Comparison of regional perfusion imaging between planning-free vessel-encoded and super-selective pseudo-continuous arterial spin labeling MRI

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Introduction

Vessel-encoded pseudo-continuous arterial spin labeling (ASL) is a regional perfusion imaging (RPI) technique to identify the perfusion territories of arteries (1). Although demonstrated to be reproducible (2), VE p-CASL also has drawbacks, eg. labeling efficiency is varied spatially for all arteries at the same time and voxels are designated to a single perfusion territory afterwards. On the other hand, super-selective p-CASL allows the imaging of a single perfusion territory by simply placing a labeling spot over the artery of interest (3). Consecutive labeling of all arteries allows visualization of distinct perfusion territories including areas supplied by more than one feeding artery. The aim of this study was to compare perfusion territories determined by both vessel-encoded and super-selective p-CASL.

Methods

Fourteen healthy volunteers were investigated on a 3 Tesla MRI scanner (Philips Healthcare). The MR protocol consisted of a sagittal localizer, MRA survey, anatomical T1-weighted imaging, and RPI techniques: one planning-free VE p-CASL sequence and four super-selective p-CASL sequences. For both sequences the parameters were as follows: TR/TE, 4000/14ms; FOV, 240×240mm2; matrix size, 80×80; slices, 17; slice thickness, 7mm; no slice gap; single shot EPI; label duration, 1650ms; post labeling delay, 1525ms; background suppression. VE p-CASL was performed as outlined in previous reports (1,2) with 5 different labeling variations and 15 averages for each variation, resulting in 5min total scan-time. Super-selective p-CASL is also outlined in a previous report (3) using 12 averages with a 100s scan-time per artery. MRA was used to position the labeling spot on the vessel of interest. Post-processing was performed in Matlab (Mathworks, Natick, MA). The flow territories were identified with VE p-CASL by means of k-means clustering (1). The super-selective p-CASL perfusion images of both VAs were combined into one perfusion image to reflect the territory of the BA. For both techniques the boundaries of the right ICA (R-ICA), the left-ICA (L-ICA) and the basilar artery (BA) were manually outlined by one observer (NH). The mean distances as well as mean maximum distance between the boundaries of both techniques for each territory was calculated. For this purpose the distance was calculated of each boundary voxel of one technique to the closest voxel of the other technique and vice versa.

Results

The mean and maximum distances between the perfusion territories for each method are reported in table 1. Figure 1 shows three example cases. The first case (A,B,C) has an interesting configuration of the perfusion territories, caused by a missing pre-communicating segment (B,C besides the star) of the anterior cerebral artery (ACA) and a hypoplastic pre-communicating segment (B,C besides the arrow) of the posterior cerebral artery (PCA). Both techniques correctly identify this, however the super-selective perfusion images show an overlap between the perfusion territories of the L-ICA and the BA (A,B besides the arrow). The second case (D,E,F) demonstrates additional blood flow from the left ICA to the right ACA (D,E besides the arrow), which is not shown on the VE p-CASL RPI map. The third case (G,H,I) also demonstrates combined flow from two arteries (R-ICA and BA) on the super-selective perfusion images (G,H besides the arrow), which is not shown on the VE p-CASL RPI map.

	Right ICA (mm)	Left ICA (mm)	BA (mm)
Mean distance	1.22 ± 1.02	1.33 ± 0.83	1.55 ± 0.68
Mean maximum distance	6.89 ± 4.47	7.67 ± 5.08	8.39 ± 6.46

Table 1. Mean and maximum distances (mm) between the boundaries of the perfusion territories for each artery acquired with plannings-free and super-selective ASL.

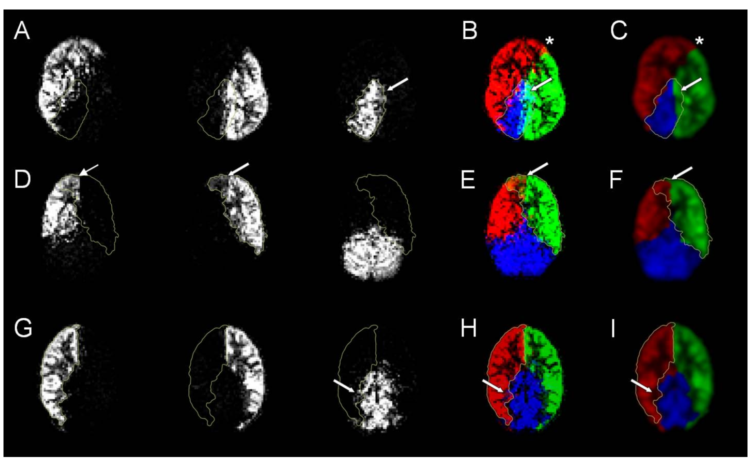

Figure 1. Super-selective perfusion images (A,D,G), the combined super-selective image (B,E,H) and vessel-encoded perfusion territories (C,F,I) of a case with a missing A1 and P1 segment (A,B,C), a case with contribution of the L-ICA to the right ACA (D,E,F) and a case with combined blood flow from the R-ICA and BA to part of the posterior perfusion territory (G,H,I).

Discussion

The results of this study show that perfusion territories of vessel-encoded and super-selective p-CASL RPI agree reasonably well. The reported difference in mean distance between boundaries of both techniques shows that the overall mismatch for each perfusion territory is less than a voxel and in agreement with the reproducibility of VE p-CASL itself (2). The reported difference in mean maximum distance shows there was however some large mismatches encountered such as demonstrated. These larger mismatches also illustrate the incapability of VE p-CASL to detect mixed perfusion when the data is analyzed as currently described (1). Unless VE p-CASL perfusion data is otherwise analyzed (e.g. with a higher cluster count), failing to detect mixed perfusion leads to erroneous flow territories in these areas. Errors in the boundaries of flow territories may also have been caused by the super-selective p-CASL technique, however when accidently labeling an extra vessel with a lower efficiency, a complete extra flow territory would show instead of a well contained and isolated area such as in our examples. Regarding practical use, the total scan-time is comparable between both techniques for investigating the perfusion territories of the major brain feeding arteries. The positioning of the labeling spot in super-selective p-CASL may require more accurate planning, whereas the planning-free VE p-CASL is demonstrated robust (2).

References

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