Perfusion-based FMRI in the monkey brain at 7T: Investigations of CASL parameters

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Introduction Perfusion-based FMRI has become a powerful tool in recent years to achieve high spatial resolution [1]. Perfusion imaging can measure cerebral blood flow (CBF) directly at the capillary level and thus has the potential of increased spatial specificity over BOLD [2]. Moreover, functional CBF changes and interleaved-acquired BOLD data can be combined to compute changes in oxygen consumption rate. Arterial spin labeling is a commonly used CBF technique.
We used continuous arterial spin labeling (CASL) with a three coil setup, which affords high SNR, multi-slice capability and at the same time is particular insensitive to magnetization transfer.
To overcome the effects of transit time in CBF images, it is recommended to use post labeling delays (PLD) longer than the mean arterial transit time [3-4]. This results in prolonged measurement times and low temporal resolution. If full quantification of CBF is not required, short PLDs can be applied to improve significance and preserve functional localization. We evaluated the effects of labeling time (LT) and PLD on functional perfusion-based imaging in the primary visual cortex of the anaesthetized monkey.

Methods MR imaging was performed on vertical 7T/60cm system dedicated to monkey research (Bruker). A three coil setup with a saddle-shaped volume coil, a 40 mm surface coil and a cravat-shaped labeling neck coil was used. All RF coils were actively-decoupled. The preparation and maintenance of anesthesia of the animal (*macaca mulatta)* has been performed as described previously [5]. The study included 12 sessions from 2 different animals.
Single-shot, multi-slice GE-EPI was acquired with in-plane resolutions from 0.75 to 0.9 mm. The preparation module for ASL consisted of a constant labeling period with a 2.5 mT/m gradient followed by a PLD of 200, 500, 800 or 1200 ms. CBF images were derived by surround subtraction and were scaled to a fully saturated M0 image to allow comparison between sessions. For visual stimulation a rotating checkerboard was presented (42 s on/ 42 s off).

Results Initial functional CASL experiments were dedicated to test the influence of parameters LT and PLD on CBF and fCBF in our setup.
We found that rCBF slowly saturated for LT larger than 4s. Simultaneously, stimulus-induced signal changes of rCBF did not increase significantly with increasing LT. In contrast, fCBF activation was highly dependant on the PLD: The contrast-to-noise ratio (CNR) of fCBF changes (expressed as t values) were higher for shorter PLD and lower for longer PLD. However, the number of detected voxels remained constant at different PLDs. Importantly, CNR was not dependant on its CBF value (see Fig.1).

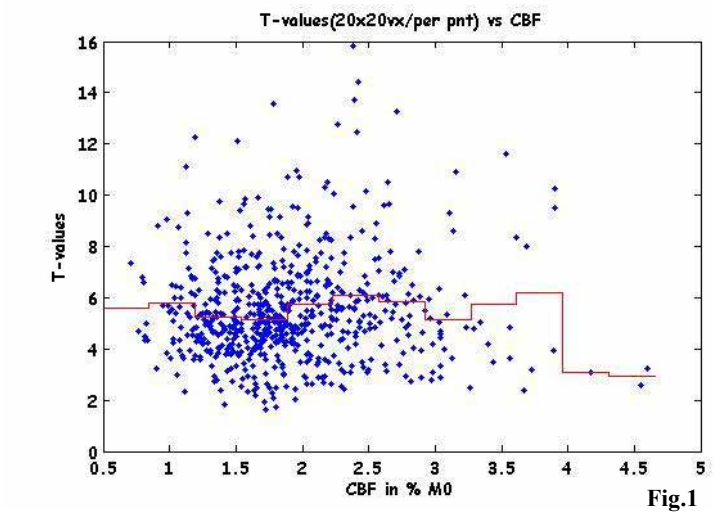

Fig.1

Discussion With short PLD, quantification of CBF is no longer possible as transit time differences contribute to CNR. However, these signal contributions are largest at the capillary bed which determines the flow velocity.
High resolution multi-slice fCBF maps could therefore be acquired with short PLD (see Fig. 2, 0.75 x 0.9 x 2 mm^3, TE 14 ms, TR 2.6 s, NA 64, LT 1.8s, PLD 0.5s). This results in higher CNR at the same total amount of measurement time.

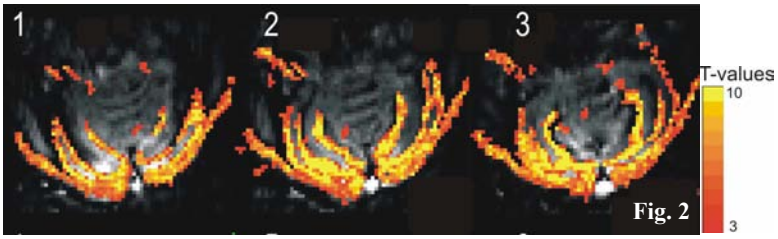

Fig. 2

To conclude, these first *in vivo* data in the monkey promise that *functional* studies in whole-brain or localized ROIs to measure fCBF, BOLD and $CMRO_2$ changes will considerably gain from this setup.

[1] Duong *et al. PNAS* (98):10904-9 (2001); [2] Duong *et al. Magn.Reson. Med* (48):589-93 (2002); [3] Alsop *et al JCBFM* (16):1236-49 (1996); [4] Gonzales-At *et al Magn.Reson. Med(43):739-46 (2000);*[5] Logothetis et al. *Nature Neurosci* 2(6):555-62 (1999);