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Distribution of the corticobulbar tract in the internal capsule

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ABSTRACT

It is generally thought that the corticobulbar tract descends through the genu of the internal capsule (IC). There have been several reports that genu lesions cause bulbar symptoms such as facial palsies, dysarthria, and dysphagia. However, the precise location of the corticobulbar tract in the IC remains controversial. The purpose of our study is to assess whether the corticobulbar tract passes through the IC genu. We reviewed 26 patients with selective IC infarction and located the sites related to bulbar symptoms. In addition, using diffusion tensor imaging, we reconstructed tracts passing through the IC in ten subjects without cerebral infarction. Patients with genu infarction, which extended to more than half of the posterior limb of the IC, showed bulbar symptoms. However, patients with genu infarction, which was limited to the genu, did not have bulbar symptoms. In contrast, patients with lesions limited to the posterior limb may show bulbar symptoms. According to statistical maps of the region of interest, the lesions related to bulbar symptoms were localized to areas that were beyond the midpoint of the posterior limb of the IC. In diffusion tensor imaging of subjects without cerebral infarctions, the corticobulbar and corticospinal tracts did not pass through the IC genu. Our data provide evidence that the corticobulbar tract does not pass through the IC genu. The proposed location of the corticobulbar tract in the level of the IC lies beyond the midpoint of the posterior limb.

1. Introduction

It was generally accepted that the corticobulbar tract descends through the genu of the internal capsule (IC) [1]. As a result of anatomical studies, Brissaud identified that the small bundle of fibers on the genu of IC could make face and tongue move voluntarily [2]. The corticobulbar tract which originates from the primary motor cortex, is known to arrive at the brainstem via the genu of IC. After decussation, it goes on to innervate the cranial nerve [3].

The cardinal symptoms of genu infarction are known to be bulbar symptoms and acute cognitive deficits. The disruption of the cotricobulbar tracts which is known to pass though genu causes bulbar symptoms. Some of the thalamocortical projections go through the genu and make reciprocal connections between the thalamus and the frontal lobe [4]. Therefore, the genu infarction causes acute cognitive deficit such as fluctuating alertness, inattention, memory loss, apathy, abulia and psychomotor retardation [5].

However, the location of corticobulbar tract in the IC is controversial, yet. Bogousslavsky et al. and Tredici et al. reported that genu lesions caused dysarthria, which was concordant with a previous anatomical study [6,7]. In contrast, Maeda et al. reported a bulbar palsy case with the posterior limb lesion of IC, not involving the genu. In addition, Bertrand et al. found that the IC areas related to facial movement were not in the genu, but areas in the posterior limb by stimulating the IC with electrodes [8]. Dueden et al. reproduced this in an electophysiological study [9].

Thus, this study aimed to localize the corticobulbar tract in IC by analyzing cerebral infarctions involving only IC and tractographies of subjects without cerebral infarctions.

2. Methods

2.1. Subjects

We included 26 patients (46.2% women, age 69.0 ± 12.8) with isolated IC lesions, among patients with cerebral infarction admitted to Ilsan hospital from January 2009 to November 2011. For tractography, we included ten neurologically normal persons (80% women, age 69.5 ± 8.6) without lesions in the magnetic resonance imaging (MRI) who were admitted to Ilsan hospital from August 2011 to March 2012. This study was approved by the Institutional Review Board of Ilsan Hospital, National Health Insurance Corporation, Koyang-Shi, South Korea.

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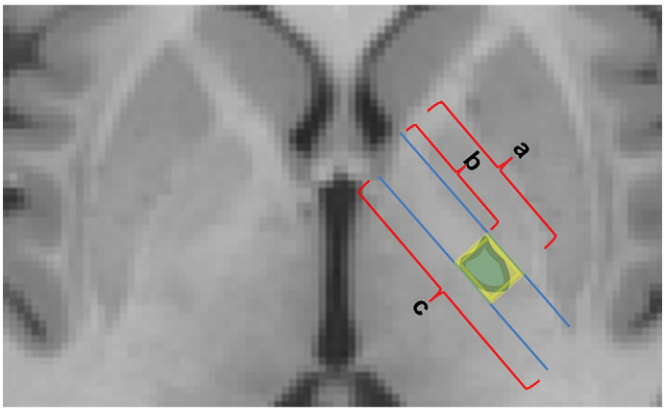

Fig. 1. The methods for ROIs. We drew ROIs with the rectangle shape from b to a. The 'a' and 'b' are distances from the genu and are expressed as the ratios compared with the length of the blue line—'c'. The yellow box means the ROI and the irregular green figure is a schematic lesion. We transposed the right lesion to the left side.

2.2. MRI protocols

Patients underwent MRI using a 1.5 T MRI machine (GE Medical Systems, Milwaukee, WI, USA) or underwent a 3.0 T MRI machine (Philips Medical systems, Best, Nertherland). We located acute cerebral infarctions by hyperintense lesions in the diffusion weighted images (DWIs) as well as hypointense lesions in the apparent diffusion coefficient map. Among subjects, 26.9% patients (7 out of 26) underwent 3.0 T MRI.

Diffusion tensor images for tractographies were obtained from a 3.0 T MRI machine. The slice matrix was 1.72 mm × 1.72 mm in the axial plane. The field of view (FoV) was 22 cm × 22 cm. The matrix was 128 × 128. Other parameters for DTI was as follows: b values of 600 s/mm^2; 45 different directions; 70 axial sections with 2 mm slice thickness without gap; TR/TE 7,696/60 ms; FA 90°.

2.3. Region of interests (ROIs) and statistical color maps

We drew imaginary IC using two lines in the MRIs of patients (Fig. 1). The first line which contacts the globus pallidus was drawn from the genu of IC to the end of the putamen. The second line which is in proximity with the thalamus was parallel to the first line. The location of the lesion was described as a ratio in relation to the first line. We needed to determine one axial plane to draw ROIs. The ROIs of the lesions were drawn in the axial ch2 template of MRIcro (http://www.cabiatl.com/mricro/mricro/index.html) in the level 4 mm rostral to the anterior commissure where IC is apparently observed. Although the irregular shaped IC lesions could be observed in two or three cuts of MRI, we drew the rectangle shaped ROIs in one template summating the lesions observed in two or three cuts (Fig. 1). If the distance from the genu to the end of the putamen 'c' and the lesion ranged from 'a' to 'b', the lesion location can be expressed as follows,

$$\text{From } a/c \text{ to } b/c$$

If there are more than one axial DWIs which show a lesion in the IC, we can determine the location of each lesion. Then, we integrated the

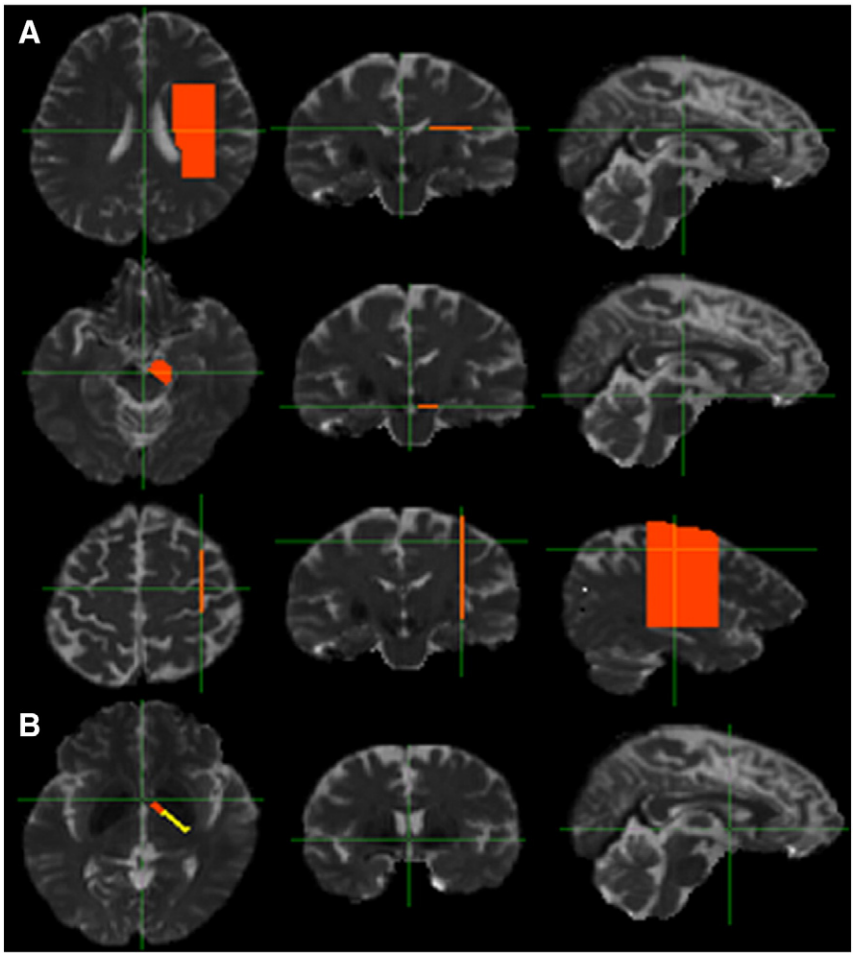

Fig. 2. ROIs for tractographies. (A) ROIs for waypoints. From the first row, the ROIs are corona radiata ROI, midbrain ROI, and precentral ROI, respectively. (B) Seed ROIs. The red one is genu ROI and the yellow one is posterior IC ROI. The green lines indicate the other planes. For example, two green lines in axial plane indicate the locations of the coronal and sagittal planes.