Different patterns of contralesional passive movement fMRI according to pattern of recovery in severe hemiplegic stroke patients.

Ji-Young Kim[1], Jeehye Seo[2], Hui-jin Song[2], Seong-Uk Jin[2], Jang Woo Park[2], Moon Han[2], Jong Su Baeck[2], Hee-Kyung Kim[3], and Yongmin Chang[4]

[1]School of Medicine, Kyungpook National University, Daegu, Jung-gu, Korea, Republic of, [2]Medical & Biological Engineering, Kyungpook National University, Korea, Republic of, [3]Applied Chemistry, Kyungpook National University, Korea, Republic of, [4]Molecular Medicine, Kyungpook National University, Korea, Republic of

Introduction

Stroke patients with hand function in severe hemiplegic are known to be determined their prognosis at acute period of stroke [1]. Brunnstrum motor recovery stage (BMS) and motor evoked potential (MEP) have been used to predict prognosis in stroke patients well. Using the BMS and MEP, stroke patients who have no MEP of affected hand or no hand movement with BMS 1 in 4 weeks from onset of stroke were usually regarded as that with poor prognosis. Nevertheless, most patients regarded as poor prognosis could recover their hand function. Recent researchers revealed functional connectivity (FC) of homologous primary motor cortex (M1) as a prognostic factor in stroke patients [2]. The aim of this study is to (1) compare inter-hemispheric functional connectivity (IHC) scores with in homologous M1 among stroke patients groups which showed different recovery patterns by means of resting state fMRI and (2) find good prognostic phenomeni to severe hemiplegic stroke patients who had no hand movement with BMS 1 and MEP response by means of fMRI with passive movement.

Subjects and methods

8 severe hemiplegic stroke patients with right middle cerebral artery infarction were recruited. Their demographic and clinical data showed at table 1. Each subject signed an informed consent before entering the scanner. Anatomical images were acquired using 3D-FSPGR sequence with following parameters: TR=7.8ms, TE=3ms, flip angle = 20, matrix=256x256, FOV=220mm, slice thickness = 1.3 mm, no gap. fMRI scans with contralesional passive hand movements (EPI, TR=3000ms, TE=40ms, flip angle =90, matrix=64x64 and FOV=210mm, 4 mm slice thickness = 4mm, no gap) and resting state (EPI, TR=2000ms, TE =30ms, flip angle =90 , matrix=64x64, FOV=220mm, slice thickness = 4 mm, no gap) were acquired using a 3.0T GE HD scanner about three weeks (25.17 ± 6.43 days) from onset of stroke. At that time, they had severe hemiplegia with no hand and finger motion. Subjects executed motor tasks which began with a 30-s resting phase followed by 30-s of contralesional passive hand movement. Image processing and statistical analyses were carried out using MATLAB v. R2010b and SPM5. Contrast which reflected the effect of motor function (movement – resting). The SPM{t}s were thresholded at uncorrected $p < 0.005$ and then the activation map were superimposed on individual T1-weighted images. We determined the bilateral M1 (spheres of 5-mm radius) based on the motor task activation maps of individual subjects using MarsBaR (http://marsbar.sourceforge.net/). In rs-fMRI analysis, the FC map associated with ipsilesional M1 and IHC scores within homologous M1 were calculated using Functional Connectivity toolbox (http://web.mit.edu/swg/software.htm). The calculated IHC scores were analyzed by one-way analysis of variance (ANOVA) among 3 groups with the Statistical Package for the Social Sciences (SPSS, Version 18; SPSS, Inc.). To assess to the IHC differences between one group and another, post hoc two sample t tests were applied. We used BMS at the time of scanning, 3 months later, and 6 months later from onset of stroke to evaluate long term prognosis.

Results and Discussion

All patients had no MEP of affected hand and no hand functions with BMS stage 1 at the time of scanning. 4 patients had good hand functions with BMS 3 or 4, while 4 patients still had no hand movement with BMS 1 after 3 months from onset of stroke. Among 4 patients who had good hand functions, they showed different recovery patterns. 2 patients showed progressive improvement of hand function for 6 months while 2 patients showed abrupt improvement of hand function at 6 months later without movement at 3 month later. BMS (Table 1) and the FC map (Fig 2, r > 0.7) inferred that 2 patients with abrupt improvement are likely to be poor recovery at 3 months later from onset of stroke. The IHC scores (Fig 3) is also likely to be poor recovery in patients with abrupt improvement. Average IHC within homologous M1 was increased in the good prognostic patients with progressive improvement compared to other groups (post-hoc two sample t test P<0.05). However, the average IHC in homologous M1 was no differences between good prognostic patients with abrupt improvement and poor prognostic patients. It is very confused to use BMS and the IHC scores as a prognostic factor in stroke patients. To find a valuable prognostic factor in stroke patients, we focused on BOLD signal change in M1 when patients performed contralesional passive hand movement (Fig 4, uncorrected p<0.005). According to different pattern of recovery, we could see different fMRI activities. In poor prognostic patients, there were no cortical activities with passive movement as we expected. In good prognostic patients with progressive improvement of hand function for 6 months, however, passive hand movement task exhibited positive activation in the ipsilesional M1 and no activation in the contralesional M1.On the other hand, in good prognostic patients with abrupt improvement of hand function at 6 months, passive hand movement task showed no activation in ipsilesional M1 and negative activation in the contralesional M1. These findings showed nearly same meaning in view of functional level. This means that if stroke patients who has no hand movement at acute stage, but they showed this kind of pattern of fMRI with passive movement like patients with abrupt improvement of hand function at 6 months later without no movement at 3 month later, rehabilitation teams should not give up their hand function and keep giving considerable thoughts to them constantly.

Reference

1. van Kuijk AA, Pasman JW, Hendricks HT, Zwarts MJ, Geurts AC. Neurorehabil Neural Repair. 2009 Jan;23(1):45-51.
2. Carter AR, Astafiev SV, Lang CE., et al. Ann Neurol. 2010; 67:365-375

Table 1. Patients demographic and clinical data

	recovery patterns	sex	age	MEP	BMS	BMS in 3months	BMS in 6months
Good prognosis	progressive improvement	F	67	Absent	1	2	3
		F	70	Absent	1	2	3
	abrupt improvement	F	32	Absent	1	1	4
		F	70	Absent	1	1	4
Poor prognosis		M	78	Absent	1	1	1
		M	41	Absent	1	1	1
		F	78	Absent	1	1	1
		M	41	Absent	1	1	1

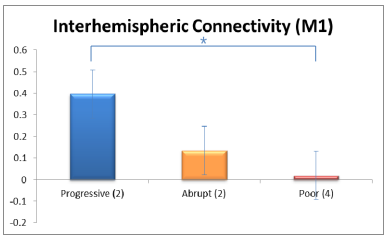

Figure 3. Average IHC in the homologous M1. One-way ANOVA of showing a significant differences across the groups (ANOVA p<0.05). Post hoc two sample t test, good prognostic patients with progressive improvement of showing significant greater than other groups (two sample t test p<0.05)

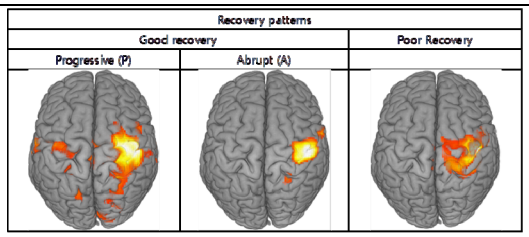

Figure 2. Functional connectivity correlated with ipsilesional (right) M1. (correlation coefficient > 0.7)

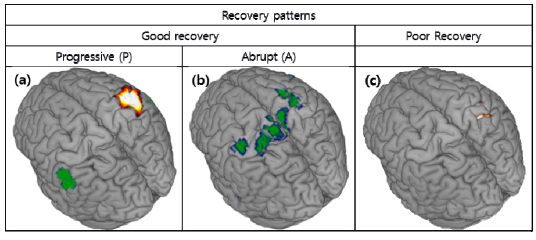

Figure 4. The BOLD signal changes in passive movement. (p < 0.005). Positive activation in the ipsilesional M1 and no signal change in contralesional M1 (a). No activation in the ipsilesional M1 and deactivation in the contralesional M1 (b). Neither activation nor deactivation in bilateral M1 (c).