PhD project 2022-2023

Preoperative high-resolution perfusion imaging of peritumoral edema in meningiomas as a biomarker of postoperative neurological functional outcome: Correlations with intraoperative optical imaging

Laboratory (acronym): CREATIS

Research team (acronym): MAGICS

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Project description including a short introduction, aim/objectives and methods/approach to be used

Introduction : Intracranial meningiomas represent the second most common intracranial tumor in adults. These usually benign tumors frequently display a variable amount of peritumoral brain edema (PTBE) which can significantly affect perioperative morbidity. We recently demonstrated the existence of major alterations of microperfusion in the PTBE with the use of intraoperative sidestream dark field imaging.[1]

Objective : Our current project (PERfusion in Peritumoral Edema in Meningiomas – PERPEM project) aims at identifying both preoperative high resolution MR perfusion modalities and intraoperative optical imaging techniques that may help linking the degree of microcirculatory alterations in the PTBE and the post-operative neurological outcome.

Methods :

Patients with intracranial meningiomas displaying PTBE will be assessed pre-operatively with multimodal brain MRI including specific perfusion sequences (high-resolution arterial spin labeling and dynamic susceptibility contrast MRI) and diffusion tensor imaging.

Intrinsic contrast optical imaging demonstrated its relevance to explore neurovascular-coupling alteration linked with brain tumors[2], but these methods are still difficult to extend in-patient during neurosurgery. Main issues are due to the lack of robust models for the quantification of intraoperative imaging biomarkers. We recently proposed new intra-operative optical hyperspectral imaging methods showing quantitative measurements of perfusion and oxygenation brain mapping on patient during neurosurgery for eloquent brain areas identification[3]. We proposed real time implementation[4] of methods, which is a key feature for intraoperative imaging in neurosurgery. We also demonstrated intraoperative metabolic (cytochrome-c-oxidase contrasts) imaging[5] (Figure 1).

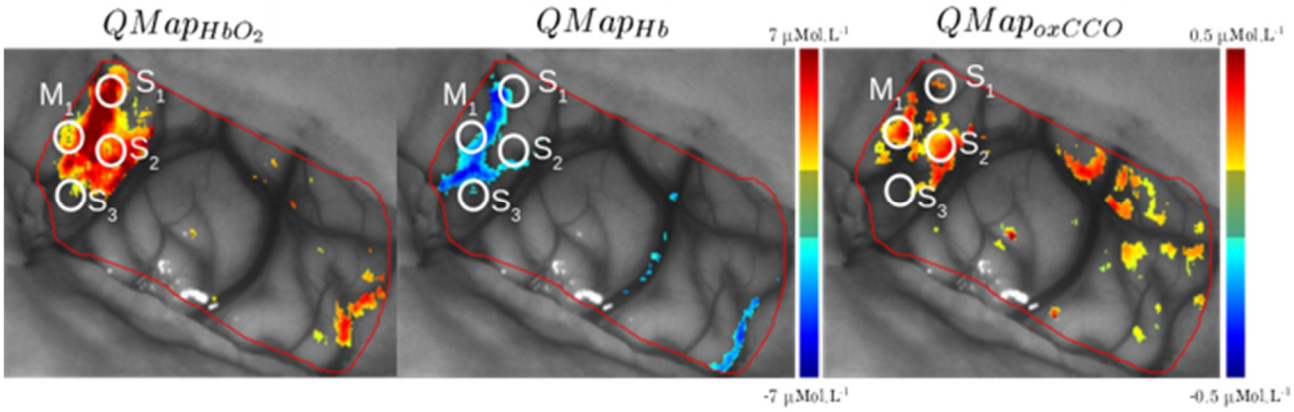

Figure 1: Intraoperative perfusion and oxygenation (Oxy- and deoxy-hemoglobin on right and middle images) and metabolic (cytochrome-c-oxidase on left image) brain mapping in-patient during neurosurgery using a hyperspectral camera. Quantification using a Monte Carlo model of light transport in tissue. The colorbar represents the scale of variations of hemoglobin and cytochrome-c-oxidase concentration changes in in µMol.L^{-1}. Letters M and S indicate motor and sensory areas, respectively.

During the PhD, we will develop complementary intraoperative methodologies (hyperspectral imaging, laser speckle imaging, sidestream dark field imaging) to assess multiparametric (metabolic, hemodynamic, morphological) microvascularisation contrasts in PTBE (Figure 2). The quantification of biomarkers will be achieved using Monte Carlo simulation based models and machine learning based models. The basic ideas is to learn the changing experimental parameters due to the operative room context during a machine learning process applied on acquired data. We already demonstrated such processes in the preprocessing step of image registration of the brain motion[6]. Neuronavigation cartography will allow correspondence between pre- and intraoperative perfusion imaging. The existing experimental set up will be improved, particularly in terms of the optimization of detection and illumination spectra.

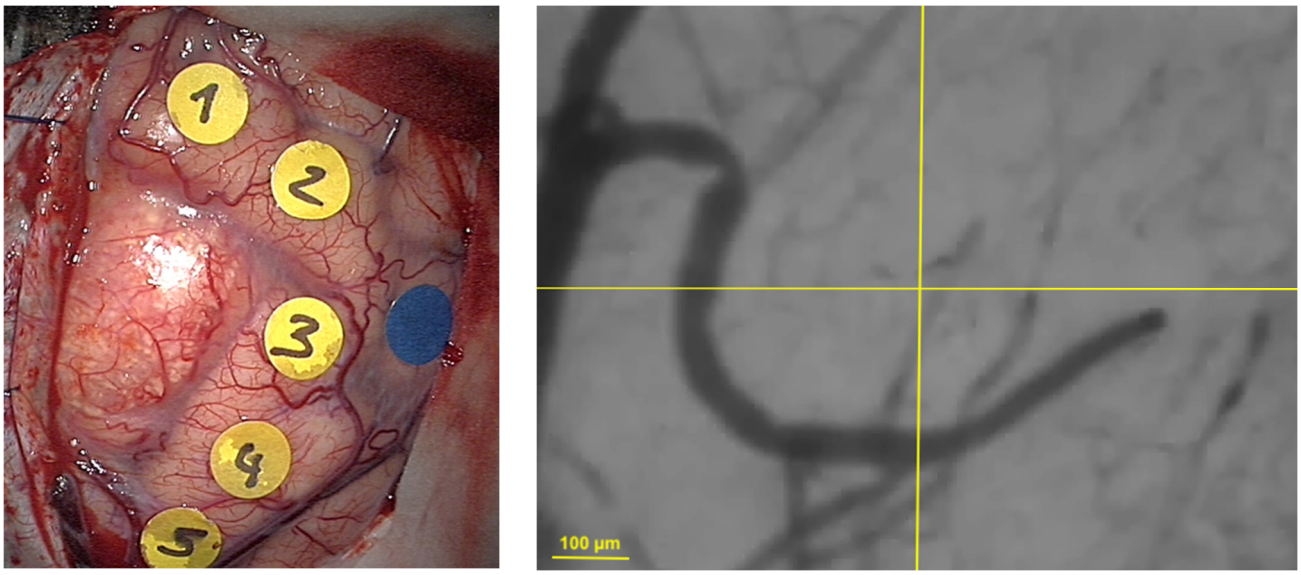

Figure 2: Intraoperative optical imaging (sidestream dark field technique) of microcirculation in peritumoral brain edema in a frontal convexity meningioma.

The postoperative neurological outcome (immediate, at 6 and 12 months) will rely on functional scales and postoperative perfusion MR imaging. Correlations between the severity of perfusion anomalies within the PTBE on both preoperative MR imaging and intraoperative optical imaging and post-operative functional status will be discussed.

Lab context :

CREATIS is an interdisciplinary research laboratory applied to medical imaging and associated to CNRS and INSERM. It is a very stimulating scientific and technologic context in the “domaine scientifique de la Doua” in Lyon which regroup the “Université Lyon1” and “INSA Lyon”. The person will integrate the MAGICS team inside CREATIS, which focus on MRI and Optics and their multimodal aspects.

References

1 - Alterations of cerebral microcirculation in peritumoral edema: feasibility of in vivo sidestream dark-field imaging in intracranial meningiomas. Berhouma M, Picart T, Dumot C, Pelissou-Guyotat I, Meyronet D, Ducray F, Honnorat J, Eker O, Guyotat J, Lukaszewicz AC, Cotton F. Neurooncol Adv. 2020 Aug 27;2(1):vdaa108. doi: 10.1093/noajnl/vdaa108
2 M.K. Montgomery, et al., Glioma-Induced Alterations in Neuronal Activity and Neurovascular Coupling during Disease Progression, Cell Reports 31, 107500 2020

3 - C. Caredda, L. Mahieu-Williame, R. Sablong, M. Sdika, L. Alston, J. Guyotat, B. Montcel, Intraoperative quantitative functional brain mapping using an RGB camera, *Neurophotonics* 6 (4), 045015, 2019. DOI: 10.1117/1.NPh.6.4.045015. PMID: 31890745

4 C. Caredda, L. Mahieu-Williame, R. Sablong, M. Sdika, J. Guyotat, B. Montcel, Real Time Intraoperative Functional Brain Mapping Based on RGB Imaging, *IRBM,* in press 2020. DOI: 10.1016/j.irbm.2020.04.004

5 C. Caredda, L. Mahieu-Williame, R. Sablong, M. Sdika, J. Guyotat, B. Montcel, Intraoperative functional and metabolic brain mapping using hyperspectral imaging, Proc. SPIE 11225, 11225-11, 2020. DOI: 10.1117/12.2545968

6 M. Sdika, L. Alston, D. Rousseau, J. Guyotat, L. Mahieu-Williame, B. Montcel, Repetitive Motion Compensation for Real Time Intraoperative Video Processing, *Medical Image Analysis*, 53, 1-10, 2019. DOI: 10.1016/j.media.2018.12.005. PMID: 30640039

Skills required: MD and/or MSc and/or Engineer with interest in MRI, optical imaging and instrumentation and data analysis.

Application procedure: send a detailed CV and the contact details of 2 academic referees to the PhD supervisor.