other movement disorders as Huntington's chorea and essential tremor, and to insert catheters into the brain to drain abnormal collections of fluid resulting from head injuries, hydrocephalus, or cysts.[5]

The earliest forms of stereotactic surgery in humans developed out of an apparatus that was designed by Victor Horsley and Henry Clarke in 1906 to study brain functions in monkeys

Stereotactic surgery was first used in 1947 by Spiegel and Wycis for tremor. Initially lesions were made in the part of the brain known as the pallidum but in the mid '50s the target moved to the thalamus and this target proved better for tremor. A lesion made in the left thalamus suppressed tremor on the right side and vice versa. This procedure gave some patients relief from tremor but other symptoms persisted; if the patient needed surgery on both sides, complications such as problems with speech often occurred.

Thalamotomy (in the ventrolateral part of the thalamic nucleus) has long-lasting effects in reducing or eliminating tremor on the opposite side and is used where there is severe, disabling tremor, preferably unilateral (and unaccompanied by marked bradykinesia), that is unresponsive to drug therapy. Deep-brain stimulation may be used on the second side. Bilateral surgery is rare and bradykinesia (slowness of movement) may increase following Thalamotomy, when tremor is obliterated. This is one of the reasons for pallidotomy becoming more popular.

Pallidotomy (in the ventroposterio-lateral area of the globus pallidus) is reported to improve bradykinesia (rigidity and akinesia), walking, hand function and verbal skills; there is significant benefit on dyskinesias opposite to the side lesioned and the pain generated by these. There is concern about bilateral surgery, and the long-term effects on cognition (mental processes) are unknown. Reports on the effect of pallidotomy on cognitive functions are varied. One study showed significant improvement in recall, verbal, visual and general memory.

Deep brain stimulation (DBS) is a reversible therapy using small implanted programmable electrodes to block brain signals that cause disabling tremor. Surgery involves insertion of one or more electrodes into the thalamus, pallidum or subthalamic region (on the contralateral side to the tremor), using an MRI scan for accuracy. It is left in position and attached to a battery-operated, high-frequency-current generator. The first stage is exact placement under local anaesthesia, allowing external testing over several days. The second stage involves implantation of the 'pacemaker' beneath the skin of the upper chest wall (the subclavicular area). Stimulation is then controlled by the patient using a hand-held magnet. Bilateral DBS is possible. Side effects are mild and reversible when stimulation is discontinued. Effects can be long-lasting and tuning can be varied to allow optimal results with few complications (some dysarthria — speech problems — and balance impairment have been observed but can be reversed with tuning). No cognitive changes have been recorded.

Available information indicates that surgery of the globus pallidus internus and thalamus (the pallidal receiving area) and of the subthalamic nucleus has a pronounced antidyskinetic effect. This effect is associated with a concomitant improvement in the parkinsonian ("off"-medication) state. Although it is more profound with pallidal and subthalamic surgery, such an effect can also be observed to some extent with thalamic surgery The conclusion is that Surgery is the only treatment available for Parkinson's disease that can predictably improve both the parkinsonian motor syndrome and LID (L-dopa-induced dyskinesia) [1]

Thalamotomy and posteroventral pallidotomy (PVP) are introduced as effective means to alleviate motor symptoms in Parkinson's disease (PD). Rigidity and dopa-induced dyskinesia are improved and abolished by either of the two procedures, but tremor is more markedly improved by Thalamotomy than by PVP. To date, surgical treatment has been important in treating PD [2]

There has been resurgence in the use of functional neurosurgery for Parkinson's disease. An important factor that has played a role in this development is the recent understanding of the functional anatomy of the basal ganglia including a knowledge of the changes in the activities of neurons in the internal segment of the globus pallidus (Gpi) and the subthalamic nucleus (STN) in Parkinson's disease as well as the knowledge of the presence of segregated functional loops within the basal ganglia which include a sensory-motor loop that involves the posteromedial globus pallidus rather than the anterior GPi where earlier pallidotomy lesions had been made. Laitinen reintroduced the modern posteroventral medial pallidotomy (PVMP) in 1992. Since then it has become clear that this treatment has major effects on levodopa-induced dyskinesias and, unlike Vim thalamotomy, improves bradykinesia and rigidity as well as tremor. [3]

Eighteen patients with medically intractable Parkinson's disease that was characterized by bradykinesia, rigidity, and marked "on-off" fluctuations underwent stereotactic ventral pallidotomy under local anesthesia. Targeting was aided by anatomic coordinates derived from the MRI, intraoperative cell recordings, and electrical stimulation prior to lesioning. A nonsurgically treated group of seven similarly affected individuals was also followed. Assessment of motor function was made at baseline and at 3-month intervals for 1 year. Following the lesioning, patients improved in bradykinesia, rigidity, resting tremor, and balance with resolution of medication-induced contralateral dyskinesia.[4]

Recent study findings showed a 44% improvement from baseline in Unified Parkinson's Disease Rating Scale (UPDRS) at 48 months in 6 patients who underwent unilateral stereotactic brain surgery to implant human retinal pigment epithelial cells (rHPE). Found in the inner layer of the retina, rHPE cells produce levodopa, a dopamine precursor. Once implanted in the brain, the levodopa produced by these cells is presumably converted to dopamine, the neurotransmitter that is decreased in PD due to progressive loss of dopaminergic neurons. These are not stem cells, they're not embryonic cells, they're not even neurons and don't require immunosuppression. This therapy offers us a way of delivering levodopa in a very smooth and regulated way without the ups and downs you get with oral medication [6]

In brain surgery, placing a microelectrode from the outer brain to the specific target becomes a new medical resource-reduced technology to alleviate Parkinson's disease. Generally speaking, this system includes versatile functions such as three-dimensional (3-D) reconstruction of the brain atlas, 3-D localization of the patient's brain CT data, registration of the brain atlas and CT data, fusion of the brain atlas and CT data, and surgical trajectory planning. More importantly, this system can correct the distortion due to the tilt of the head frame and make the localization result more accurate than other systems. [7]

Complications

Pallidotomy, thalamotomy and DBS are safe procedures. There is less than a 1 percent incidence of intracranial bleeding and infection in stereotactic neurosurgery patients. The risk of bleeding is probably lower in DBS than in pallidotomy or thalamotomy.

Thalamotomy and pallidotomy both carry a small risk of developing weakness of facial muscles, the arm or the leg on the side opposite the surgery. There is also a small risk of stroke occurring near the treated brain area within the first two months after the operation. This risk is much lower with DBS.

Thalamotomy has a small risk of speech impairment or difficulty swallowing. This risk may be higher if the procedure is done on both sides of the brain. This risk is much lower in DBS.

Pallidotomy carries a small risk of producing a blind spot in the visual field. If this complication develops in the right side of the visual field (when surgery is performed on the left side), it may make reading difficult.

Contraindications

Parkinson's disease patients with mental impairment are not candidates for any of these operations. Respiratory, cardiovascular or other health problems that could increase the risk of any surgery should be discussed with surgeon.

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