PRE- AND POSTPRANDIAL ARTERIAL AND PORTAL VENOUS LIVER PERFUSION USING SELECTIVE SPIN LABELING MRI WITH LOOK-LOCKER READ-OUT

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PURPOSE: Spin labeling (SL) MRI is a non-invasive technique for perfusion evaluation. Drug-related risks, which is a concern in contrast-enhanced MRI, are eliminated by using labeled blood as endogenous contrast. In a few studies SL-MRI of the liver has been explored [1-5]. However, in humans only readouts with a single post labeling delay (PLD) were used, limiting quantification accuracy. The aim of this study was to investigate SL-MRI with Look-Locker (LL) readout, accounting for bolus arrival time in quantification of liver perfusion. The global and parenchymal liver perfusion were compared pre- and postprandial and correlated to portal venous flow changes.

METHODS, *Experiments*: Portal venous and arterial liver perfusion were measured with selective SL in 11 healthy volunteers (6 female, mean 27 yrs, range 24-33). Written informed consent was obtained. To evaluate our technique, two different perfusion conditions were evoked by scanning before and after ingestion of a fat and carbohydrate rich meal. The caloric content (mean 754±105 kilocalories) was one third of each volunteers daily need [6]. Pre- and postprandial scan sessions were 30 minutes, with a 30 minutes break for meal ingestion.

Image acquisition: All imaging was performed on a 1.5T MR Ingenia scanner (Philips Healthcare, Best, The Netherlands) equipped with an anterior and posterior 28-channel coil. Every scan session included a whole-liver T1-weighted acquisition, one pseudo-continuous arterial SL (pCASL), one pulsed portal SL (PPSL) sequence and three spoiled gradient echo based flow sequences (Philips Q-flow) of the portal vein. pCASL was performed with pseudo-continuous label [7] covering the descending aorta (1650ms duration) and PPSL with a pulsed label (EPISTAR [8], 150mm) positioned over the portal vein and its feeding vessels. SL read-out was a single shot gradient echo planar imaging (GR-EPI) LL sequence of 9 transversal slices (8mm slices, spacing 0.8mm, TR_{LL}=400ms, flip angle 30º, TE=18.4ms, EPI factor 53, parallel imaging factor 2). Minimum PLD was 50ms for pCASL (5 images) and 900ms for PPSL (7 images). Breathing was easily synchronized to the fixed TR of 6500ms by all volunteers, ensuring expiratory breath-hold during label and readout.

Data analysis: SL experiments were averaged over 20 label/control subtractions. Models for pulsed and pseudo-continuous quantification with LL readout were derived from [9] and [10], and were adjusted for PLD>0 and fitted to the data. Perfusion rates were evaluated quantitatively for the liver, excluding large vessels. SL-based portal perfusion was compared to perfusion measurements derived from portal flow: (mean portal velocity x cross-sectional area)/(liver volume).

Figure 1: Example of PPSL-based pre- and postprandial perfusion

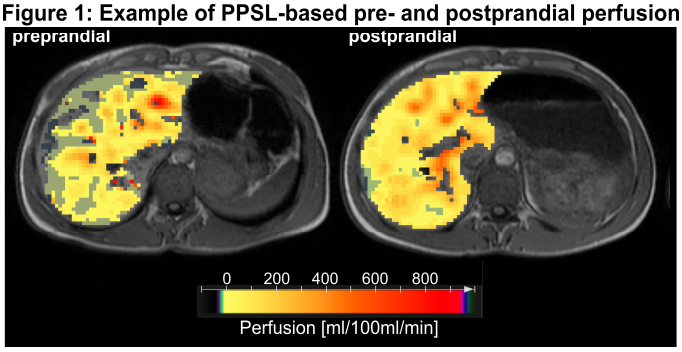
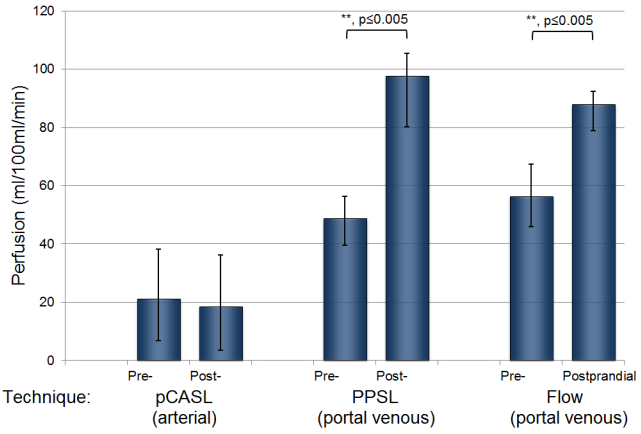


Figure 2: Pre- and postprandial liver perfusion



RESULTS: Figure 1 shows an example of pre- and postprandial PPSL- and pCASL-based perfusion. The portal perfusion significantly increased (p≤.005), from 49±17 preprandially to 98±26 ml/100ml/min postprandially. The arterial perfusion was lower than portal perfusion both pre- and postprandially, 21±18 and 18±17 ml/100g/min, respectively. (Figure 2) The PPSL-based perfusion correlated well with flow-based perfusion (r^2=0.73). Bolus arrival times differed (p=0.074) pre- (876±280ms) and postprandially (726±236ms) for PPSL, and differed regionally throughout the liver.

DISCUSSION: Our results confirm feasibility of SL-based hepatic perfusion imaging using LL readout and shows a good correlation of the portal venous SL and flow-based perfusion. Postprandial portal perfusion increased significantly, while arterial perfusion decreased - although not significantly. The arterial and portal perfusion were in accordance with literature values [11]. Quantification using SL with LL readout adjusted for individual variation in bolus arrival time, supporting our hypothesis that it allows for more accurate quantification. This non-invasive technique could potentially contribute to diagnosis and treatment monitoring of liver diseases with elimination of contrast-related risks. SL could be applied during thermal ablation or high-intensity-focused-ultrasound (HIFU) of focal lesions, where use of contrast agents is contraindicated, and could possibly benefit diagnostics by evaluation of the specific ratio between the dual blood supply.

CONCLUSION: Spin labeling MRI of the liver with Look-Locker read-out is feasible and showed significant postprandial increase in portal venous liver perfusion.

References: [1]Cox et al. ISMRM 2013, [2]Hoad et al. ISMRM 2011, [3]Gach et al. ISMRM 2002, [4]Katada et al. Jpn J Radiol 2012;30(10):p863, [5]Ramasawmy et al. ISMRM 2012, [6]Frankenfield et al. J Am Diet Assoc. 2005;105(5):p775, [7]Silva et al. MRM 1999;42(3):p425, [8]Patel et al. MRI clin of N Am 1995;3(3):p425, [9]Buxton et al. MRM 1998 Sep;40(3):p383, [10]Günther et al. MRM 2001 Nov;46(5):p974 [11]Weidekamm et al.AJR 2005 Feb;184(2):p505