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Pallidotomy – outdated procedure or modern therapeutic alternative? – a review

Authors:

Agnieszka Pociecha [AP]

Silesian Women's Health Center in Katowice, 6 Kotlarz Street, 40-139 Katowice, Poland

e-mail: pociechaagnieszka15@gmail.com

ORCID: https://orcid.org/0009-0001-6879-1107

Marta Kozikowska [MK]

Upper-Silesian Medical Center in Katowice, 45 Ziołowa Street, 40-635 Katowice, Poland

e-mail:marta669@onet.eu

ORCID: https://orcid.org/0000-0002-5054-9187

Bożena Kmak [BK]

District Railway Hospital in Katowice, Medical University of Silesia, 65 Panewnicka Street, 40-760 Katowice, Poland

e-mail: bozenakmak13@gmail.com

ORCID: https://orcid.org/0000-0003-2112-4910

ABSTRACT

Introduction and purpose

Pallidotomy is a neurosurgical procedure involving the ablation of the globus pallidus, resulting in reduced activity in this area of the brain. Pallidotomy is an irreversible stereotactic procedure performed only under local anesthesia. It was first used in the treatment of dyskinesias associated with Huntington's chorea, but its widespread application has been in Parkinson's disease. This method is increasingly less common in developed countries due to its replacement by deep brain stimulation (DBS); however, it remains an effective treatment, particularly in drug-resistant, idiopathic Parkinson's disease. Unilateral pallidotomy is considered safer than bilateral pallidotomy due to the risk of severe complications, and thus, the bilateral approach is not recommended.

Materials and methods

A comprehensive literature review was conducted through an extensive bibliographic search, with a primary focus on original research articles obtained from reputable databases such as PubMed, BioMed Central, Polish Medical Platform, and Google Scholar. The search was specifically targeted towards articles pertaining to Pallidotomy.

Conclusions

The study shows that pallidotomy is a well-established neurosurgical treatment primarily used in drug-resistant Parkinson's disease. It should only be performed in centers specializing in stereotactic procedures. Symptoms that respond best to pallidotomy are those that previously responded to treatment, such as rigidity and tremors. The replacement of pallidotomy by deep brain stimulation (DBS) is due to the increased safety, effectiveness, and the availability of bilateral and continuous stimulation. Bilateral pallidotomy leads to severe complications and is currently not recommended. Pallidotomy has become a procedure used in specific situations and may be an alternative surgical treatment when there are contraindications to deep brain stimulation.

Keywords:

pallidotomy, globus pallidus, ablation, stereotaxy

Pallidotomy - Basic Information

Pallidotomy is a neurosurgical procedure performed on the globus pallidus to destroy it, thereby reducing its activity. The expected outcome of the procedure is a reduction in tremors, and alleviation of muscle rigidity and bradykinesia. The procedure also affects other

symptoms, such as dystonia and limb dyskinesia, but it has limited application in treating non-motor symptoms, including speech disorders. Typically, symptoms that responded positively to pharmacological treatment with levodopa also respond well to the surgical procedure. The recommended target for ablation on the globus pallidus is its posterior-ventral part, as operating in this area most effectively leads to long-term relief of tremors, bradykinesia, and rigidity. Ablation performed only partially on the posterior-ventral or external part of the globus pallidus is less effective. It is important to note that bilateral pallidotomy is considered a risky procedure due to the increased incidence of complications and is therefore not currently recommended. The most commonly reported deficits resulting from bilateral pallidotomy involve drooling or speech disorders, potentially leading to complete loss of speech, reduced volume, or impaired articulation [1-7].

Globus pallidus - aim of pallidotomy

The globus pallidus is a pale, spherical area in the brain whose name comes from the Latin "globus pallidus". "Globus" indicates a spherical shape denoting a sphere, and "pallidus" indicates a pale shape, due to the distinctive part compared to other structures in the brain tissue. It consists of two parts, external and internal, which are separated by a core plate. In the area of the globus pallidus interna, there is a somatotopic organization, indicating that the neurons responsible for the lower limbs are located dorsally, the lower limbs are located medially, and the neurons responsible for the face are located ventrally. The globus pallidus is an element of a larger structure - the lenticular nucleus, which is also part of the corpus striatum. It is rich in neuropeptides and endocannabinoids, thanks to which it influences the activity of nerve cells through many mechanisms. The globus pallidus plays an important role in controlling motor functions, which means that abnormalities in this area are associated with motor disorders such as dyskinesia, Parkinson's disease or Huntington's disease [8, 9].

Historical Overview

Pallidotomy as a surgical method was first described in the 1930s. The first pallidotomy was performed on a patient with Huntington's disease by neurologist Ernest Spiegel and neurosurgeon Henry Wycis in Philadelphia. Shortly thereafter, Parkinson's disease became the primary indication for pallidotomy. The 1950s saw a shift toward using thalamotomy to treat Parkinson's disease, and the following decade introduced levodopa for the treatment of dyskinesias, which nearly eliminated the use of pallidotomy in neurosurgery. In the 1980s, with growing awareness of the limitations of levodopa pharmacotherapy, interest in the ablation of the globus pallidus resurfaced, and in the 1990s, its positive effects in treating dystonia were recognized. The 21st century once again saw a decline in interest in

pallidotomy, largely due to the adoption of deep brain stimulation (DBS) of the subthalamic nucleus and the internal globus pallidus (GPi) for the treatment of movement disorders [10-12].

Description of the stereotactic procedure

Over the past 50 years, there have been numerous changes related to neurosurgical procedures. The main aspect is the fact that it is now possible to locate the site of damage or the target structure with great precision. Stereotactic techniques enable accurate localization of a given area in the brain using three-dimensional magnetic resonance imaging and computed tomography scans [13]. The first stage is the application of local anesthesia to the area of the scalp where the stereotaxic frame will be attached and where the surgical instruments will be inserted. The patient is conscious during the procedure.

Computed tomography is used to determine the target, the internal globus pallidus, and the course of electrode insertion in relation to the metal frame. During surgery, the frame remains attached to the patient's head because it also stabilizes the head so that it is in a fixed position. Then, a hole of approximately 3 mm is drilled in the skull through which the probe is inserted into the appropriate place. Its action is aimed at damaging the globus pallidus internala. The next important step is to see if you can control the tremors or other symptoms of the disease without causing any side effects, such as slurred speech or tingling in your hand or arm. When the test is successful, an electric current is passed through the wire to reach a temperature of approximately 70 degrees Celsius. By heating the electrode, it can coagulate and permanently damage a selected small area. Finally, the probe is removed and the wound is dressed. T1- and T2-weighted magnetic resonance imaging is used after surgery to investigate bleeding complications and assess the effects of tissue ablation. After the surgery, at least a two-day hospital stay is required, and the full convalescence period with complete return to health is usually about 6 weeks [2, 9-10, 14-17, 30].

Indications and contraindications to the procedure

The basic indications for pallidotomy in special cases are Parkinson's disease and dystonia. Scientific research is also trying to use it in other diseases. The qualification for surgery should be permanent disability despite treatment. There is no maximum or minimum age or stage of disease that would preclude pallidotomy. Pallidotomy should be considered or considered the first choice in patients who have low CD4 lymphocyte counts because of the increased risk of infection associated with implantation of pacemakers for DBS. This value of CD4 lymphocytes is observed during HIV infection or other immunodeficiencies. Additionally, pallidotomy should be considered among patients who cannot or do not consent

to undergo general anesthesia, because pallidotomy can then be safely performed under local anesthesia [4, 17, 18].

Contraindications to unilateral pallidotomy include encephalitis and other brain abnormalities, neuroleptic treatment, or evidence of dementia or other brain abnormalities revealed on MRI. Furthermore, the risk of hemorrhage or any disease that complicates the assessment of health status, including cerebrovascular disease, are factors that should be considered for exclusion from the procedure [17, 18].

Complications

It is estimated that the incidence of complications after pallidotomy is approximately 20%, but almost half of them disappear within 12 months after the procedure. The most serious complication that may occur as a result of pallidotomy is hemorrhagic stroke with a risk of approximately 0.5-4%. Bleeding may cause weakness on one side of the body, difficulty speaking or damage to vision depending on its location and severity. Moreover, surgery may not bring the expected improvement. There is a very low chance of wound infection, and epilepsy may be induced during the procedure. The probability of this complication is estimated at less than 1%. The most common complications are fatigue, excessive sleepiness, visual field defects and weakness on the side opposite the injury. The risk of death as a result of surgery is very small and amounts to approximately 0.2% [4, 17].

Comparison of pallidotomy to deep brain stimulation (DBS)

Ablative treatments and deep brain stimulation are procedures whose effectiveness is estimated in a large range, from 40 to 90%. Deep brain stimulation is the surgical treatment of choice for Parkinson's disease. However, pallidotomy should not be abandoned as a therapeutic option as it is considered a cost-effective and safe procedure that does not require close monitoring as in DBS. Implanting stimulators for deep brain stimulation may also cause infections. In this situation, postoperative patient care is more difficult in DBS than in pallidotomy. Another difference between treatments is the costs associated with performing the procedure. A more expensive method is deep brain stimulation, which involves the use of expensive stimulators. It is worth noting that pallidotomy poses a much lower risk of complications when other comorbidities occur. This is due to the use of only local anesthesia. Deep brain stimulation is a reversible procedure, unlike irreversible pallidotomy, during which it is possible to adjust and update the stimulation. This condition reduces the risk of lasting side effects. DBS also allows for a safe, bilateral procedure, which is not possible with bilateral pallidotomy. Additionally, deep brain stimulation confirmed a reduction in the doses of drugs used in the underlying disease after the procedure [4, 19]. To sum up, deep brain

stimulation is the surgical procedure of choice in Parkinson's disease. It provides greater benefits in improving motor functions. The reason for this condition is probably the 24-hour, programmed stimulation and probably due to continuous stimulation lasting 24 hours a day, which translates into a better reduction of symptoms.

Use in selected units

Parkinson's disease

Parkinson's disease is the second most common neurodegenerative disease in the world. The incidence of this disease increases with age. The main motor symptoms of Parkinson's disease are tremor, stiffness, bradykinesia and postural instability. Other non-motor symptoms may also be observed in the clinical picture, but the diagnosis of the disease should be based mainly on clinical symptoms. Detailed tests are used to differentially diagnose other forms of parkinsonism. Treatment of Parkinson's disease is symptomatic. Neuroprotective pharmacotherapy and symptomatic treatment with dopamine receptor agonists, including levodopa, are used [21-23]. Unilateral pallidotomy is performed in idiopathic Parkinson's disease only if exclusion conditions are met. Exclusion criteria include striatal degeneration as the cause of symptoms, dementia and severe dyskinesia or other disease caused by levodopa treatment [4, 18]. In the past, stereotactic surgical intervention for Parkinson's disease was considered indicated only in patients with active motor symptoms refractory to medical treatment, symptoms such as tremor, rigidity, dystonia, and dyskinesia. After the improvement of pallidotomy, both motor and non-motor symptoms are now subject to surgical treatment [23].

Dystonia

Dystonia is a movement disorder characterized by long-lasting or intermittent muscle contractions. As a result of these abnormalities, repetitive involuntary movements occur. Symptoms develop from a few to several years after their appearance, and then most often stabilize and do not deepen. The cause is usually still unknown. It is suspected that factors including genetics, trauma, infections, and the toxic effects of drugs and other chemicals may contribute to the development of dystonia. Dystonia is a debilitating disorder. The treatment involves anticholinergic drugs, benzodiazepines and botulinum toxin, but it is often very unsuccessful. After the ineffectiveness of pharmacotherapy, the next step in the guidelines is stereotactic functional neurosurgery. Surgical treatment primarily uses deep brain stimulation. However, one should remember about the therapeutic option of bilateral pallidotomy. Despite the significant number of complications, it is considered an effective short-term treatment for

dystonia. They are used primarily when there is resistance to pharmacotherapy for dystonia [24-26, 28, 29].

Meig's syndrome (ZM)

Meige syndrome is a syndrome that combines blepharospasm with oral dystonia. The clinical picture describes complex movements of the lower muscles of the face, mouth, jaw, tongue, throat and even the cervix. The causes of this syndrome are not specified. They may be primary, idiopathic, or appear secondary as a result of brain injury or the use of neuroleptic drugs. The treatment begins with botulinum toxin injections, which, if ineffective, allow the next stage to be introduced, which is deep brain stimulation. Meig's syndrome may be associated with essential tremor, Parkinson's disease and atypical parkinsonism [7, 27]. Meig's syndrome is an example of dystonia in which pallidotomy is unexplored and therefore not included in the syndrome's treatment guidelines. Experimental studies of unilateral and bilateral pallidotomy in Meig's syndrome have been performed and were at least as effective as DBS. These tests are only single treatments that cannot be compared statistically at this point [7].

Conclusions

Pallidotomy is a recognized neurosurgical treatment used primarily in drug-resistant Parkinson's disease. It should only be performed in centers that specialize in stereotactic procedures. The symptoms that respond best to pallidotomy are those that have responded to treatment, such as stiffness and tremor. The replacement of pallidotomy in treatment by deep brain stimulation results from the requirements of increased safety, effectiveness and access to bilateral and 24-hour stimulation. The use of bilateral pallidotomy leads to severe complications and is currently not recommended. Pallidotomy has become a procedure used in special situations and may be an alternative to surgical treatment if there are contraindications to deep brain stimulation.

Disclosures

Author’s contribution:

Conceptualization-Agnieszka Pociecha, Bożena Kmak, Marta Kozikowska

Formal analysis- Bożena Kmak, Agnieszka Pociecha, Marta Kozikowska

Investigation- Marta Kozikowska, Agnieszka Pociecha, Bożena Kmak

Writing-rough preparation- Bożena Kmak, Agnieszka Pociecha, Marta Kozikowska

Writing-review and editing- Marta Kozikowska, Bożena Kmak, Agnieszka Pociecha,

Visualization- Agnieszka Pociecha, Bożena Kmak, Marta Kozikowska

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