

DISTRIBUTION OF CEREBRAL BLOOD FLOW IN THE NUCLEUS CAUDATUS, NUCLEUS LENTIFORMIS AND THALAMUS: A TERRITORIAL ARTERIAL SPIN LABELING MRI STUDY

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Introduction Anatomical variations of the circle of Willis are known to influence the distribution of cerebral blood flow to cortical brain regions (1-3). The aim of the present study is to investigate the effect of variations in the circle of Willis anatomy on the perfusion territory to the nucleus caudatus, nucleus lentiformis and the thalamus.

Methods The ethics committee of our institution approved the study protocol. A total of 159 patients with clinical symptoms of cerebral ischemia lasting for more than 24 hours and no history of previous cerebro-vascular disease were included in the study. All MRI studies were performed on a 3.0 T Philips Achieva System. For ASL perfusion territory MRI we used the recently developed QUAntitative STAR labeling of Arterial Regions (QUASAR) pulse sequence.(4) Scan parameters: 7 slices; thickness = 8 mm; gap = 1 mm; matrix = 64×64; FOV = 240 mm; $\alpha = 35^\circ$; TR/TE = 4000/23 ms; T11/ Δ TI = 50/390 ms; time points = 10, SENSE = 3; 96 averages (32 for each territory); scan time 6:40 min. The prevalence of perfusion territory contributions was reported for the nucleus caudatus, nucleus lentiformis and thalamus for sides with/without a fetal type posterior communicating artery and sides with/without a hypoplastic or absent A1 segment of the anterior cerebral artery.

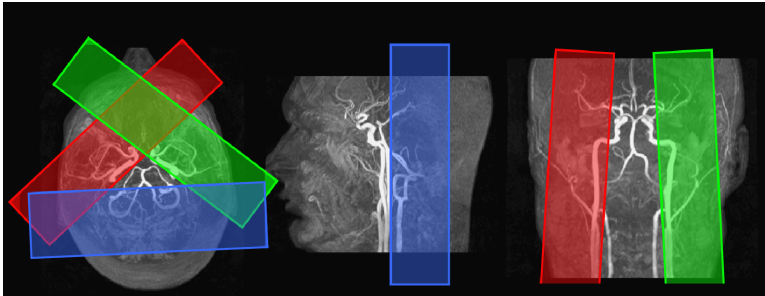


Fig. 1. Positioning of the labeling slab for territory arterial spin labeling using the axial, sagittal and coronal maximum intensity projections of the time-of-flight MR angiography scan. Right internal carotid artery labeling in red, left internal carotid artery labeling in green and posterior circulation labeling in blue.

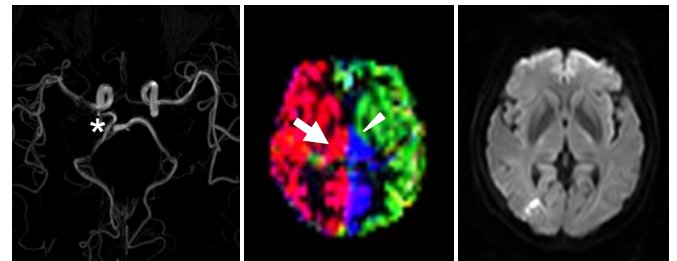


Fig 2. Configuration of the circle of Willis on a time-of-flight MR angiogram (A) shows a fetal type posterior communicating artery on the right side indicated by the asterisk. Perfusion territory image (B) with colors representing the perfusion territory of the right ICA (red), left ICA (green) and the vertebrobasilar arteries (blue). On the right side the posterior cerebral artery perfusion territory is fed from the right ICA, including the right thalamus (arrow). The thalamus on the left side is predominantly fed by the vertebrobasilar arteries with only a small lateral area fed from the left ICA (arrowhead). The last image (C) shows a corresponding diffusion weighted image with a small area of ischemia on the posterior aspect of the right hemisphere.

Results The perfusion territory contributions to the deep brain structures could be evaluated in 119 patients. In patients with a fetal type circle of Willis, there was a contribution from the ipsilateral ICA to the thalamus in all 41 hemispheres (100%), compared to 96 of the 197 hemispheres (49%) without a fetal type circle of Willis ($p < 0.01$). In patients with a hypoplastic A1 segment, there was more often a contribution of the contralateral ICA to the perfusion of the nucleus caudatus and the nucleus lentiformis ($p < 0.05$).

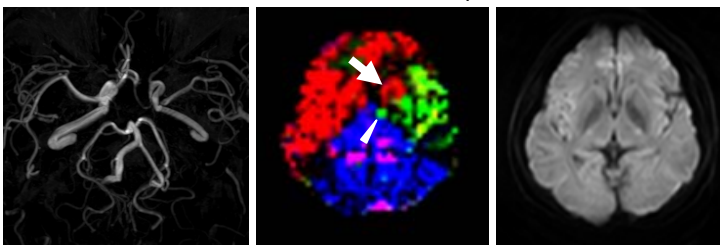


Fig. 3. Configuration of the circle of Willis on a time-of-flight MR angiogram (A) shows a hypoplastic A1 segment of the left anterior cerebral artery indicated by the asterisk. Perfusion territory image (B) with colors representing the perfusion territory of the right ICA (red), left ICA (green) and the vertebrobasilar arteries (blue). The anterior cerebral artery territory on both sides is fed from the right ICA. Furthermore, the head of the nucleus caudatus and part of the nucleus lentiformis on the left side are fed from the right ICA (arrow). A small anterior portion of the left thalamus is fed from the left ICA (arrowhead) while the rest of the thalamus is supplied by the vertebrobasilar arteries. The last image (C) shows a corresponding diffusion weighted image. No focus of acute ischemia is seen.

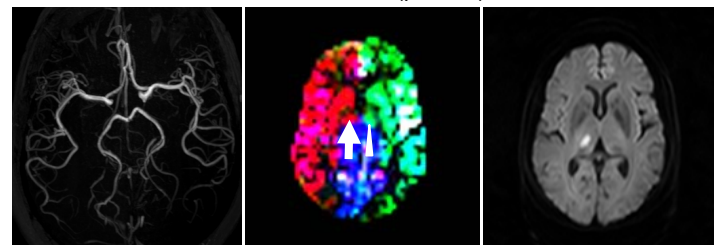


Fig 4. Configuration of the circle of Willis on a time-of-flight MR angiogram (A) shows a non-variant type circle of Willis. Perfusion territory image (B) with colors representing the perfusion territory of the right ICA (red), left ICA (green) and the vertebrobasilar arteries (blue). The anterior aspect of the thalamus on the right side is fed from the right ICA (arrow) while the anterior aspect of the thalamus on the left side is fed from the left ICA (arrowhead). The last image (C) shows a corresponding diffusion weighted image with a small area of ischemia in the right thalamus.

Conclusion A large variation is present in the perfusion territory contributions to the deep brain structures, which can be partly explained by variations in the anatomy of the circle of Willis.

References: 1. Osborn AG. Diagnostic imaging: brain. First edition. 2005 1:4-4 to 1:4-7. 2. Grossman RI, Yousem DM. Neuroradiology: the requisites. 2003, 84-92. 3. Hendrikse, Petersen, Golay. Stroke. 2009;40:1617-22. 4. Petersen ET, Lim T, Golay X. MRM 2006;55:219-32.