Specialty area: Advanced Neuroimaging 1 – Brain & Spinal Cord

Lecture title: Task-Based BOLD fMRI for Presurgical Brain Mapping

Speaker name: Christoph Stippich, M.D., Professor; christoph.stippich@usb.ch

Target audience: Physicians, Physicists / Engineers, Neuropsychologists

Outcome objectives: - Essentials of BOLD-fMRI and DTI methodology
                       - Relevant functional neuroanatomy, motor system & language
                       - Paradigms for presurgical fMRI, diagnostic evaluation
                       - fMRI & DTI applications in brain tumor patients (examples)
                       - Diagnostic aims, atypical brain activation (reorganisation)
                       - Limitations, artefacts & important pitfalls

Purpose:
To provide comprehensive information on task based BOLD-fMRI with a focus on presurgical applications in patients with brain tumors affecting the motor system and language.

Methods:
Recapitulation of BOLD-fMRI, diffusion tensor imaging (DTI), tractography and of the basic neuroanatomy of motor function and language relevant to the topic. Presentation of optimised fMRI paradigms and data evaluation strategies, physiological activation. Clinical applications in brain tumor patients, characteristic findings: localisation of motor and language areas, language lateralisation, functional reorganisation. Diagnostic interpretation, application for neuronavigation, validation studies. Limitations, artefacts and important pitfalls.

Results:
BOLD-effect, anisotropic diffusion and DTI principles, functional neuroanatomy. Requirements and indications for presurgical application of task based BOLD-fMRI. Optimised block-design paradigms for motor and language activation studies, data evaluation routines. Motor system: Somatotopic mapping in rolandic brain tumors (1). Protocols for patients with tumor associated paresis (2, 3). Language: Localisation of Broca and Wernicke language areas (4). Determination of language dominance. Functional reorganisation motor & language (5, 6). FMRI-integration with DTI-tractography for neuronavigation. Validation studies. Limitations and caveats: Movement, BOLD and susceptibility artefacts, determination of resection borders (7).

Conclusion:
Presurgical task based BOLD-fMRI is currently the best established clinical application of fMRI. The method is valid for localising motor and language areas and for determination of the language dominant hemisphere when optimised and standardised protocols are employed, and limitations and caveats are encountered. Implementation in routine MR protocols is feasible. A combination with DTI and tractography is often useful. Selection of candidates for surgical treatment and of optimised treatment strategies tailored to the individual pathology is supported. Invasive presurgical measures may be substituted, such as intraarterial amytal testing (Wada-Test). FMRI data help to identify candidates for awake craniotomies and facilitate the intraoperative placement of cortical electrodes. Limitations, artefacts and caveats include various patient and methodology related aspects.

Figure 1
Presurgical fMRI somatotopic mapping of the primary motor cortex in a rolandic brain tumor.

Motor & Somatosensory

M1 foot right
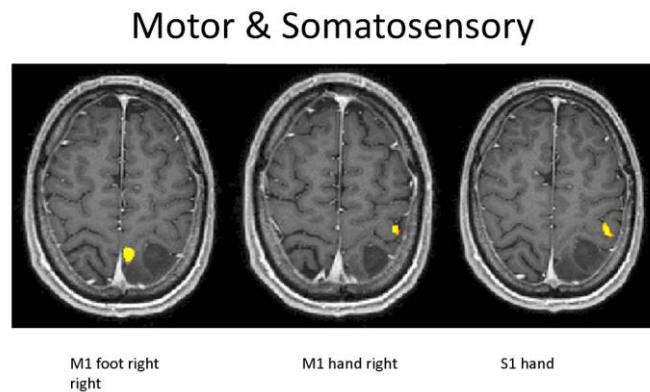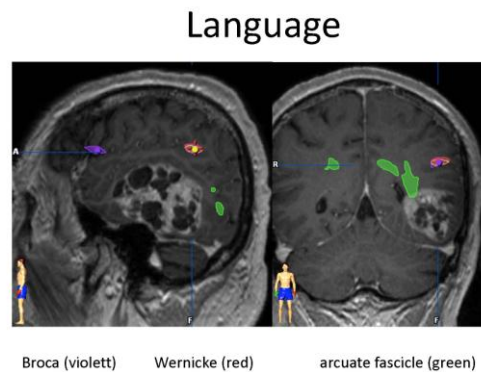right

M1 hand right

S1 hand

Figure 2
Presurgical fMRI language localisation of Broca and Wernicke areas and DTI tractography of the arcuate fascicle in a left temporal brain tumor.

Language

Broca (violett)   Wernicke (red)   arcuate fascicle (green)

References:
(1) Stippich C. et al., Neuroscience Letters 2002; 331: 50-54O
(2) Stippich C. et al., Neuroscience Letters 1999; 277: 25-28
(3) Stippich C. et al., Neuroscience Letters 2000; 285: 155-159
(4) Stippich C. et al., Radiology 2007; 243: 828-836
(5) Partovi S. et al., AJNR 2012; 33:2151-2157
(6) Tozakidou M. et al., Neuroimage Clinical 2013 (e pub ahead of print)
(7) Stippich C. (Ed.), Clinical functional MRI, Springer Verlag 2007