Thalamic surgery for tremor
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Summary

Results from our research

Severe pharmacoresistant tremor can be treated neurosurgically by stereotactic thalamotomy or by thalamic deep brain stimulation with implanted electrodes. The target structure for both procedures is the nucleus ventro-intermedius of the thalamus. The indications for surgery can be tremor due to Parkinson's disease, essential tremor, multiple sclerosis or other, less common diseases accompanied by tremor.

The effects of thalamotomy and thalamic stimulation in patients with tremor due to Parkinson's disease, essential tremor, and multiple sclerosis, were examined in a randomized clinical trial. Sixty-eight patients were treated (45 with Parkinson's disease, 13 with essential tremor, 10 with multiple sclerosis) by thalamotomy (N=34) or thalamic stimulation (N=34).

Six months after surgery, the functional status of the patients had improved more in the thalamic stimulation group than in the thalamotomy group, according to both the functional scale used as primary outcome measure, and the subjective evaluation of the effect of surgery by the patients.

Both treatments were equally effective in the reduction of tremor. Tremor was suppressed completely or almost completely in the majority of patients in both the thalamotomy group and the thalamic stimulation group. One patient in the thalamic stimulation group died perioperatively after an intracerebral hemorrhage. With the exception of this incident, thalamic stimulation was associated with significantly fewer adverse effects than thalamotomy. The main complications of thalamotomy were dysarthria and gait or balance disturbances. All adverse effects of thalamic stimulation were reversible and disappear when the stimulators were turned off.

Detailed neuropsychological investigation of the patients before and six months after surgery showed that both thalamotomy and thalamic stimulation were associated with a minimal overall risk of cognitive deterioration. The only change that was found, was decreased performance on a verbal category-fluency task after both left-sided thalamotomy and left-sided thalamic stimulation. This was not noticed by the patients themselves.

After two years of follow-up, thalamic stimulation was still associated with more functional improvement than thalamotomy, although the difference was smaller than at six months after surgery. Both procedures remained effective for the suppression of tremor in the majority of patients, but a wearing off of the effect of stimulation on tremor was seen in several of the patients with essential tremor and multiple sclerosis. There were a number of equipment related complications after stimulation, but adverse effects of surgery were still higher in the thalamotomy group after two years.

The general conclusion from the study is that thalamic stimulation is preferable to thalamotomy as a means of improving functioning in daily life activities for patients with pharmacoresistant tremor caused by Parkinson's disease and essential tremor. In essential tremor, additional investigations are needed to ensure a permanent effect of treatment in all patients. In multiple sclerosis, the choice of treatment must be further studied with respect to the balance of therapeutic benefit and adverse effects.

Accurate localization of the target structures is of crucial importance in these stereotactic procedures. This can be performed by ventriculography or by three-dimensional magnetic resonance imaging (3D-MRI), but image distortion is a potential source of inaccuracy when using MRI images. A comparison of stereotactic coordinates obtained by ventriculography with coordinates derived from 3D-MRI showed that there is sufficient agreement between ventriculo-
graphy-derived and 3D-MRI-derived stereotactic coordinates, to justify the use of 3D-MRI target determination in frame-based functional stereotactic neurosurgery.

**Future prospects**

Our clinical study showed that deep brain stimulation is safer than lesioning in the thalamus, which finding can probably be extended to functional stereotactic procedures in other target nuclei within the brain. In Parkinson’s disease, thalamic stimulation will be replaced largely by subthalamic nucleus stimulation, which seems to produce an overall improvement of parkinsonian motor symptoms, including tremor. For stable, tremor-dominant Parkinson’s disease and for other causes of tremor, thalamic stimulation will remain a useful tool to improve the functional status of the patient.

The development of the technique of brain stimulation has opened up an entirely new approach to the surgical treatment of various neurological diseases. The dramatic effects of brain stimulation in movement disorders has led to interest for its use in the treatment of chronic pain, epilepsy, psychiatric disorders, and other emerging areas. This will involve close collaboration between neurosurgeons, neurologists, psychiatrists, physiologists, radiologists, and workers in the field of stimulation device technology.

Further development of the pathophysiological understanding of various disorders, functional imaging, and next generation stimulation equipment with electrical feedback functions, can be used to reversibly modulate nervous system function in many ways.

**Additional considerations**

When functioning in daily life and perceived health become dependent on advanced medical technology, there are certain specific factors to take into consideration.

Technology can always fail, and patients must be prepared for this event, which must be dealt with promptly when it occurs. Furthermore, in the case of electrodes implanted into the brain, patients and physicians must be aware of the possible risks of other medical interventions, such as monopolar cautery often used in surgery or electrical cardioversion, which can seriously harm the patient. Additionally, interactions with the environment are possible, such as the strong electromagnetic field generated by a simple household drill or a nice set of new speakers, unexpectedly turning off the stimulators.

Besides technical failure, risk of other medical interventions and unwanted interaction with the environment, we must also consider what it means for an individual to have a stimulator implanted, in order for the body to function properly. For the subject there is no control over the function of the electrical system. This might lead to a feeling of decreased control over one’s own body, creating an additional feeling of dependency. Although it can be argued that many processes in the body are not under conscious control, an implanted stimulator remains an essentially ego-dystonic patch, towards which mixed feelings of gratitude for its effects and resentment for its necessity might occur.

Nevertheless, when we are aware of these considerations, neuromodulation by electrical stimulation of the brain can be used to enhance the functional abilities of patients, whose functioning is undermined by neurological disease. Hopefully this will lead to an improvement in the lives of many otherwise untreatable patients.