Resting-state fMRI in a High-Field Intraoperative MR-setting: Feasibility and Preliminary Results

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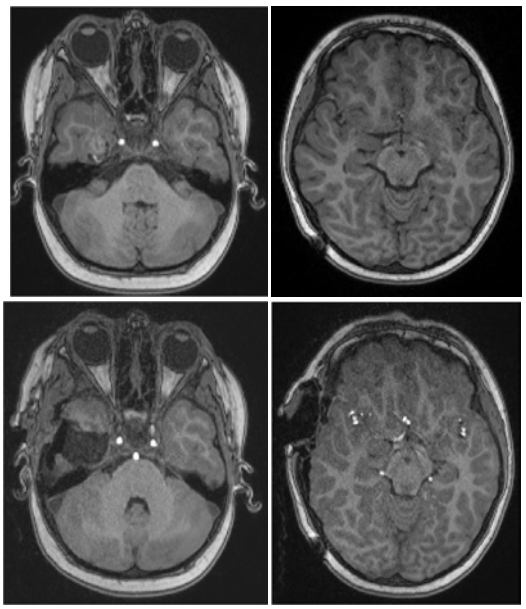

Fig. 1: Anatomical images from a patient in the intraoperative MR scanner before (top) and during (bottom) surgery.

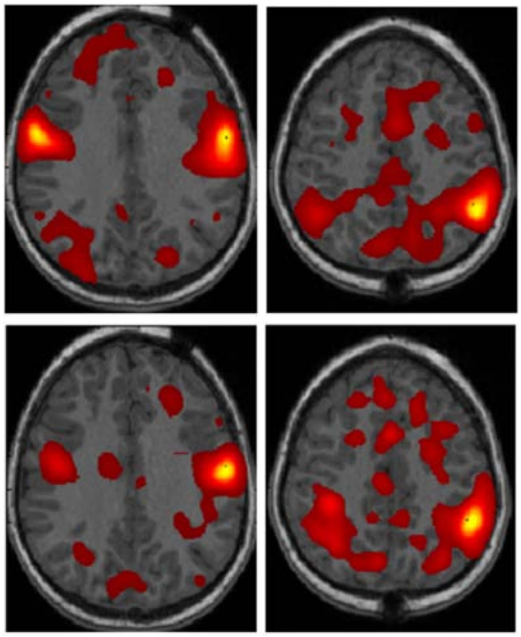

Fig. 2: Two RSN components, which correspond to IC 7 (left) and IC 23 (right) in healthy subjects[1], before (top) and during (bottom) surgery for resection of an intracranial mass.

Target audience: Neuroradiologists, Neuroscientists

Purpose

Resting-state functional MRI (fMRI) has emerged as an important method for assessing neural networks, enabling extensive connectivity analyses between multiple brain regions. This method might provide important results in an intraoperative setting of high-field intraoperative MR scanners. The aim of this study was to investigate the feasibility of performing resting-state fMRI during neurosurgical procedures in anesthetized patients.

Methods

Three patients referred for a surgical resection of intracranial masses were included in this study after informed consent was obtained. All patients received total intravenous anesthesia with propofol 2% and fentanyl being continuously monitored and ventilated by MR-compatible devices. An intraoperative 1.5-T MR scanner with an adapted operating table (IMRIS, Winnipeg, Canada) was used for resting-state fMRI. Three-dimensional anatomical T1- and T2-weighted images for co-registration were acquired prior to the EPI measurements (TR 2 s, TE 50 ms, resolution 3.4*3.4*3 mm^3, 153 repetitions). In one patient, measurements were performed before and after the surgical intervention (Fig. 1). Single-subject independent component analysis was performed with the GIFT toolbox (MIALAB, Mind research Network) using methods and algorithms described by Allen et al [1]. Smoothed data were decomposed into 41 components. The components were assigned as far as possible to published resting state network (RSN) components[1].

Results

In all cases, up to 12 from the 28 published RSN components could be identified in each patient examination. In one patient, resting-state fMRI could be performed directly after the mass resection with still opened skull (Fig. 1) and in that case 10 RSN components could be identified. Two clusters of the sensorimotor network are shown as examples in Fig. 2.

Discussion

Up to now, neurosurgical patients are often examined using preoperative fMRI to identify eloquent brain structures. The transfer of these results to patients on the operating table may be difficult. Intraoperative fMRI may proof as a feasible "image-based solution" to cortical mapping. Gering and Weber[2] performed active motor tasks in two awake subjects in an intraoperative setting. Gasser et al.[3] have identified eloquent brain areas in anesthetized patients using a passive stimulation paradigm with increased stimulation intensity, compared to awake patients, as they found that the BOLD signal in fMRI experiments under anesthesia was strongly reduced. This finding was in accordance to the observation of Lahti et al.[4]. In our study in anesthetized patients, certain components could be clearly identified without reduction of the RSN intensity in comparison to awake subjects. There were no hampering artefacts in the case of a patient with an opened skull during the intraoperative MR imaging.

Conclusion

Our preliminary results show that resting-state fMRI measurements can be performed in anesthetized patients using intraoperative high-field MRI system. This opens new avenues for functional navigation allowing a real-time intraoperative identification of resting-state connectivity.

References

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3. T. Gasser, et al., NeuroImage, 2005, 26: 685-693
4. K.M. Lahti, et al., Magn. Reson. Med., 1999, 41:412–416