Utility of shared rotating control acquisition for territorial ASL

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INTRODUCTION: Regional or territorial ASL (tASL) offers unique opportunity to visualize vascular territories of main brain feeding arteries completely non-invasively. Already a number of approaches for performing selective vessel labeling have been proposed [1]. In real clinical situations, especially when scanning acute patients, relative advantages and disadvantages of different methods with respect to labeling efficiency and selectivity must be considered together with more practical issues such as ease of planning and speed of image acquisition to reduce motion artifacts. Planning is usually based on TOF images with multiple perfusion territories acquired in consecutive acquisitions. Patient motion may not only degrade the quality of perfusion maps, but completely invalidate planning of yet to be acquired territories because selected vessels may no longer be within "labeling region". One way to minimize this effect is to interleave acquisitions of different territories in a single sequence [2]. Additionally, any method allowing total scan time reduction will be beneficial, as long as clinically relevant information remain unaffected. Here we consider a modification of the method proposed by Hendrikse et al [3] were in addition to cycling of the labeling slab we evaluate the possibility of using shared rotating control slab for subtraction. Compared to the original 3 slabs method, this would allow reduction of scan time by 30% or 50% in combination with dual-vessel labeling [4]. If expected incomplete magnetization transfer (MT) compensation effects are small, the gain in speed would justify this acquisition strategy.

METHODS: In a full cycled acquisition of 3 territories (Right ICA, Left ICA, Posterior), labeling/control scheme is "Ll Lc Rl Rc Pl Pc Ll Lc…" Shared rotating control scheme would correspond to "Ll Rl Pl Lc Ll Rl Pl Rc Ll Rl Pl Pc…"

Full tASL data was acquired in 4 volunteers and 8 patients on a 3T clinical scanner (Philips Achieva R2.1). QUASAR sequence [4] was used with the following parameters: FOV=240 mm, matrix=64x64, 7 slices (6mm, 2mm gap), TR/TE=4000/22 ms, flip=35°, $TI_1/\Delta TI$=50/300 ms (13 time points), SENSE=2.5, $V_{enc}=\infty$. 22 label-control pairs per territory were acquired in 9 min. For each subject, two sets of perfusion maps were generated as normal averaged control-label in corresponding territories and as simulated rotating control scheme. No motion correction or discarding of data was performed. Individual territories were combined into RGB maps for visual assessment. Normal subtraction data was used to generate territories masks by averaging perfusion maps trough time points 2 to 6 and taking positive values. Mean $\Delta M/M_0$ signal within these masks was calculated in normally subtracted and rotating control data.

RESULTS: Figure 1 shows combined RGB tASL maps in a normal volunteer. The first two time-points in rotating subtraction are visibly more affected by MT or saturation effects. However, after the arterial phase, subsequent perfusion maps show very similar territorial information. Figure 2 shows tASL maps in a patient with right MCA occlusion. Here too, we can see more pronounced saturation in the first two time points of rotating control data. It appears that errors in posterior circulation territory propagate even into later time points. "Ringing" around the brain indicates some motion artifacts, but it is easily identified as such even on normally subtracted data. Despite these artifacts, conclusion on territorial perfusion information is likely to be very similar from normal or rotating control data.

Mean $\Delta M/M_0$ values computed in 3 territorial masks both for normal and rotating control are shown in Fig.3. Except for the first time point, there are no significant differences between two subtraction methods. Rotating control data seems consistently slightly higher (0.04%) than normal subtraction data between time points 2 to 9 in left and right ICA territories while the situation is opposite in Posterior territory. This difference could be due to the fact that left and right labeling slabs are typically placed closer to the isocenter (smaller offset freq.) compared to posterior one and in general smaller size and more localized posterior territory.

CONCLUSION: Territorial ASL using shared rotating control acquisition seems to be a viable option for scan time reduction in clinical applications. Additional verification would be necessary for specific cases, for instance in regions with mixed blood supply.

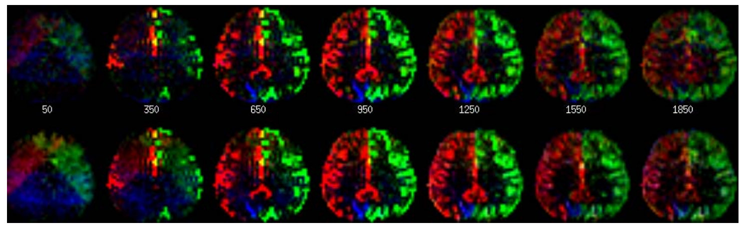

Fig.1: Combined tASL maps in normal volunteer (top) normal (bottom) rotating control

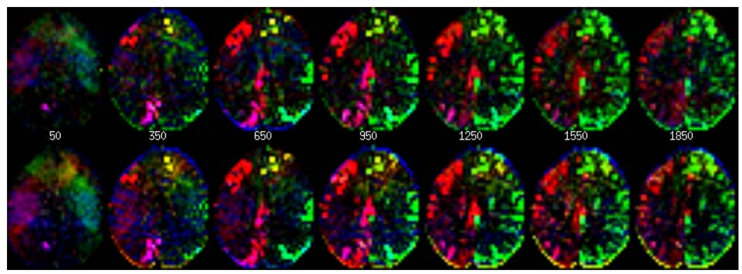

Fig.2: Combined tASL maps in patient with right MCA occlusion (top) normal (bottom) rotating control

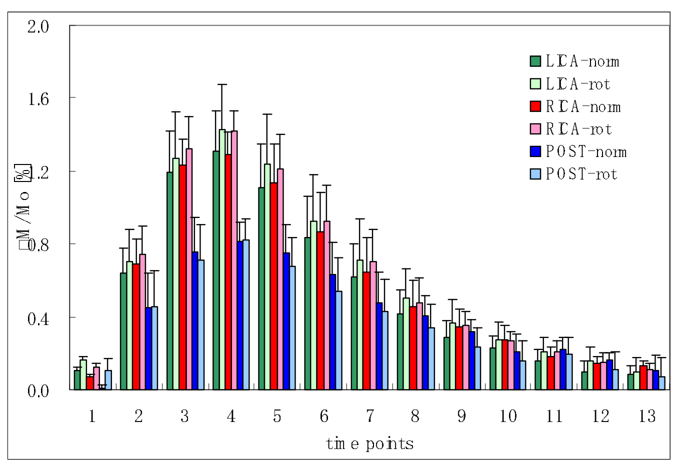

Fig.3: Mean $\Delta M/M_0$ in all territories averaged across all subjects

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