Clinical Case Report

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The allocentric neglect due to injury of the inferior fronto-occipital fasciculus in a stroke patient

A case report

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Abstract

Rationale: We report on a patient who developed allocentric neglect due to injury of the inferior fronto-occipital fasciculus (IFOF) following intracranial hemorrhage, diagnosed using diffusion tensor tractography (DTT).

Patient concerns: Her cognition seemed normal (A 17-year-old, right-handed female patient). However, in spite of a normal visual field, her perception was missing on the left side, and she had no awareness of her deficit. She was unable to perceive the left side in each of 2 objects, regardless of position of the 2 objects, and failed at detail exploration of the left side of 1 object. In addition, the line bisection test, the most representative neglect test, did not reveal any abnormality.

Diagnoses: She was diagnosed with an intracerebral hemorrhage (right thalamus), intraventricular hemorrhage, and subarachnoid hemorrhage due to arteriovenous malformation in the right thalamus.

Interventions: Seven weeks after onset, she began rehabilitation. Consequently, the apple cancellation test to discriminate between allocentric and egocentric neglect was performed, with the result of severe allocentric neglect.

Outcomes: The right superior longitudinal fasciculus and inferior longitudinal fasciculus were well-reconstructed without definite injury compared with those of the left side. However, the right IFOF was discontinued in the anterior portion around the frontal lobe.

Lessons: Allocentric neglect due to injury of IFOF was demonstrated in a stroke patient using DTT. It appears that DTT would be helpful in demonstrating the neglect type and pathway in patients with neglect.

Abbreviations: DTI = diffusion tensor imaging, DTT = diffusion tensor tractography, EPI = echo planar imaging, FA = fractional anisotropy, IFOF = inferior fronto-occipital fasciculus, ILF = inferior longitudinal fasciculus, NEX = number of excitations, ROI = regions of interest, SD = standard deviation, SLF = superior longitudinal fasciculus, TE = echo time, TR = repetition time.

Keywords: allocentric neglect diffusion tensor tractography, arteriovenous malformation, inferior fronto-occipital fasciculus

1. Introduction

Neglect is a disorder that often occurs after brain injury in the nondominant hemisphere and is characterized by inability to attend to the contralateral side.[1] There are 2 subtypes of neglect: egocentric and allocentric neglect.[1,2] The characteristic of egocentric neglect is missing on contralateral side with respect to the viewer (subject-centered neglect), whereas allocentric neglect is missing on contralateral side with respect to the object (object-centered neglect).[3]

With the development of diffusion tensor tractography (DTT), which is derived from diffusion tensor imaging (DTI), many studies have reported on the neural tracts which are related to neglect.[4–10] These neural tracts include superior longitudinal fasciculus (SLF), inferior longitudinal fasciculus (ILF), and inferior fronto-occipital fasciculus (IFOF).[4–9] However, no study of the neural tract for egocentric and allocentric neglect has been reported.

In this study, we report on a patient who showed allocentric neglect due to injury of IFOF after intracranial hemorrhage, demonstrated using DTT.[11,12]

1.1. Case report

A 17-year-old, right-handed female patient was diagnosed with intracerebral hemorrhage (right thalamus), intraventricular hemorrhage, and subarachnoid hemorrhage due to arteriovenous malformation in the right thalamus, and underwent stereotactic drainage of intraventricular hemorrhage at the neurosurgery department of a university hospital (Fig. 1A). Seven weeks after onset, she began rehabilitation at the rehabilitation department of the same university hospital. Her cognition was good [Mini-Mental State Examination: 25 (full score: 30)].[13] However, in spite of normal visual field, her perception was missing on the left side, and she was unaware of the deficit. She was unable to perceive the left side in each of 2 objects, regardless of position of

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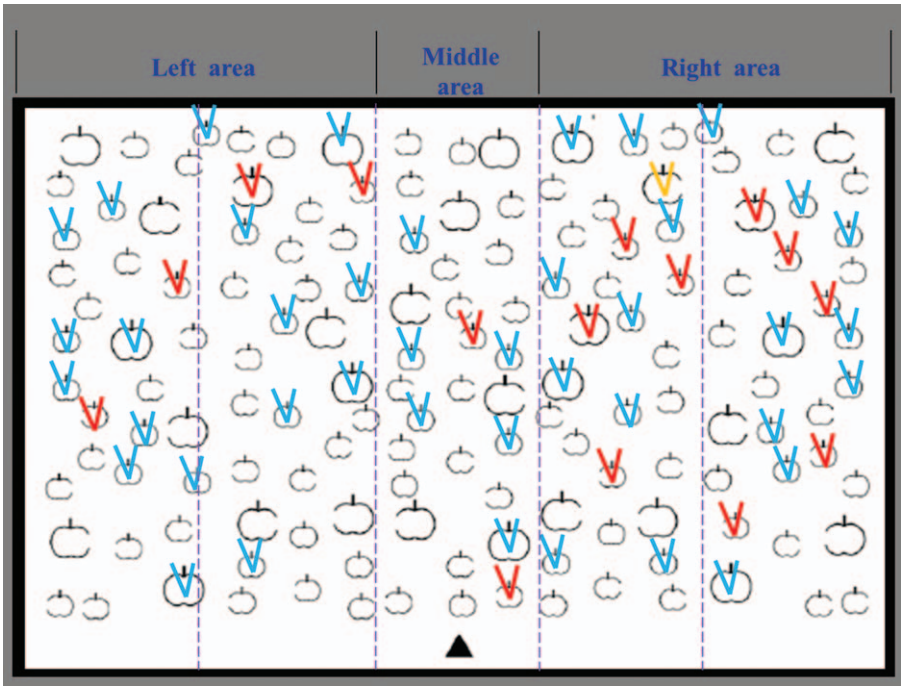

Figure 1. The results of the Apple Cancellation Test. All "√" marks are responses by the patient, who was asked to check the full apples and to ignore the ones with holes (correct answer: blue, incorrect answer: red: left open, yellow: right open). The patient was unable to see the grid. The score of egocentric neglect is 1 (blue mark numbers of right area [18] − blue mark numbers of left area [17]). The score of allocentric neglect is 14 (red mark numbers [15] − yellow mark numbers in all area [1]).

the 2 objects, and failed at detail exploration of the left side of 1 object. The line bisection test, the most representative neglect test, was normal [standard deviation (SD): 0.5, (SD > 1: mild, SD > 2: moderate, SD > 3: severe)].[14] Consequently, the Apple Cancellation test to discriminate between allocentric and egocentric neglect was performed. The apple cancellation test consisted of 150 apples [50: target (full apple), 100: distractor (left or right open apple)] on A4 paper.[12,15] The page is divided into 5 areas (2 areas: left, 1 area: middle, 2 areas: right) by an invisible grid and 150 apples are pseudorandomly scattered (30 apples in each area). The score for egocentric neglect is the difference between the correct number of right area and the correct number of left area (excluding the middle area), and for allocentric neglect, the difference between the number of left opening apples and number of the right opening apples (including the middle area). The cut-off score for left side neglect: egocentric neglect >2, allocentric neglect >1 (minus score means right side neglect).[12] The apple cancellation test was validated with the Star Cancellation test for clinical usefulness.[12,16] This patient's apple cancellation test showed severe allocentric neglect [egocentric score: 1 (cut-off >2), allocentric score: 14 (cut-off >1)].[12,17] The patient provided signed, informed consent and our institutional review board approved the study protocol.

1.2. Diffusion tensor imaging

DTI data were acquired 7 weeks after onset using a 6-channel head coil on a 1.5 T Philips Gyroscan Intera (Philips, Ltd, Best, The Netherlands) with single-shot echo-planar imaging. For each of the 32 noncollinear diffusion sensitizing gradients, we acquired 70 contiguous slices parallel to the anterior commissure-posterior commissure line. Imaging parameters were as follows: acquisition matrix = 96 × 96, reconstructed to matrix = 192 × 192 matrix, field of view= 240 × 240 mm^2, repetition time = 10, ms, echo time = 72 ms, parallel imaging reduction factor (SENSE factor) = 2, echo planar imaging factor = 59 and b = 1000 s/mm^2, number of excitations = 1, and a slice thickness of 2.5 mm.

Fiber tracking was performed using the fiber assignment continuous tracking algorithm implemented within the DTI task card software (Philips Extended MR Workspace 2.6.3). Each of the DTI replications was intraregistered to the baseline "b_0" images to correct for residual eddy-current image distortions and head motion effect, using a diffusion registration package (Philips Medical Systems, The Netherland). All tract analyses used 2 regions of interest (ROIs) in color map. ROIs of the SLF analysis were a triangular shape just lateral to the CST near the anterior horn of the lateral ventricle and a triangular shape near the posterior horn of the lateral ventricle.[18–20] ROIs of the ILF were located in the occipital and temporal lobes in green fibers of the sagittal plane (ILF).[21,22] ROIs of the IFOF were located in the ventral and medial part of occipital and orbitofrontal regions in green fibers of the sagittal plane.[21,22] Fiber tracking was performed with a fractional anisotropy threshold of >0.15 and a direction threshold of <27°.

On the configuration of the 7-week DTT, the right SLF and ILF were well-reconstructed without definite injury compared with those of the left side. However, the right IFOF was discontinuated in the anterior portion around the frontal lobe (Fig. 1C) (Fig. 2).

2. Discussion

In this study, we investigated the relationship between allocentric neglect in a patient with stroke and the neural tracts (SLF, ILF, IFOF) that are associated with neglect using DTT. Based on the following results, we think that the allocentric neglect in this patient was attributable to injury of the right IFOF: clinical

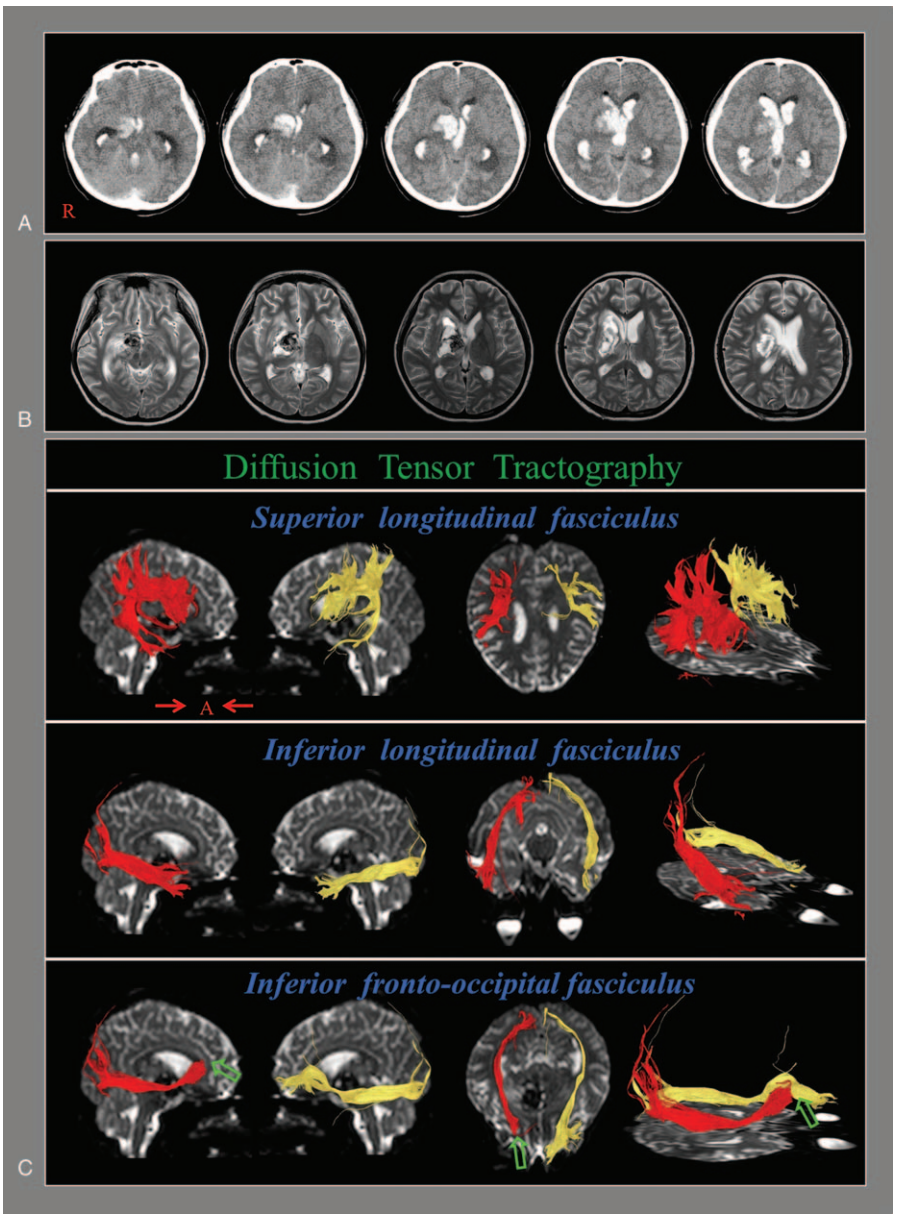

Figure 2. A, Brain computed tomography images at the onset show intracerebral hemorrhage (right thalamus), intraventricular hemorrhage, and subarachnoid hemorrhage. B, T2-weighted brain magnetic resonance images at 7 weeks after onset reveal leukomalactic lesions in the right thalamus and subcortical white matter. C, Results of diffusion tensor tractography. On the configuration of the 7-week diffusion tensor tractography, the right superior longitudinal fasciculus and inferior longitudinal fasciculus are well-reconstructed without definite injury compared with those of the left side. However, the right inferior fronto-occipital fasciculus is discontinuated in the anterior portion around the frontal lobe (green arrow).

characteristics of neglect: missing the left side in each of 2 objects, regardless of position of the 2 objects, failure of detail exploration of the left side of 1 object, and lack of awareness of own deficit; no abnormality on the line bisection test for egocentric neglect and severe allocentric neglect finding in the Apple Cancellation test; on 7-week DTT, the injury in the anterior portion of the right IFOF without any injury findings in the SLF and ILF.

With the development of DTT, a few neural tracts, including the SLF, ILF, and IFOF, are reported associated with the neglect.[4–9] In 2005, Thiebaut de Schotten et al[6] suggested that the major neural tract for was the right SLF in 2 patients with brain tumor. In 2006, Bird et al[7] found that injury of the right ILF was related with the left side neglect in 15 patients with right posterior cerebral artery infarction. Subsequently, Shinoura et al[4] demonstrated that injury of the right SLF is critical in neglect in 2 patients with brain tumor. In 2008 and 2011, Urbanski et al found that injury of the IFOF and fronto-parietal connection were the major causes of neglect in stroke patients. Recently, Thiebaut de Schotten et al[5] found that SLF II among 3 SLFs (I, II, and III) was the best predictor of the left neglect in 58 patients with middle cerebral artery infarction. However, these studies did not use specialized tests to distinguish between egocentric and allocentric neglect. To the best of our knowledge, this is the first study to demonstrate allocentric neglect and injury in a stroke patient.

However, limitations of this study should be considered. First, it is a single case report. Second, there are limitations to DTT analysis: DTT technique might be operator dependent and

regions of fiber complexity and crossing may cause underestimation of reconstruction of a neural tract.[23,24] Therefore, further studies to overcome the above mentioned limitations should be encouraged.

In conclusion, allocentric neglect due to injury of IFOF was demonstrated in a patient with stroke by using DTT. It appears that DTT is helpful in demonstrating the neglect type and pathway in patients with neglect.

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