Evaluation of Language and Hand Motor Function with fMRI in patients with a brain mass lesion: validation with intraoperative Electrocortical Mapping

A. Bizzi[1], V. Blasi[2], M. Cadioli[2], U. Danesi[1], C. Marras[3], P. Ferroli[3], D. Caldiroli[4], G. Broggi[3], A. Falini[2]

[1]Neuroradiology, Neurologico Carlo Besta, Milan, Italy, [2]Neuroradiology, Università Vita-Salute San Raffaele, Milan, Italy, [3]Neurosurgery, Neurologico Carlo Besta, Milan, Italy, [4]Neuroanesthesiology, Neurologico Carlo Besta, Milan, Italy

Purpose: Aim of the study was to evaluate sensitivity and specificity of preoperative fMRI by correlating activation maps with intraoperative electrocortical mapping (ECM) in patients with a brain mass lesion.

Methods: Twenty patients with a mass lesion were evaluated preoperatively with fMRI at 1.5 Tesla. The histological diagnosis was the following: 17 gliomas (5 high grade; 12 low grade), 1 metastasis, 1 meningioma, 1 cavernous angioma. Twelve patients were evaluated for language (auditory verb generation task), eight patients for hand motor task. The location of the lesions was homogeneous within each of the two tasks: the left fronto-insular-temporal region was investigated with the language task; the right or left prerolandic or postrolandic region was investigated with the motor task. The fMRI was performed with the following parameters: SS-EPI (TR/TE= 3700/60 ms; isotropic voxel (4x4x4mm^3); 24 slices/volume). The paradigm was presented as a block design. The fMRI data were analyzed with SPM99 software (http://www.fil.ion.ucl.ac.uk/spm) with analysis threshold ($p < 0.001$). fMRI data were registered in a frameless stereotactic neuronavigational device (Stealth Station, Sofamor Danek). Surgery was performed in awake anesthesia (asleep-awake) with total intravenous anesthesia (propofol-remifentanyl BIS-tritated). Cortical areas essential for language and hand motor function were identified with intraoperative direct ECM using the Ojemann cortical stimulator. The awake patient was performing the task (verb generation) while direct cortical stimulation was applied. Failure to respond and other errors, such as word repetition, were considered a sign of cortical inhibition. The site of each cortical stimulation was identified on the fMRI dataset using the neuronavigational device. We performed a site-by-site correlation between the preoperative fMRI data and the cortical stimulated site in order to determine true positive (TP), true negative (TN), false positive (FP) and false negative (FN) using the ECM results as a gold standard. Sensitivity and specificity were determined for language and motor task.

Results: FMRI was able to localize Broca's area (inferior frontal gyrus (IFG), BA 45) and the left dorsolateral prefrontal cortical (DLPFC) (BA44) in 85% of patients. In 88% of patients fMRI activated the left superior temporal gyrus (BA21). Other activated areas were anterior cingulate (42%), supplementary motor area (33%) and right superior temporal gyrus (58%). A total of 94 cortical sites were tested for language with ECM in 12 patients. For the verb generation task a sensitivity of 82% and a specificity of 61% were observed. Higher sensitivity and specificity were observed for the left DLPFC than for the IFG and the temporo-parietal areas. As a measure of surgical outcome, language proficiency was unchanged compared with preoperative conditions in 9 of the 12 patients. A mild to moderate permanent deficit (dysphasia) was observed in 3 patients. A total of 41 cortical sites were tested for hand motor function in 8 patients. The sensitivity was 87% and the specificity 76%. There were no permanent post-operative deficits in hand motor function in the 8 patients with a lesion adjacent to the central sulcus.

Conclusions: The correlation of preoperative fMRI with intraoperative ECM was good but not perfect. FMRI preoperative evaluation is useful to decide which patients may have a higher risk of developing language or motor deficits during removal of a brain tumor. FMRI may help to plan corticotomy and the surgical approach to the tumor. FMRI results must be interpreted with caution due to conceptual and technical differences from direct ECM.
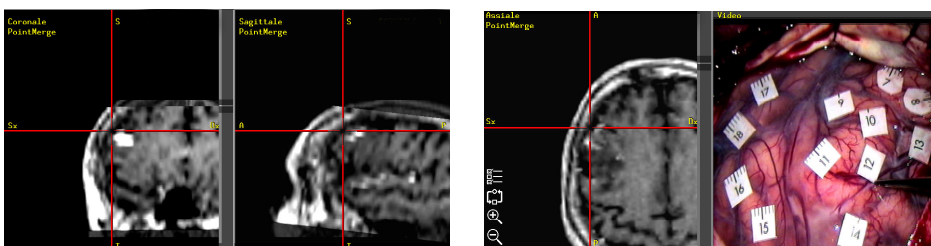

Fig. 1. Registered fMRI are displayed on the monitor of the neuronavigation station. The coordinates of the cortical site were identified on the fMRI dataset and correlated with fMRI results intraoperatively. In this case EC stimulation of site # 12 determined an error during the verb generation task. Cortical site #12 correslates with the activated left DLPFC in the registered fMRI.