Journal of Clinical Neuroscience 22 (2015) 1438–1443

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

Brain functional plasticity at rest and during action in multiple sclerosis patients

Anthony Faivre [a,b,*,1], Audrey Rico [a,c,1], Wafaa Zaaraoui [a], Françoise Reuter [a,c], Sylviane Confort-Gouny [a], Maxime Guye [a,d], Jean Pelletier [a,c], Jean-Philippe Ranjeva [a], Bertrand Audoin [a,c]

[a] Aix-Marseille University, National Center for Scientific Research, Center for Magnetic Resonance in Biology and Medicine UMR 7339, Faculté de Médecine, 27 Boulevard Jean Moulin, Marseille 13385, France
[b] Sainte-Anne Military Teaching Hospital, Department of Neurology, Toulon, France
[c] Assistance Publique Hopitaux de Marseille, Timone University Hospital, Department of Neurology and Clinical Neurosciences, Marseille, France
[d] Assistance Publique Hopitaux de Marseille, Timone University Hospital, Department of Medical Imaging, Marseille, France

ARTICLE INFO

Article history:
Received 27 February 2014
Accepted 21 February 2015

Keywords:
Brain plasticity
Functional connectivity
Functional MRI
Motor system
Multiple sclerosis
Resting state

ABSTRACT

We aimed to demonstrate that basal functional connectivity reorganization observed in a specific network at rest using resting state functional MRI (rs-fMRI) could be associated with functional cortical reorganization in such network during action (ta-fMRI) in a population of early multiple sclerosis (MS) patients. Altered basal functional connectivity has been previously reported in patients with MS but relationships with cortical reorganization during action have not been explored. Thirteen patients with early relapsing-remitting MS and 14 matched healthy controls were explored on a 3T MRI scanner at rest and during a motor task (conjugate finger flexion and extension movements of each hand). Hand motor networks were extracted from rs-fMRI data using group spatial independent component analysis. For the non-dominant motor network, patients presented a higher basal functional connectivity at rest and recruited a supplementary prefrontal cortical area during action compared to the controls. The levels of hyperconnectivity at rest and of activation in the recruited area during action were significantly correlated. No differences were demonstrated for the dominant motor network at rest and during action. The present study, combining rs-fMRI and ta-fMRI in non-disabled patients with early MS, revealed for the first time a direct association between functional reorganization depicted at rest and during action within the same system.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Task-associated functional MRI (ta-fMRI) studies have widely demonstrated the phenomenon of brain functional plasticity in multiple sclerosis (MS) from the early stages of the disease [1–4]. Brain plasticity may significantly counteract the functional impact of tissue injury, contributing to the lack of strong correlation demonstrated between structural MRI parameters and clinical deficits. However, assessment of brain plasticity remains difficult in clinical practice. Several factors limit the potential clinical application of ta-fMRI. First, this technique needs the active participation of the patient, which is influenced by motivation and/or disability. Second, the results obtained using functional MRI (fMRI) are highly influenced by the paradigm selected.

A promising alternative is to acquire fMRI data at rest and study correlations between spontaneous low frequency fluctuations of the cerebral blood oxygenation level-dependent (BOLD) signals extracted from remote cortical areas [5]. These fluctuations have shown strong temporal coherence between brain regions that represent functional systems like the sensorimotor network [6,7]. With the recent optimization of post-processing methods such as independent component analysis (ICA), it is now possible to extract basal brain activity within the major neuronal networks from low frequency BOLD signal fluctuations [7]. Several studies performed in MS patients at all stages of the disease [8–15] have shown consistent changes in the level of functional connectivity in various resting state networks (RSN), suggesting that this technique is sensitive to brain functional reorganization [16].

In the present study, we aimed to investigate whether functional connectivity reorganization at rest in the motor network could be associated with cortical reorganization assessed during a simple motor task in patients at the early stages of MS and

* Corresponding author. Tel.: +33 48 3162459; fax: +33 48 3162738.
E-mail address: anthonyfa@wanadoo.fr (A. Faivre).
[1] These authors have contributed equally to the manuscript.

http://dx.doi.org/10.1016/j.jocn.2015.02.033
0967-5868/© 2015 Elsevier Ltd. All rights reserved.

without any motor disability. For this aim, we performed an fMRI protocol combining a resting state fMRI (rs-fMRI) and a ta-fMRI during a simple motor task in a single session for a homogenous group of non-disabled patients with early MS compared to healthy matched controls.

2. Materials and methods

Approval was received from the local Ethics Committee for human experimentation (Timone University Hospital, Marseille, France) and written informed consent was obtained from all subjects participating in the study.

2.1. Subjects

A homogenous group of 13 patients with early relapsing remitting MS (median disease duration [range] = 8 months [3–40]; median age [range] = 32 years [21–43], 10 women and three men) was included in this study. A control group of 14 age and sex-matched healthy subjects was also included (median age [range] = 30 years [20–51], 10 women and four men). All were right-handed (determined using the Edinburgh handedness scale [17]). All patients fulfilled MS diagnostic criteria according to McDonald, revised in 2010 [18]. None of the patients had experienced a relapse or treatment with steroids in the preceding 3 months. Their disability level was rated using the Kurtzke expanded disability status scale [19] and the multiple sclerosis functional composite score, which is a three part composite of quantitative measures of ambulation (timed 8 meter walk), upper extremity function, (nine hole peg test [NHPT] with left and right hand) and cognitive function (paced auditory serial addition test, 3 seconds) [20,21].

2.2. Conventional MRI

MRI was performed on a 3T whole body MRI system (Verio; Siemens AG, Munich, Germany) using a 32 channel phased array head coil. The MRI protocol included localizer scout imaging, transverse fast spin-echo proton density-weighted and T2-weighted sequences (repetition time [TR] 8000, echo times [TE] 15 and 85 ms, 44 contiguous sections, 3 mm section thickness, field of view [FOV] 256 mm, matrix 256^2, 1 mm × 1 mm × 3 mm resolution, acquisition time 3 min 54 s).

2.3. Functional MRI

2.3.1. rs-fMRI

Echo planar images (250 volumes) were acquired during resting state with a single shot gradient-echo echo planar imaging sequence (TR 3600 ms, TE 28 ms, 50 axial slices, thickness 2.5 mm, FOV 244 mm, matrix 122^2, resolution 2 mm × 2 mm × 2.5 mm, acquisition time 15 min 12 s). Subjects were instructed to rest with their eyes closed, not fall asleep, and think of nothing in particular during this scan.

2.3.2. ta-fMRI

For the ta-fMRI, patients and controls performed a simple motor task consisting of successive finger flexion-extension movements of one hand in response to an acoustic signal (1 Hz). Movement amplitude was guided by a hard ball placed in the palm of the hand and held in place with the patient's thumb and adhesive tape. Subjects alternated four periods of movement (two periods of dominant hand movement and two of non-dominant hand movement) with four periods of rest. An operator supervised the performance of the task to check that it was properly executed. We used a block design for the ta-fMRI acquisition. Each period of activation and rest lasted 30 seconds and consisted of 10 measurements (3 seconds/measurement).

The acquired measurements consisted of 80 volumes using single shot gradient-echo echo planar imaging sequences (TE = 30 ms, TR = 3000 ms, 36 contiguous slices, thickness 3 mm, FOV 192 mm, matrix 64^2, voxel resolution 3 mm × 3 mm × 3 mm, bandwidth 2.232 Hz/pixel).

2.4. Image processing

2.4.1. rs-fMRI

Sources of spurious or regionally non-specific variance related to physiological artifacts (cerebrospinal fluid pulsations, head motions) were removed by regression, including the signal averaged over the lateral ventricles and the signal averaged over a region centered in the deep cerebral white matter to reduce non-neuronal contributions to BOLD correlations [22–24]. The MELODIC toolbox of FSL (version 4.1.3; The Oxford Centre for Functional MRI of the Brain, Oxford, UK) was used to perform a concatenated group ICA to extract 51 different components, including the predefined RSN described in previous works [25,26]. Images were corrected for acquisition delays (slice timing), realigned before spatial normalization (non-linear registration) and smoothed (8 mm). This data driven method allows for the extraction of distinct spatio-temporal patterns by identifying spatially independent and temporally synchronous brain regions [27]. Among all components obtained after ICA analysis, those related to the non-dominant and the dominant motor functional networks were selected by visual inspection according to the best correspondence with motor networks described by past studies [10,25,28,29]. Next, a dual regression approach was applied using the independent component time course from each subject in order to obtain a connectivity map corresponding to each subject. Global connectivity indices were determined for each subject and each network from the mean value of regions corresponding to the significant clusters of the correlation maps. This index represents the magnitude of the correlation between all the regions composing the network [30].

The connectivity maps of each subject were used to perform group analyses using SPM5 statistical parametric mapping software (Wellcome Trust Centre for Neuroimaging, London, UK). Connectivity maps of all subjects were made and comparisons between patients and controls were performed ($p < 0.005$; k = 20; corrected for cluster extent $p < 0.05$).

2.4.2. ta-fMRI

Images were post-processed using the SPM5 software. After realignment, images were normalized to Montreal Neurology Institute (MNI) coordinates, coregistered and smoothed with a 12 mm Gaussian filter. After obtaining a single image for each subject parameterizing the effect of interest, intra-group analysis was done (one sample t-test $p < 0.005$; k = 20; corrected at cluster level $p < 0.05$). Then, we performed inter-group analysis (two sample t-test $p < 0.05$; k = 20; corrected at cluster level $p < 0.05$). MNI coordinates were transformed into Talairach coordinates using a non-linear transformation method in order to locate activation clusters which were assigned to Brodmann areas. Correlations between global motor resting connectivity indexes, motor task activations and clinical scores were assessed using Spearman rank tests.

3. Results

3.1. Clinical and conventional MRI characteristics

Demographic and clinical data of patients and controls are reported in Table 1. Patients showed significantly decreased left

Download English Version:

https://daneshyari.com/en/article/3058909

Download Persian Version:

https://daneshyari.com/article/3058909

Daneshyari.com