Analysis of localization error of decoded vascular sources in random vessel encoded arterial spin labeling

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Purpose:

Vessel-encoded arterial spin labeling (VEASL) was introduced to allow for mapping of the perfusion territories of several feeding arteries simultaneously. However, VEASL requires prior information about the location of feeding arteries to be tagged in order to prescribe a series of Hadamard encoding steps across the feeding arteries [1]. To automate the VEASL prescription process, efforts have been made to acquire perfusion territories without prior knowledge of vessel locations. One of these methods is Random VEASL (R-VEASL), which was proposed to not only map vascular territories without planning, but to also uniquely identify the locations of the source arteries in the tagging plane [2-3]. However, localization of the decoded vascular sources is inaccurate in some subjects. In this work, we investigate three potential causes of this mis-registration: 1) subject motion; 2) outliers in the data causing a poor fit; and 3) inaccuracy of the tagging plane.

Methods:

Five healthy subjects were studied in a General Electric MR750 3T scanner, using a commercial 8-channel head RF coil, under a protocol approved by the local IRB.

The tagging plane was chosen at the level of the sphenoid sinus where there is a triangular arrangement of internal carotid and basilar arteries. 60 pairs of random encoding steps were generated once and then were acquired for each subject, in addition to two pairs of non-vessel encoded encoding steps for total of

Figure 1. The distribution of difference between data and the best-fit theoretical response. The blue circles indicate the encoding steps that were discarded.

124 TR periods per scan. Scan parameters are as in [3]. Images were subtracted pairwise for each encoding step, resulting in 61 difference images, one without transverse encoding averaged from the two pairs of non-encoded scans. 3D volume registration of images was done using 3dvolreg in AFNI to correct errors due to motion during the scan. Filtering was then applied as follows to attempt to improve the accuracy of vessel estimation. During the calculation of the correlation coefficients between the data and the theoretical responses during the post-processing of random VEASL data, the contribution of each encoding step to the difference between the data and the best-fit theoretical response was measured. If one or a few of the encoding steps dominates the errors in the fit, they were removed and the data reprocessed. Our criterion for removal of data was when the mean±STD of the difference between data and model, calculated in one encoding step, fell outside [-1.5 1.5], in units of tagging efficiency (**Fig 1**). In addition, the angiographic images above and below the nominal tagging plane were examined for improved correlation with the detected vessel locations.
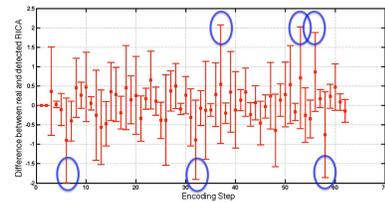
Results:

For two of five subjects, localization of the decoded vascular sources was inaccurate (**Fig 2.A**). In particular, the localization of the right internal carotid artery (RICA) in these subjects was significantly off. After 3D volume registration, the estimation of vessel locations was not significantly improved (**Fig 2.B**). In these two data sets, 6 and 4 encoding steps, respectively, were identified as outliers and removed. After filtering of data, the estimation of vessel location was slightly improved (**Fig 2. C**), as the estimated locations of both the RICA and the basilar artery were more accurate than before.

The incorrect estimation of vessel location may not only relate to the correlation coefficients calculation process. In one subject, a sharp bend of the RICA was present in the plane 5mm inferior to the tagging plane (**Fig 3.A** yellow line). The detected RICA location plotted on this plane (**Fig 3.C** yellow arrow) shows better correlation to the anatomy than in the nominal tagging plane.
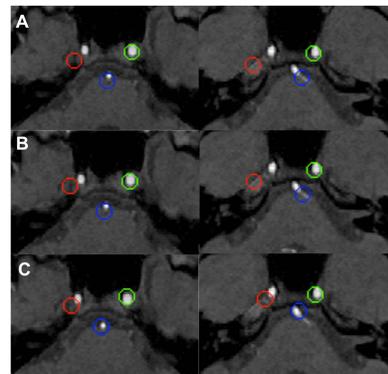
Conclusions:

In our data, motion during the scan did not dominate the errors in the detecting process. The estimation of vessel locations was only slightly improved by selective filtering of data. In some cases, the detected vessel locations correlated closely with the vascular anatomy several millimeters inferior to the nominal tagging plane. The thickness of the slice selective tagging pulses is approximately 6mm, and we postulate that the effective location of the vessel encoding is skewed toward the proximal edge of the tagging slice, though this effect requires further study.
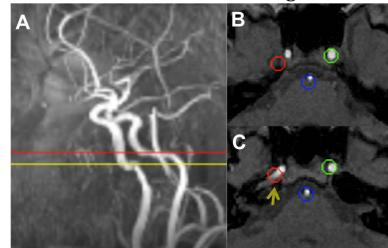

Figure 2. A: Original estimation of vessel locations; B: Estimation of vessel locations after 3D volume registration; C: Estimation of vessel locations after filtering of data;

Figure 3. A: MR Angiogram image of one subject; B: The tagging plane (red line in A) with detected vessel locations. C: The plane 5 mm away from the tagging plane (yellow line in A) with detected vessel locations.

References: [1]Wong, EC, MRM, 58:1086–1091, 2007. [2]Wong, EC, Guo, J, ISMRM p.294, 2011. [3]Wong, EC, Guo, J, MAGMA, 25(2):95-101, 2012.