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Motor cortex excitability after thalamic infarction

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Abstract

Objective: We examined 8 patients with hemihypesthesia due to an ischemic thalamic lesion to explore the effects of a central sensory dysfunction on motor cortex excitability.

Methods: Motor excitability was assessed using transcranial magnetic stimulation techniques and electrical peripheral nerve stimulation. Motor function was evaluated by the Nine-Hole-Peg Test and measurement of hand grip strength. The affected side was compared with the non-lesioned side and with an age-matched control group.

Results: Patients had a loss of inhibition and an increase of facilitation in the motor cortex of the affected side. The silent period was prolonged and motor function was impaired on the affected side.

Conclusions: A thalamic lesion can modulate motor cortical excitability.

Significance: This study suggests that, under normal conditions, somatosensory afferents influence inhibitory and excitatory properties in the motor cortex.

Keywords: Thalamic infarction; Transcranial magnetic stimulation; Intracortical inhibition; Intracortical facilitation; Silent period; Sensory–motor interaction

1. Introduction

Normal sensory input is a prerequisite for optimal motor behaviour. Lesion studies in animals (Pavlides et al., 1993) and humans have demonstrated that the loss of sensory discrimination abilities affected motor functions and could impair the success of rehabilitation after stroke (Rose et al., 1994). A loss of sensation usually deteriorates dexterity. Only a few studies have addressed the question of whether the loss of sensory function has direct consequences on motor cortex excitability. Current results suggest that a peripheral sensory nerve block decreases motor excitability of the muscle beneath the anesthetic skin (Liepert et al., 2004; Rossi et al., 1998; Rossini et al., 1996). In contrast, excitability is enhanced in adjacent, non-affected areas (e.g. in the upper arm muscles during an ischemic forearm block) (Brasil-Neto et al., 1992; Ziemann et al., 1998).

Less is known about the consequences of lesions in central somatosensory pathways. A patient with an isolated ischemic lesion in his primary sensory cortex showed an increase of motor cortex excitability as demonstrated by a loss of intracortical inhibition, an increase of intracortical facilitation and a decrease of the duration of the silent period on the affected side (Liepert et al., 2003).

In this paper, we used transcranial magnetic stimulation (TMS) to explore if an impairment of central sensory functions produced by an ischemic thalamic lesion would change motor cortical excitability. In addition, we examined if motor function was impaired. The ventro postero lateral (VPL) nucleus of the thalamus is an important area since sensory afferents are close together. Animal studies have shown that connections originating from ventro-lateral thalamic nuclei project to the primary somatosensory cortex (S1) (Areas 3a and 3b) (Brown and Carman, 1979; Darian-Smith and Darian-Smith, 1993), but also to the primary motor cortex (M1) and the supplementary motor cortex (Darian-Smith et al., 1990; Shindo et al., 1995). A small lesion in the VPL nucleus or the thalamocortical fibers is able to produce hemihypesthesia without affecting

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the corticospinal tract. We chose patients with thalamic lesions resulting in hemihypesthesia as a model for the understanding of sensory–motor interactions: this type of a subcortical ischemic lesion might induce some functional effect on the motor cortex but does not result in a structural motor cortical lesion as visible in conventional magnetic resonance tomography.

2. Methods

We studied 8 patients (5 men, mean age: 60.4 ± 13 years; [±SD], range: 33–74 years) with unilateral ischemic thalamic lesion documented by magnetic resonance imaging of the brain (Fig. 1). The results obtained from the affected side were compared with the patients' unaffected side and with an age-matched healthy control group ($n=8$; 5 men, mean age: 59.2 ± 11.6 years [±SD], range: 40–77 years). It was the first stroke in all patients. In 6 patients, stroke had occurred within 3 weeks prior to the electrophysiological investigation, in two patients the stroke was more than 6 months ago. All patients were right-handed. In 6 patients, the dominant hand was affected. Clinical examination showed hemihypesthesia, hemihypalgia and a reduced vibration perception on the affected side. When extending the arms with the fingers outstretched and the eyes closed, there was no pronator drift and no downward movement. One patient (no. 3; Table 1) complained about neuropathic pain in his affected side. None of the patients exhibited involuntary hand or finger movements at rest. Further clinical and electrophysiological details are given in Table 1.

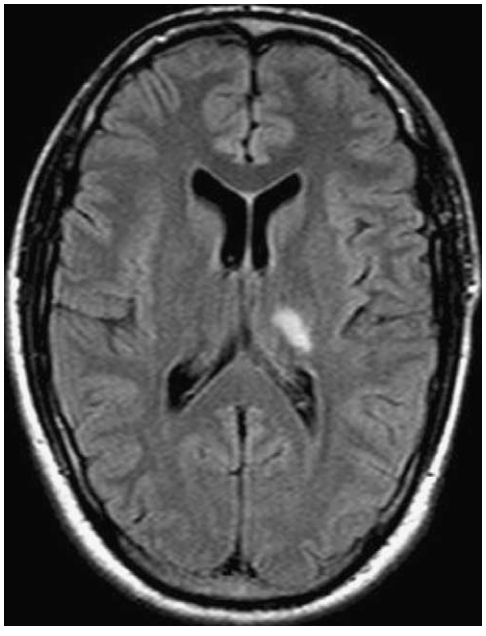

Fig. 1. Magnetic resonance imaging scan of a left-sided postero-lateral thalamic lesion in a patient with hemihypesthesia (pat. no. 8).

Patients and healthy subjects gave informed consent prior to participating in the study that was approved by the local ethics committee. Exclusion criteria were: epilepsy or other neurological or psychiatric diseases, heart pace maker, metallic implants in the brain, ingestion of drugs known to affect brain excitability, pregnancy, any condition that interfered with the ability to understand the instructions.

2.1. Transcranial magnetic stimulation (TMS)

TMS measurements were carried out bilaterally in all patients and on the dominant side in healthy subjects.

Recordings were taken with surface electrodes (belly-tendon montage) from the first dorsal interosseous muscle bilaterally. The ulnar nerve was stimulated electrically at the wrist with supramaximal intensities to elicit M responses and F waves. TMS was performed with a figure-of-eight coil (The Magstim Comp., Dyfed, UK) which was connected to a magnetic stimulator (Magstim 200 HP). To apply paired pulses, the coil was connected to a Bistim device which triggered two magnetic stimulators. The coil was held with the grip pointing posteriorly and perpendicular to the central sulcus. Resting motor threshold (MT) was defined as the stimulus intensity needed to produce motor evoked potentials (MEPs) with a size of 50–100 μV in 5 out of 10 consecutive trials during complete muscle relaxation. Total MEP latencies and central motor conduction time (CMCT) were determined with suprathreshold (150% MT) single TMS pulses during activation with 20% maximum voluntary contraction. Silent period (SP) was elicited by single TMS pulses with an intensity of 120% MT during voluntary contraction of the target muscle. Intracortical inhibition and facilitation (ICI and ICF, respectively) were examined in a conditioning-test pulse TMS paradigm (Kujirai et al., 1993) at complete rest. The first conditioning shock had an intensity of 75% of MT. The intensity of the second pulse was adjusted to produce an MEP of approximately 0.5 mV peak-to-peak size. The following interstimulus intervals (ISI) were tested: 2, 3, 10 and 15 ms. Stimulus–response curves were tested at rest using single TMS pulses at intensities of 110, 120, 130, 140 and 150% MT (Ridding and Rothwell, 1997). For each stimulus intensity, 8 trials were performed.

Recordings were stored on a Viking IV (Nicolet, Kleinostheim, Germany) and analysed off-line. M responses and MEP amplitudes were measured peak-to-peak.

CMCT was determined according to the formula: Total MEP latency − ([M response latency + F wave latency − 1]/2). The duration of the silent period was measured from the onset of the MEP to the re-occurrence of on-going EMG activity. In the paired pulse paradigm, conditioned MEP amplitudes were expressed as a percentage of the mean MEP amplitude following single TMS pulses. Each ISI was tested 8 times and unconditioned test MEPs 24 times in a random order. To increase the power and to obtain a representative mean value for ICI and ICF we combined