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Research report

Contribution of posterior corpus callosum to the interhemispheric transfer of tactile information

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Abstract

Three total and three partial callosotomy patients underwent neuropsychological testing to evaluate interhemispheric transfer of tactile information. Tactile transfer is required to name objects presented to the left hand, to compare objects held in either hand, and to transfer topological information between hands. Tactile Naming, Same–Different Recognition, and Tactile Finger Localization Tests (intra- and intermanual tasks) were administered as specific tools. Results were compared with previous fMRI data from the same subjects and with the performance of a control group (20 age-matched subjects). Total callosotomy patients performed modestly: mean correct responses were 93% and 30% (right and left hand, respectively) in Tactile Naming; 68% in Same–Different Recognition; 84% and 76% (right and left hand stimulation, respectively) in intermanual Tactile Finger Localization, and 100% in the intramanual task. Partial callosotomy patients achieved 93–100% accuracy: all have an intact splenium, and one, and possibly all, also an intact posterior callosal body. Controls scored 99% in Tactile Naming, both hands, and Same–Different Recognition; 100% in intramanual Tactile Finger Localization; and 96% and 95%, with right and left hand stimulation, respectively, in the intermanual task. Differences between the two callosotomy groups were significant, as were those between total callosotomy patients and controls. The partial callosotomy group scored like the control subjects. Neuropsychological data agree with previous functional findings, further demonstrating that interhemispheric tactile transfer requires posterior corpus callosum integrity.

Theme: Sensory systems
Topic: Somatosensory cortex and thalamocortical relationships

Keywords: Callosal transfer; Tactile modality; Neuropsychological tests; Callosotomy

1. Introduction

The corpus callosum (CC) links the hemispheres and provides the interhemispheric integration and transfer of information. Autoptic studies of human brains [11] and data from non-human primates [33,34] suggested that the CC is topographically organized. This organization seems to result in modality-specific regions [16]: the anterior fibers, which connect the frontal lobes, are involved in the transfer of motor information, whereas the posterior fibers, which connect the temporal, parietal, and occipital lobes, are involved in the integration of somatosensory (posterior midbody), auditory (isthmus), and visual (splenium) information.

Consequently, patients with callosal lesions of different extents and at different locations should present distinct disconnection symptoms depending on which callosal region has been damaged [7,21]. However, interhemispheric

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transfer studies in callosotomized patients have not yielded conclusive results, probably due to high patient variability, the different extents of resections [2,4], and the different methods adopted to study the deficits.

A previous functional MRI (fMRI) study of callosotomized patients [13] showed somatosensory cortical activation by unilateral tactile stimulation of the hand in the sole contralateral hemisphere of patients with resections including the posterior part of the callosal body (posterior callosal body, PCB). By contrast, patients with an intact PCB displayed activation of somatosensory areas in both hemispheres, like control subjects [13,36]. Among the patients who were administered the Tactile Naming Test (TNT), those with an intact PCB performed quite well. All these data suggested that both activation of the ipsilateral hemisphere and good TNT scores require the integrity of the interhemispheric fibers running through the posterior part of the body of the CC conveying tactile information.

A combined neuropsychological and functional study performed in a two-stage callosotomy patient before and after the resection of PCB and splenium (second stage [14]) confirmed this hypothesis. Before the second operation, the patient scored high in the neuropsychological tests evaluating interhemispheric tactile transfer and showed bilateral fMRI activation by unilateral tactile stimulation of the hand in the posterior parietal cortex (PPC) of the post-central gyrus (PCG) and in the second somatic sensory area (SII) of the parietal operculum (PO). After PCB resection, the ipsilateral activation disappeared and test scores fell below chance level, as in completely callosotomized patients [14].

To confirm and extend these data with information on interhemispheric tactile transfer, we administered three specific neuropsychological tests to six patients who had been studied with fMRI in the investigations mentioned above [13]. Performances were correlated with the extent of the callosal resection and, most importantly, with the fMRI cortical activation evoked in PO and PCG by tactile stimulation of the ipsilateral hand.

The present data have been published in abstract form [32].

2. Methods

2.1. Subjects

The study involved 6 patients (4 males and 2 females) aged 24–38 years who had undergone complete or partial CC resection to treat drug-resistant epilepsy [35,37,38]. Three patients (D.D.C., D.D.V., and R.N.) had complete CC resection. In three other patients (A.P., P.M., and L.P.), the entire splenium was intact; in one of them (L.P.; Fig. 1), the PCB was spared as well, and possibly also in the other two, even though here the extent of the resection could not be evaluated since the border between splenium and callosal body is not clearly identifiable anatomically [28]. Since preoperative MR scans were not available, the extent of the intact surface was calculated by comparing each patient's area of spared midsagittal callosal surface with the midsagittal surface area measured in the MR scans of 20 control subjects (unpublished data). The outlines of the corpora callosa of control subjects were subdivided according to the Straight-line Method (for a review, see Ref. [6]). All patients were right-handed as determined by the Edinburgh handedness inventory [31]. However, D.D.C., who was originally left-handed, was made to write with the right hand ever since primary school. Post-operative intelligence scores (IQ) according to the Wechsler Adult

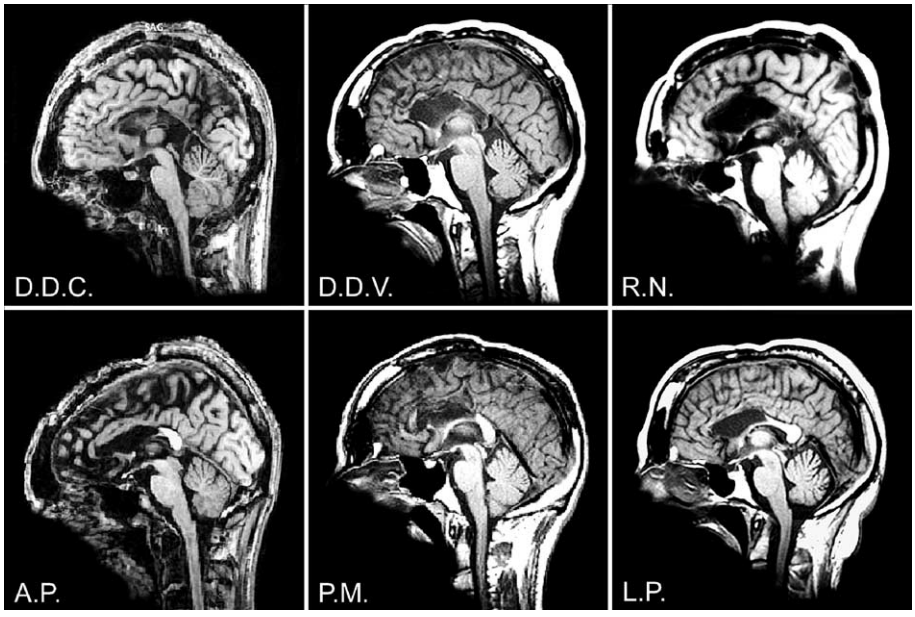

Fig. 1. MR images of midsagittal brain slices obtained from T1-weighted spin-echo sequences showing the extent of callosal resection in 6 patients.