Validating Arterial Spin Labeling Cerebral Blood Flow measure with perfusion phantom

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Introduction & Motivation:

- Arterial Spin Labeling (ASL) used to assess Cerebral Blood Flow (CBF)
- "white paper" with recommendations [1] for optimal acquisition.
- High repeatability, high reproducibility and high reliability desired.
- CBF measure may still have large inter- and intra-subject variability, however.
- CBF to be used as surrogate for physiological features.

Solution:
- A phantom that allows systematic changes of a limited and controlled set of ASL parameters.

Cross-check validation of CBF measure: Transparent perfusion-phantom.
- Independent "optical based" CBF assessment. Injection of a bolus of dye at the location of the "carotid artery".
- 3D-CCD cameras will capture signal. Measure of the integral of the local dye concentrations along the line of sight.

Results:
- The perfusion phantom is operating (Fig. 1A and B).
- Due to the large amount of different sequence and pump settings we present a limited set only. Setting the pump Flow volume/Flow rate at 200 [ml/min], a flow ratio of 1, post-labeling delay of 500 ms revealed an extraordinary high precision of CBF estimation by the perfusion phantom: 198.3029 ± 0.76 [ml/100g/min] (Fig. 1C and D).
- The signal to noise ratio (SNR) was 4.2. The expected value of CBF was therefore underestimated by 1.7 [ml/100g/min].
- The error in CBF estimation is 0.5% which is at same level as the accuracy of the pulsatile pump.

Discussion & Outlook:
- A perfusion phantom was constructed and is working with 125 cm3 volume filled with SiO2 spheres of different diameters [e.g. 0.01 mm 0.05 mm and 0.1 mm]. Due to this set of diameters an average pore size of 0.0138 mm was achieved: which is a factor 2 larger than average diameter of capillaries of ~6 μm (Fig. 1A).
- The perfusion phantom with the pulsatile pump showed high accuracy of CBF estimation that was reliable and reproducible. The observed CBF values showed high precision (i.e. low standard deviation) that allows to draw conclusion about the variance of the CBF measure originated by the ASL sequence only.
- Uncertainty in CBF estimation by ASL technique may therefore be assessed [5]. This novel approach will finally allow clinicians, physicists and researchers to unambiguously estimate disease-related CBF effects [5]. Therefore, it is relevant for patients as well as for socioeconomic aspects. The perfusion phantom will be generalized to be used at other institutions to enable quality controls on different scanners with different ASL sequences and different field strengths: since the phantom is stable and easy to send. The present phantom will be tuned with smaller SiO2 spheres in order to reach the average diameters of capillaries.

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