Application of pseudo-continuous arterial spin labeling for quantification of hepatic perfusion

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TARGET AUDIENCE – Basic and clinical researchers involved in the design or application of ASL-MRI protocols

PURPOSE –The development of new antiangiogenic treatments for patients with cancer requires a specific monitoring especially for hepatic lesions. In this case, the evaluation of hepatic perfusion, currently done using contrast enhanced dynamic MRI, is crucial but alternative methods are desirable, especially for hybrid PET-MRI scanners. Although the method of pseudo-continuous arterial spin labeling (pCASL) has been widely applied in the brain [1, 2], few studies have explored the use of ASL approaches for estimating liver perfusion [3, 4]. The purpose of this study was to assess the feasibility of pCASL for quantification of hepatic perfusion in healthy volunteers.

METHODS –Six healthy volunteers were examined using a 3T scanner (Siemens TIM TRIO) and an abdominal coil. A localizer sequence and anatomical sequence (MPRAGE with 2x2x5mm^3 resolution) were first acquired to define the labeling plane of the pCASL scan as orthogonal to the portal vein. The sequence parameters were: 2D echo-planar imaging (EPI) with a respiration trigger; field of view: 288 mm x 90.6%; 4.5x4.5x8 mm^3 resolution (six or seven slices); distance factor: 10%; flip angle: 90°; fat suppression with fat sat; PAT mode GRAPPA; EPI factor 58; bandwith 3256 Hz/pixel; echo spacing 0.39 ms. The distance between the imaging and tagging planes was set at 50 mm. All sessions included a post label delay (PLD) set at 600ms and for two subjects, four additional PLD varying from 1000 ms to 1600 ms were performed. Two series of pCASL acquisitions allowed test of 4 and 20 repetitions. The data were analyzed using in-house software. The mean ASL difference signal was computed and converted to maps of hepatic perfusion (HP) using the ASL kinetic model described in [5]. Voxels with apparent flow values exceeding 500 ml/100g/min were excluded to eliminate intravascular signals from hepatic blood vessels, and the mean of liver perfusion (HP) was computed inside a large region of interest (ROI) encompassing the hepatic parenchyma.

RESULTS –Mean HP values for the six examinations (Figure 1) acquired at a PLD of 600 ms ranged from 56 to 119 ml/100g/min for 4 repetitions, and from 71 to 114 ml/100g/min for 20 repetitions. Using 20 repetitions enables to reduce the standard deviation. For the two subjects acquired with different PLD values and 20 repetitions, mean HP values were 79 and 84 ml/100g/min (PLD =600 ms), 83 and 86 ml/100g/min (PLD =1000 ms), 95 and 145 ml/100g/min (PLD =1200 ms), 93 and 125 ml/100g/min (PLD =1400 ms) and 88 and 108 ml/100g/min (PLD =1600 ms). Figure 2 shows typical tag /control pCASL images of liver (top) and perfusion maps in ml/100g/min (bottom) corresponding to a PLD of 600 ms and 1200 ms (20 repetitions). We systematically observed high values of perfusion inside portal vessels for PLD values of 600 ms. Furthermore the global hepatic perfusion increased for higher values of PLD while being reduced in portal vessels.

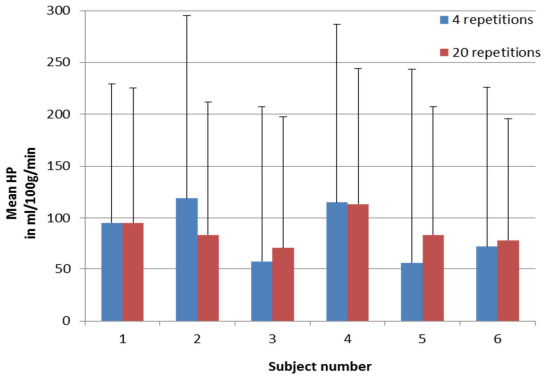

Figure 1: Mean HP (in ml/100g/min) and standard deviations from pCASL liver imaging ROIs with 4 and 20 repetitions at a PLD of 600 ms.

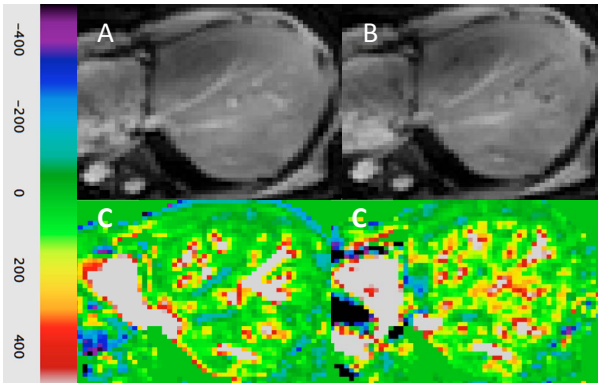

Figure 2: liver pCASL images; a) Tag b) control C) Perfusion maps (PLD=600 ms on left and PLD=1200 ms on right)

DISCUSSION –Hepatic perfusion values are within known physiological values [3, 4]. Of course, the number of repetitions (4 or 20) is crucial and needs to be optimized to have the most accurate HP evaluation, while keeping the acquisition in reasonable durations for patients. The variability in results is due to multiple factors: a high vascularization of the liver, difficulties to have a correct respiratory motion correction and noise issues. Mean HP obtained with PLD values higher than 600 ms tend to increase up to 1200 ms or 1400 ms before decreasing. This result suggests that the value of PLD could provide HP values weighted by the hepatic artery blood flow (low values of PLD) or the portal vein blood flow (high values of PLD). Indeed, the tagging plane goes across both the hepatic artery and portal vein and the hepatic artery blood flow is about two times faster than the portal vein blood flow.

CONCLUSION –Pseudo-Continuous Arterial spin labeling is a non-invasive MRI sequence which could be used to evaluate and quantify liver perfusion. Our pilot study shows the influence of the number of repetitions. Furthermore, using different post label delays could help to distinguish perfusion between hepatic artery and portal vein. These preliminary results are of prime interest for the follow-up of an antiangiogenic treatment on hepatic tumors, showing generally an increased hepatic arterial perfusion.

REFERENCES – [1] Wang J. et. al., Magn. Reson. Med., 50(2003). [2] Wu WC. et. al., Magn. Reson. Med., 58(2007). [3] Hoad C. et. al., Proc. ISMRM., 19(2011). [4] Katada Y. et. al., Jpn. J. Radiol., 30(2012). [5] Liu TT. et al., Neuroimage, 24(2005). **ACKNOWLEDGEMENTS** – This research was supported by grant RBIQ 5886. We also thank Carollyn Hurst and André Cyr for their help and involvement in this study.