Mixed cerebral perfusion territories in the posterior circulation investigated using super-selective arterial spin labeling MRI

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Introduction

The posterior circulation is supplied with blood by the vertebral arteries (VA) that fuse into the basilar artery (BA), which subsequently splits up into both posterior cerebral arteries. Previously another research group proposed there was little evidence of mixing of blood in the BA as their results showed separate perfusion territories for both VAs in the cerebellum and cerebrum (1). At the level of the cerebellum this might easily be explained since in almost 80% of the population the posterior inferior cerebellar arteries (PICA) branch from the VA and supply their ipsilateral hemisphere with blood (2). The anterior inferior arteries (AICA) and superior cerebellar arteries (SCA) often branch from the BA (2) and predominantly supply the petrosal and tentorial surface of the cerebellum (2). The observation of separate perfusion territories at the level of the cerebrum could be explained by blood traversing the BA relatively unmixed or, alternatively, it might be argued that it is caused by an artifact of the measurement technique. The observation of limited mixing in the BA was performed by employing vessel-encoded arterial spin labeling (ASL) (1). This method depends on encoding several vessels at once and then calculating perfusion ratios per voxel. Voxels are clustered in one perfusion territory by using a cut-off value (1) or by using more advanced techniques such as k-means clustering (3). It could be argued that both variants of regional perfusion MRI do not accurately reflect mixed perfusion territories, especially not when the amount of mixed blood would vary spatially. Super-selective ASL allows the labeling of blood in one single artery (4) so that the amount of ASL-signal in a voxel is directly attributable to the targeted artery. Super-selective ASL is therefore better suited to identify mixed perfusion. In this study we aim to reproduce or disprove the results of limited mixing in the BA by super-selective labeling of the individual VAs.

Methods

Five healthy volunteers were investigated on a 3 Tesla MRI scanner (Philips Medical Systems). The MR protocol consisted of a sagittal localizer, MR angiography (MRA), anatomical T1-weighted imaging, and two super-selective pseudo-continuous ASL perfusion imaging sequences (4) of which the parameters were: FOV 240x240 mm^2; 17 slices; SENSE 2.5; background suppression pulses at 1680 and 2830 ms; label duration, 1650 ms; post label delay, 1525 ms; TR 825 ms; TE 14 ms. On the MRA both VAs were located and marked separately for super-selective labeling. The labeling spot was placed at the level of the second cervical vertebra. Post-processing was performed in Matlab (Mathworks, Natick, MA). Using the anatomical T1 image, four regions of interest (ROIs) were drawn manually for the left and right hemisphere of the cerebellum and cerebrum.

		Vertebral	Cerebellar hemisphere		Cerebral hemisphere	
Subject	Anatomy	Artery	Ipsi	Contra	Ipsi	Contra
1	Hypoplastic	Left	-	-	-	-
	left VA	Right	53%	47%	87%	13%
2	Normal	Left	74%	26%	76%	24%
		Right	84%	16%	68%	32%
3	Normal	Left	54%	46%	55%	45%
		Right	82%	18%	54%	46%
4	Normal	Left	70%	30%	56%	44%
		Right	88%	12%	54%	46%
5	Normal	Left	60%	40%	64%	36%
		Right	71%	29%	66%	34%

Table 1. Relative contributions of the left and right vertebral arteries in both the ipsilateral and contralateral hemispheres of the cerebellum and cerebrum.

Results

The relative amount of ASL-signal from each VA to either hemisphere of the cerebellum and cerebrum are summarized in table 1. Due to a variant anatomy on MRA in which the posterior circulation was almost exclusively supplied by one VA, subject 1 was excluded from further analysis. The perfusion images of both the left and right VA from subject 5 shown in figure 1. Examination of the perfusion images reveals areas in the cerebellum exclusively supplied by either the left or the right VA (also shown in figure 1). The perfusion images show increasing overlap in the cerebrum. Both for the cerebellum and the cerebrum most of the ASL-signal is observed ipsilateral from the labeled VA, although significant signal is also observed contralaterally, especially in the cerebrum.

Discussion and conclusions

The main finding of this study is that although most ASL-signal in the posterior flow territory originates from the ipsilateral VA, a considerable amount of ASL-signal stems from the contralateral VA, indicating mixing of blood or at least exchange of magnetization between blood streams in the BA. Although mixing in the basilar vasculature does not produce a completely homogeneous blood supply to the cerebral posterior circulation and is in part asymmetrical in the distribution between cerebral hemispheres, it is apparent that in our subjects blood from the vertebral arteries does not arrive at the cerebral posterior circulation unmixed. This disproves the earlier proposition that blood flow through the vertebrobasilar vasculature is unmixed.

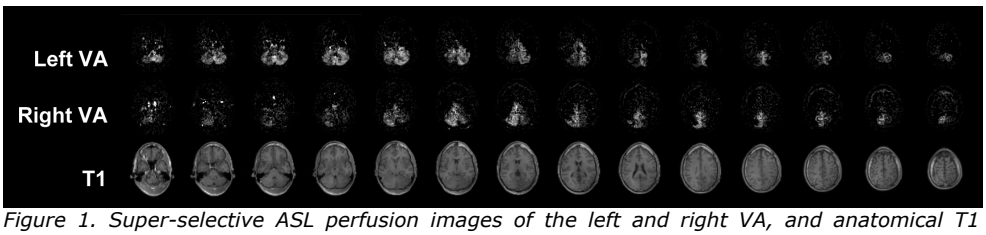

Figure 1. Super-selective ASL perfusion images of the left and right VA, and anatomical T1 weighted images from subject 5. A subtle asymmetrical distribution of ASL-signal between both hemispheres may be seen in the perfusion images, indicating a heterogeneous blood supply to the posterior circulation from both VAs.

References

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