MR-based Oxygen Extraction Fraction OEF using Spatial ICA of breath-hold PARSE Acquisitions.

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Introduction:

Cerebral Oxygen Extraction Fraction (OEF) has been shown to be an independent predictor of stroke risk [1]. Increased hemispheric OEF was linked to poor long term outcomes. We have developed a means of quantifying OEF with MRI using PARSE [2]. Observation of OEF alteration under mild physiologic stress induced by breath-holding reflects cerebrovascular reserve which may provide complimentary information on collateralization, and correlate with favorable outcome to revascularization therapy. We present an analysis of breath-hold MR-OEF images using spatial independent component analysis (sICA). Traditionally, ICA analysis is performed in the time domain and component selection is motivated by anatomic landmarking and often manual selection, and the associated biases. We present here a sICA analysis of raw free-induction decay signals, which is completely independent of the normal bias associated with anatomic landmarking.

Methods:

PARSE acquisitions acquired a 2D k-space volume using a well-described rosette trajectory in 65 ms. By acquiring 20 PARSE datasets(1/5 seconds) and inducing a short 15 second breathhold we are able to observe frequency shifts ($\delta\omega$) resulting from increased de-oxyhemoglobin in the draining veins of the head, similar to BOLD contrast. These 4-10 Hz shifts are de-noised using sICA with spatial coordinates defined as the length along the PARSE readout and temporal domain being the 20 time points separated by ΔT=5 s. Spatial ICA uses blind-source separation to extract time-courses, which correspond to bulk signal enhancement associated with the breath hold. Only the time courses that showed an enhancement of greater than 20% during breath hold were used to reconstruct the de-noised free-induction decay signal; allowing us to create a signal containing only the dynamic components affected by the induced stress.

MRI-BASED OEF Images Before (left) and After (right) sICA Analysis

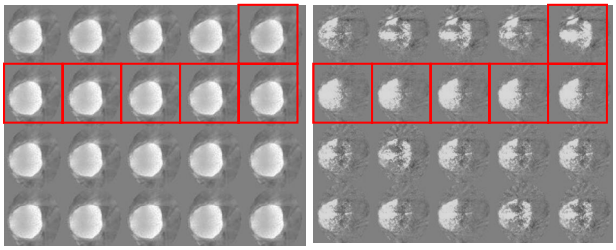

Figure 1: Twenty consecutive MR-OEF images acquired with a breath-hold (red boxes) show the sensitivity of ICA-processed MR-OEF images. Note the Occipital region OEF enhancement at baseline, and frontal shift in OEF under stress.

Results:

Figure 1 shows a comparison between 20 consecutive MR-OEF images created before and after sICA analysis. Though little can be deduced from the time-course created before de-noising, the sICA images clearly show a frontal shift in OEF during the period of induced stress followed by a return to the baseline after the stress is removed.

Discussion/Conclusion: We have found that MR-PARSE has high sensitivity to frequency shifts induced by transient alterations in de-oxyhemoglobin. The use of ICA to extract and quantify cerebrovascular reactivity represents a new simple, non contrast approach to stratifying patients toward therapies to prevent stroke.

References: [1] Derdeyn, Brain 2002,[2]Twieg, MRM 2002

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