Quantitative functional brain mapping imaging using Arterial Spin Labelling for safe neurosurgery

**Rationale**

- BOLD signal is widely used in research and clinic to map functional cortex. However, it does not allow for a quantitative measure, and it has several limitations associated to the variability of the HRF model, particularly affected in cases of altered neurovascular coupling. This can induce false positive and/or false negative activations, which are critical especially when BOLD is used to map brain regions to be preserved in patients who are candidate for brain surgery.

- Arterial Spin Labelling (ASL) is an alternative non-invasive imaging technique that allows for a direct and quantitative measurement of the cerebral blood flow (Fig. 1). Although ASL demonstrated to locate more directly and more precisely the neuronal activity, it is still only occasionally used for functional mapping.

**Objective**

To validate the spatial specificity of ASL compared to BOLD in healthy subjects during the execution of tasks, before the application on the neurological population and translation in the clinical practice.

**Methods**

- 30 healthy subjects: [18-60] years old; 18 F
- 1st session -> MRI:
  - High resolution 3D-T1 (MEMPRAGE, 1mm isotropic)
  - Dual echo pseudocontinuous ASL allowing simultaneous BOLD/ASL acquisition (TR=3500ms, TE1/TE2=10/25ms, label = 1500ms, PLD=1000ms, 20 slices = 3.2x3.2x3mm)
  - Hand clenching
  - Pneumatic stimulation of thumb
- 2nd session -> neuronavigated TMS (Fig. 2):
  - Stimulation of the motor area and motor evoked potentials (MEP) measure (thumb and little finger)
  - Distances of the coordinates of maxima of activation:
    - ASL versus BOLD
    - ASL-TMS versus BOLD-TMS

**Results**

- In clenching task, for both hands:
  - In respect to BOLD, ASL was found (Fig.3, Fig.4):
    - More lateral (x direction, axial plane)
    - Significantly more anterior (p<0.05)
    - Significantly deeper (p<0.001)
  - The comparison of MRI modalities with TMS, revealed that ASL was significantly closer to TMS than BOLD (Fig. 4)
    - Along the posterior-anterior direction
    - Along the ventral-dorsal direction
- In pneumatic stimulation (Fig.5) group-analysis showed that in respect to BOLD, ASL was
  - More towards the midline, in agreement with literature
  - More anterior
  - Deeper

**Discussion**

Our results show the higher spatial specificity of functional ASL in respect to BOLD for the mapping of somatosensory and motor areas. Functional ASL could potentially substitute or at least complement fMRI studies based on BOLD. In the clinical context, functional ASL could be a valid alternative to BOLD, specially to target in the pre-surgical workflow eloquent cortex to be preserved during neuro-surgery.

**References**


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