Control of persistent hemiballismus by chronic thalamic stimulation

Report of two cases

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Persistent hemiballismus after stroke is often difficult to treat. The ballistic movement is sometimes so violent that progressive exhaustion results. The authors report two such cases, which were successfully treated by chronic thalamic stimulation. The lesions responsible for the ballistic movement in these patients were located near the subthalamic nucleus and in the putamen, respectively. The thalamic nucleus ventrolateralis and nucleus ventralis intermedius were stimulated with 0.2 to 0.3 msec pulses at 50 to 150 Hz and 4 to 7 V continuously during the day. Several weeks later, complete control of the hemiballismus was achieved during stimulation. The improvement was clearly not attributable to spontaneous recovery, because ballistic movement reappeared after termination of the stimulation. The stimulation has remained effective for more than 16 months in both cases without any serious complications. Chronic thalamic stimulation appears to be useful for controlling persistent hemiballismus, as it is for other involuntary movement disorders.

KEY WORDS • hemiballismus • thalamic stimulation • stereotaxy • thalamus

The clinical picture of hemiballismus consists of abrupt and extensive involuntary movements of the limbs of one-half of the body, involving the proximal muscles of the limbs more than the distal ones. The ballistic movements continue unceasingly during waking hours. Although stroke damage occurs in the contralateral subthalamic nucleus in most cases, efferent or afferent connections of the subthalamic nucleus, such as those with the caudate nucleus and/or putamen, are damaged in some cases. It has generally been inferred that this movement disorder is caused by a release of ventral thalamic nuclei neuronal activity from the inhibitory control exerted by the subthalamic nucleus through the medial segment of the globus pallidus.

Although hemiballismus tends to diminish spontaneously within the first few months in many cases, it sometimes persists for a long time. When the ballistic movement is extremely violent, death can take place because of progressive exhaustion, cardiac failure, or pneumonia. Radical forms of treatment such as limb amputation and destruction of the brachial plexus have been employed in the past. The effects of drug treatment are not great in such cases unless the dosages are sufficient to induce sleep. Although ablative surgical treatment involving mainly the ventral thalamic nuclei can alleviate the ballistic movement completely in some cases, the results are not always satisfactory.

During the last decade, it has become clear that chronic thalamic stimulation can often control a wide range of involuntary movement disorders. Most reports of involuntary movement treated with this therapy involve parkinsonian or essential tremor cases. We describe two cases of persistent hemiballismus treated by chronic thalamic stimulation, which proved to be quite useful for controlling this movement disorder.

Illustrative Cases

Patient Profiles

Case 1. This 57-year-old woman had suffered a minor stroke and subsequently developed hemiballismus on the
right side. Magnetic resonance (MR) imaging revealed a small lesion in the area of the left subthalamic nucleus (Fig. 1 left). The patient’s progress was monitored while she underwent conservative therapies for 2 months at another hospital. She received dopamine receptor antagonist haloperidol, which demonstrated only a slight effect. Because no spontaneous recovery had occurred at all and progressive exhaustion had resulted, she was referred to our service for neurosurgical treatment.

Case 2. This 62-year-old man had suffered a stroke resulting in hemiparesis on the right side. Although the hemiparesis had greatly improved within a week, he had developed hemiballismus on the right side. Observations made while the patient received conservative therapies for 2 months at another hospital revealed no tendency for the ballistic movement to diminish. He received the dopamine receptor antagonist haloperidol, which demonstrated only a slight effect, similar to Case 1. Because progressive exhaustion had resulted, he was referred to our service for neurosurgical treatment. Magnetic resonance imaging revealed a lesion in the left putamen (Fig. 1 right). Due to unceasing involuntary movements, he was unable to walk (Fig. 2 left). He was also incapable of sitting down for more than a minute.

The patients and their families gave informed consent for the performance of the procedures described below. This study was approved by the Committee for Clinical Trials and Research on Humans of our University and by the Japanese Ministry of Health and Welfare as part of an Advanced Medical Care Program. Thalamic stimulation was not considered unless the violent and exhausting involuntary movements had persisted without showing any tendency for spontaneous recovery. These two patients were observed for 2 more months while they received drug treatment, and deterioration of their condition due to exhaustion led to a decision to perform thalamic stimulation therapy at 4 months after the onset of movement disorder. These cases represent 33% of the six patients with hemiballismus who have been referred to us for surgical therapy during the last 5 years. The remaining four patients did not undergo surgical therapy, because they demonstrated a relatively benign course. No thalamotomy or pallidotomy was performed during this period.

Surgical Procedures

Deep brain stimulation electrodes were inserted through a burr hole using a stereotactic apparatus. The electrodes were placed in the ventrolateral part of the thalamus. The tip of the electrode array was placed at a position 5 mm posterior to the midpoint between the anterior and posterior commissures and 10 mm (patient 1) or 13 mm (patient

![Fig. 1. Left: A T1-weighted magnetic resonance (MR) image in Case 1 revealing a small lesion (arrow) in the area of the left subthalamic nucleus. Right: A T2-weighted MR image in Case 2 revealing a lesion (arrow) within the left putamen.](image)

![Fig. 2. Left: Photographs showing the patient in Case 2 before thalamic stimulation therapy. Due to the unceasing involuntary movements, the patient was unable to walk or even to sit down for more than a minute. Right: Photographs showing the same patient after thalamic stimulation therapy. Several weeks following the beginning of stimulation therapy, control of the hemiballismus with thalamic stimulation became complete and the patient became able to walk, sit, and write.](image)
Effects of Chronic Stimulation

Stimulation was performed with 0.2 to 0.3 msec pulses in a continuous mode during waking hours. The violence of the ballistic movements began to lessen immediately after the start of stimulation in both cases. Clinical improvement required a stimulation frequency of 50 to 150 Hz and an intensity of 4 to 7 V in both cases. When the stimulation frequency or intensity was decreased below these levels, clinical improvement became unclear. As the stimulation frequency was increased at the same level of intensity, the effect appeared to be reduced. When the stimulation intensity was elevated, the involuntary movement was rather accentuated. It was thus necessary to establish an appropriate combination of optimum levels of stimulation frequency and intensity. We chose to stimulate at 50 Hz and 4 to 7 V in both cases.

During the initial 2 to 3 weeks after the beginning of stimulation therapy, control of hemiballismus was incomplete and ballistic movement quickly reappeared when the stimulation was terminated. After several weeks, however, control of the hemiballismus became complete. The patients were able to walk, sit down, and write during stimulation (Fig. 2 right). When the stimulation was terminated, the ballistic movement continued to be attenuated for a while but gradually returned to its original level of violence after several hours. Revision of the stimulation system was required in one patient due to accidental disconnection at 10 months after the commencement of thalamic stimulation therapy. The disconnection was associated with the reappearance of ballistic movement. Complete control of the ballistic movement was again achieved as a result of the revision. The follow-up periods for the two patients now exceed 16 months. The stimulation remains effective without any complications.

Discussion

Indications for Surgical Treatment

When spontaneous recovery from hemiballismus occurs, the ballistic movements usually begin to diminish within 1 to 3 weeks of the onset and subside completely within 3 months in most cases, although in some cases2 spontaneous recovery can occur more slowly. Such recovery may be attributable in part to the resolution of edema and/or ischemia that had reversibly depressed the neuronal activity within the subthalamic nucleus or related neuronal structures.2 The present cases clearly did not follow such a benign clinical course. Hyland15 has suggested that spontaneous recovery is more likely to take place if the lesion involves the afferent connections of the subthalamic nucleus and the latter escapes destruction. Thus, recovery could also be attributable to a readjustment in the function of the extrapyramidal system, which compensates for the imbalance of the neuronal circuits caused by damage to the subthalamic nucleus or related structures.18,22

Because the hemiballismus subsides during sleep, medical treatment involves the administration of drugs at dosages sufficient to induce sleep. This approach is useful for preventing exhaustion in many cases in which spontaneous recovery eventually occurs but not in cases with persistent hemiballismus. Dopamine receptor antagonists have been reported to be useful for controlling hemiballismus.1,17 There are, however, patients who display a long unremitting course or deterioration of their condition due to exhaustion even when receiving drug treatments including dopamine receptor antagonists. Surgical treatment is indicated in such cases.

Effects of Ablative Surgical Treatment

It has long been recognized that hemiballismus cannot occur unless the corticospinal tract is able to function. Thus, surgical transections of the corticospinal tract, such as corticotomy, cerebral pedunculotomy, or ventral quadrant cordotomy have been employed in the past as therapies.6,7,15 Although these operations alleviate the ballistic movements, all are followed by some degree of permanent hemiparesis.

The surgical intervention currently used is thalamotomy involving the thalamic nucleus ventrolateralis together with the nucleus ventralis intermedius, the neuronal activity of which has been considered to be released from inhibitory control.1 These ventral thalamic nuclei appear to be the last relays of complex neuronal loops which project to the motor and premotor cortex. The effect of thalamotomy may be related to the removal of abnormal activities within the neuronal loop projecting to the motor cortex and corticospinal tract. We have been performing pallidotomy involving the lateral segment of the globus pallidus.22 This procedure appears to be useful for controlling hemiballismus induced by lesions outside the subthalamic nucleus, in which the neuronal activity of the subthalamic nucleus may be depressed through disinhibition of the lateral segment of the globus pallidus.1,28,29

The results of such ablative surgical treatments are satisfactory, however, in little more than 50% of cases of hemiballismus.9,13,23 We have performed thalamotomy or pallidotomy on five patients in the past. Although all patients demonstrated at least some clinical improvement, the involuntary movement was completely abolished in only three cases. Because of the relative unpredictability of the effects and the irreversibility of the procedures, these treatments have been performed only in selected cases. In addition, thalamotomy carries a potential risk of unpleasant side effects such as motor weakness or iatrogenic central pain. Thalamotomy and pallidotomy were considered as therapeutic options in the present cases.
because of the patients’ unremitting clinical course and the deterioration of their condition. However, we chose to test the effect of thalamic stimulation therapy first, since stimulation is essentially a reversible procedure, unlike ablative surgery.

**Role of Chronic Thalamic Stimulation**

Chronic thalamic stimulation for the treatment of tremor was first reported by Brice and McLellan and later by Benabid and coworkers. Although most cases previously treated by thalamic stimulation have been of tremor, thalamic stimulation has been applied in other involuntary movement disorders as well. Cooper and coworkers reported that clinically useful improvement was observed after thalamic stimulation in six of nine cases with unspecified poststroke involuntary movement. Andy described a case in which poststroke thalamus syndrome with choreiform movements was successfully treated by thalamic stimulation. The present cases suggest that hemiballismus is also responsive to thalamic stimulation.

The improvement that occurred during thalamic stimulation therapy is not attributable to spontaneous recovery, because the violence of the involuntary movements began to lessen immediately after the start of thalamic stimulation and reappeared after the termination of treatment. The need for revision of the disconnected stimulation system that occurred in Case 2 at 10 months after the commencement of therapy also supported the interpretation that the improvement was caused by thalamic stimulation. Thalamotomy involving the thalamic nucleus ventrolateralis and nucleus ventralis intermedius also improves hemiballismus; thus, the effects of thalamic stimulation may be ascribable to an electrophysiological ablation of the thalamic nucleus ventrolateralis and nucleus ventralis intermedius. Unlike thalamotomy, however, thalamic stimulation can be used to control the extent of electrophysiological ablation, which may enhance efficiency, and does not involve irreversible destruction of the brain tissue.

The mechanism underlying the progressive increase in efficiency of thalamic stimulation in controlling ballistic movement is unclear. It may be that continuous stimulation induces a readjustment in the function of the extrapyramidal system and that this readjustment favors endogenous mechanisms of compensation for the imbalance in neuronal activity caused by damage to the subthalamic nucleus or its connections. This inference, in turn, suggests that thalamic stimulation may enhance the potential for spontaneous recovery. As mentioned above, hemiballismus is usually considered to be caused by a release of neuronal activity of the ventral thalamic nuclei due to damage to the subthalamic nucleus. In some cases, however, the subthalamic nucleus escapes destruction. In such cases, the movement disorder may be attributable to depressed neuronal activity of the subthalamic nucleus through disinhibition of the lateral segment of the globus pallidus. It has been suggested that spontaneous recovery is more likely to take place in the latter. The cases presented here, each of which involved a patient with a different type of lesion, suggest that readjustment in the function of the extrapyramidal system can be induced by continuous stimulation regardless of whether the subthalamic nucleus is directly damaged or not.

The reversibility of the procedure makes thalamic stimulation an ideal therapeutic option in patients in whom a potential for spontaneous recovery appears to exist even if recovery does not actually occur. We believe that chronic thalamic stimulation is a therapy that should be tested before ablative surgery is carried out for hemiballismus.

**References**

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