circulation that reflects tissue supply much better than detection and quantification of a stenosis itself. The regional intracapillary blood volume (RBV) almost represents the whole intramyocardial blood volume and reflects the autoregulatory adaptation of microvessels. A recently developed model provides relaxation time as a function of intrinsic relaxation times in the intra- and extracapillary space, exchange frequency, RBV and perfusion. The aim of this pilot-study was to determine the intra-extracapillary water proton exchange frequency f and the RBV in human myocardium using an intravascular CA.

Materials and Methods: Sequences were implemented on a 1.5 T whole body scanner (SIEMENS Vision, Erlangen, Germany) using the integrated body coil for rf-excitation and a four-element phased array coil for signal reception. T1 values were estimated using a saturation recovery TurboFLASH (SRTFL) sequence as recently proposed and administered to myocardial perfusion in humans by our lab. Ten ECG-triggered images at ten different saturation times were acquired in a single breathhold during diastole in a short-axis view of the left ventricle. The RBV was estimated from the T1 values of myocardium (T1, myo, slice selective) and T1 values of blood (T1, blood, global spin preparation) before and after injection of 0.5 mg Fe/kg NC100150 (Feruglose, USPIO agent, Amersham). Six patients with CAD (X-ray) were studied.

Results: RBV values were calculated as 12.9%. The intra-extracapillary water proton exchange frequency was determined as $f = 0.48$ 1/s.

Discussion: The aim of this pilot-study was to determine the intra-extracapillary water proton exchange frequency f and the RBV. Therefore, the effect of an intravascular CA on relaxation rate in myocardium (R1, myo) in the steady state was investigated. The dependence of R1, myo on R1, blood was characterized and compared with a theoretical model which allowed determination of the intra-extracapillary water proton exchange frequency and the RBV. A linear response range of R1, myo on R1, blood was estimated which, in future studies, will allow the determination of RBV with intravascular CA.

References:

[1] Schwarzbauer C et al., Magn Reson Med 1993;29:709–12.
[2] Bauer WR et al., Magn Reson Med 1996;35:43–55.
[3] Bauer WR et al., Magn Reson Med 1997;38:917–23.
[4] Waller C et al., Radiology 2000;215:189–97.
[5] Wacker CM et al., Magn Reson Med 2000;41: 686–95.
[6] Wacker C.M. et al., Magn Reson Med 2002;47:1013–6.

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Improvement of the perfusion analysis by registration of MRI images sequence

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Purpose/Introduction: Myocardial perfusion can be measured from the transit time curves obtained by MRI and contrast media injection. The registration of the dynamic images of MR perfusion study is the first step of this analysis that is usually done manually. This work describes an automatic registration process that overcomes the difficulty related to the time dependent intensity variations inside the heart section to be registered.

Subjects and methods: The registration method was evaluated on cardiac perfusion MRI exams (two slices per study) obtained in nine patients.

The registration is based on a fully automated registration algorithm that uses the original gray levels as feature space and that considers a Euclidean least-squares criterion for the determination of a general 3-D affine transform. It is based on splines in a multi-resolution context, and was applied to 2-D data. The registration process required only one region of interest (ROI) centered on the organ to be registered. This ROI must have the particularity to be hollowed of the region where image intensities change due to the perfusion of the contrast agent.

Registration accuracy was estimated by monitoring the position of the Left Ventricle (LV) inside the myocardium. Several transit time curves inside the myocardium were determined from the raw images, from the automatic registered images and from the manually registered images used as a gold standard. Statistical analyses of these curves were realized and agreement between measurements obtained with or without registration stage was assessed according to the method described by Bland and Altman.

Results: Registration has been successfully implemented on nine patients. The maximum excursions of the LV position decreases from 21 pixels for acquired images, to three pixels for registered images (1.8 mm wide pixels). On short-axis views, free breathing is clearly dominant in the Anterior-Inferior direction (mean $\pm$SD $= 2.25 \pm 1.11$ pixels). Transit time curves obtained from non-registered images present a lower correlation ($r = 0.84$, $P < 0.01$) with the gold standard than those obtained from registered images ($r = 0.99$, $P = 0.47$). Statistical analyses have shown that transit time curves obtained without registration were significantly different from gold standard curves contrary to curves obtained from registered images.

Discussion/Conclusion: This automatic registration algorithm, which is freely available, corrects for most of the motion induced by physiology and free breathing, which allows performing simpler perfusion analysis by avoiding the tedious and time-consuming manual shift of the ROIs over each image of a dynamic sequence.

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Automated registration and outlier identification for the improvement of cardiac MR perfusion quantification

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Introduction: Myocardial perfusion imaging using MRI and contrast agent injection usually requires an acquisition window of several minutes. As a result, perfusion images suffer from respiration-induced movements which limit the accuracy of perfusion quantification based on intensity-time profiles of individual pixels [1]. 2-D rigid image registration techniques have been proposed to compensate in-plane motion [2]. However, 2-D methods cannot address through-plane components of motion artifacts which can lead to invalid registration results. We therefore propose to further enhance registration by an automated identification of images which are not correctly aligned by image registration.

Method: Given a short axis view of the myocardium, the images of the dynamics are registered with respect to a reference image by maximizing correlation using a 2-D rigid transformation [3]. Outliers are addressed by a novel method which depends only on the reported registration results. For each triplet of images cyclic registrations are performed yielding composite transformations indicating registration errors. Their mean quantifies the inherent registration consistency. The most s severe outliers are determined by removing combinations of s images while calculating the consistency of the n-s remaining ones. Among the subsets the one with the smallest consistency determines the s most significant outliers. The number of outlier images to be replaced must ensure a tradeoff between improvement of quality and preservation of diagnostic information. The number s is determined as the largest number such that at most two consecutive images are identified as outliers.