Arterial input function reconstruction for DCE-MRI of the liver using pre-bolus acquisition with low dose gadolinium contrast

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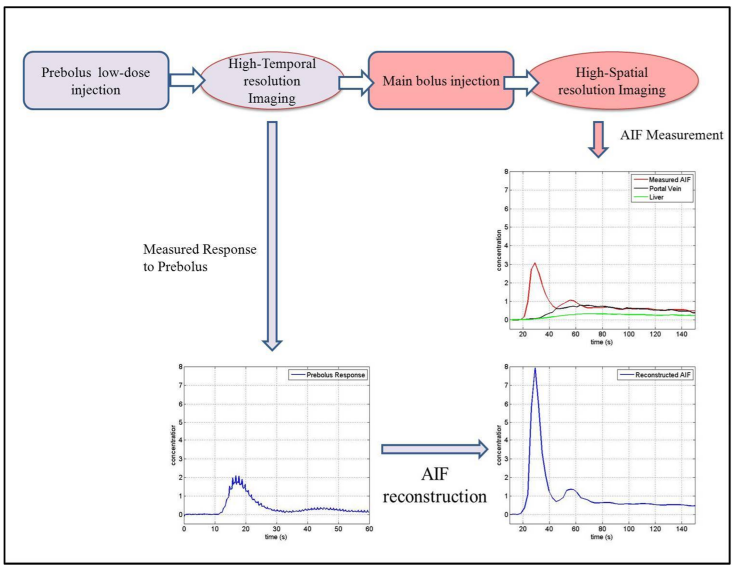
Target audience: Radiologists and physicists/scientists interested in perfusion quantification.

Introduction: Changes in liver perfusion and flow quantified with DCE-MRI have been observed in advanced liver fibrosis and cirrhosis. Quantification of liver perfusion modeled parameters depends on the determination of the contrast agent concentration in the blood plasma (the so called arterial input function, AIF), which is typically challenging because of several possible artifacts, for example signal saturation. In this study we assessed the quality of the reconstructed AIF using a pre-bolus injection of low dose gadolinium contrast and we compared it with the measured AIF after the injection of the main gadolinium bolus during DCE-MRI of the liver.



Flow diagram showing the reconstructed and measured AIF using first low dose gadolinium injection before main bolus.

	Pre-bolus AIF	Main bolus AIF	p
Peak (mmol)	7.69 ± 4.56	3.45 ± 1.53	**< 0.001**
Time to Peak (s)	8.68 ± 2.7	10.14 ± 5.11	0.07
Upslope (mmol/s)	0.96 ± 0.6	0.42 ± 0.22	**< 0.001**
AUC60 (mM.s)	99.04 ± 26.91	72.7 ± 21.2	**< 0.001**
FWHM (s)	8.98 ± 2.67	12.21 ± 6.01	**< 0.001**

Mean values ± SD for parameters of the pre-bolus and main bolus AIFs

Methods: In this prospective IRB approved study, 23 DCE-MRI examinations were performed in 20 patients with liver disease (M/F 16/4, mean age 56.9 y), including 3 patients scanned twice (on different days) at 1.5T (Siemens Avanto). As shown in Fig., a pre-bolus of 1.3 mL of Gd-BOPTA (Multihance) was injected for AIF acquisition using a high temporal resolution coronal oblique (parallel to abdominal aorta) 2D-TurboFLASH sequence (TR/TE/FA 198.9/0.21/12°, matrix 128x93, slice thickness 1 cm, temporal resolution 0.2 s, acquisition time 1 min). The main bolus consisting of 0.05 mmol/kg of Gd-BOPTA was then injected, and DCE-MRI was obtained with a coronal 3D-FLASH sequence covering the whole liver and the aorta (TR/TE/FA 2.96/0.95/12°, matrix 192x121, slice thickness 4 mm, mean temporal resolution 2.7s, 64 volumes acquired). ROIs were placed in the abdominal aorta and signal intensity was converted to gadolinium concentration by using SPGR signal equation [1]. Pre-bolus AIF was reconstructed by shifting, adding and scaling the concentration-curve in the aorta after the pre-bolus injection **(Fig.)** [2]. Two observers assessed blindly and independently pre-bolus and main bolus AIF curves qualitatively (for peak and width). Quantitative AIF curve features including peak concentration, time to peak (TTP), upslope, area under the time activity curve of gadolinium contrast at 60 s (AUC60) and the full width at half maximum (FWHM) were calculated and compared between pre-bolus and main bolus data.

Results: Pre-bolus curve quality was significantly better than main bolus AIF curves (in 19/23 for observer 1, and 20/23 for observer 2). AUC60, peak concentration and upslope of pre-bolus AIF were significantly higher and FWHM was significantly lower than those of main bolus **(Table)**. In the 3 patients that underwent test-retest studies, all parameters showed better reproducibility using pre-bolus AIF (CV 9.5-42.5% for pre-bolus AIF and 26.2-67.7% for main bolus AIF).

Discussion: The differences observed in the computed AIF parameters are likely due to signal saturation and/or temporal resolution effects. The high temporal resolution used during the pre-bolus injection preserves the signal intensity peak, while the high spatial resolution used after the main bolus might misrepresent the AIF due to temporal undersampling. A pharmacokinetic model is currently being evaluated using the different AIFs to evaluate which AIF provides more meaningful hepatic physiological parameters.

References
1. Schabel, M.C. Phys Med Biol., 2008. **53**: p. 2345-73.
2. Koestler, H., et al. Magn. Reson. Med, 2004. 52(2): p. 296-299
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Conclusion: Estimation of pre-bolus AIF using high temporal resolution low dose gadolinium injection has the potential to overcome the saturation effects shown in the measured AIF after a higher dose of contrast agent is injected, and allows for higher spatial resolution imaging of the liver after main bolus injection.