Commentary

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Pseudo-asymmetry of cerebral blood flow in arterial spin labeling caused by unilateral fetal-type circle of Willis: Technical limitation or a way to better understanding physiological variations of cerebral perfusion and improving arterial spin labeling acquisition?

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Abstract

In the recently published article, "Unilateral fetal-type circle of Willis anatomy causes right-left asymmetry in cerebral blood flow with pseudo-continuous arterial spin labeling: A limitation of arterial spin labeling-based cerebral blood flow measurements?", it was shown by the method of arterial spin labeling (ASL) that unilateral fetal-type circle of Willis could induce variation of blood flow in cerebellar and posterior cerebral artery territory. We believe that the reported observation, rather than being a limitation, gives several interesting cues for understanding the ASL sequence. In this commentary, we formulate some suggestions regarding the use of ASL in clinical practice, discuss the potential causes of the above-mentioned pseudo-asymmetry and consider future improvements of the ASL technique.

Keywords

Cerebral blood flow, posterior cerebral artery, circle of Willis, artifacts

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Arterial spin labeling (ASL) is a non-invasive, contrast-free magnetic resonance (MR) perfusion method for quantifying cerebral blood flow (CBF). In the last few years, an increasing amount of research has focused on the place of ASL in routine clinical neuroimaging.

In the recently published article entitled "*Unilateral fetal-type circle of Willis anatomy causes right-left asymmetry in cerebral blood flow with pseudo-continuous arterial spin labeling: A limitation of arterial spin labeling-based cerebral blood flow measurements?*", Barkeij Wolf JJ et al.[1] demonstrated, by means of the ASL perfusion method, that unilateral fetal-type circle of Willis in the absence of P1 segment caused the decrease of cerebellar CBF, while in the territory of the ipsilateral posterior cerebral artery (PCA), CBF increased.

We do agree with the described above observations as we also obtained similar results studying ASL perfusion in patients with the above-mentioned anatomical variations, which are found frequently.[2] However, we do not consider these pseudo-asymmetries as a technical limitation of ASL, but believe they can shed

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light on the factors that influence the ASL signal and help to improve the ASL technique.

First, it should be underlined that the ASL perfusion data and their interpretation should be integrated into the whole clinical and imaging picture. It is particularly crucial to compare the ASL results to morphological imaging in order not to misinterpret the pseudo-asymmetry effect as a pathological finding. Unilateral fetal-type PCA can result in ipsilateral pseudo-hyper-perfusion images, which can be mistakenly interpreted as seizure or migraine-like patterns, while contralateral pseudo-hypo-perfusion may be mistaken for transient ischemic attack or precocious acute ischemia. Thus, we believe that ASL perfusion that shows significant abnormalities, especially in the context of acute neurological deficit, should always be analyzed along with the complementary MR angiography sequence. Moreover, ASL CBF map abnormalities should always be compared to the clinical symptoms. Isolated ASL abnormalities that are not supported by any specific clinical or other imaging peculiarities should be interpreted most cautiously in view of the above-mentioned sources of artifacts.

Second, the physiological parameters that influence ASL CBF maps still need better understanding. We agree with the authors in that the ASL CBF asymmetry in unilateral fetal-type circle of Willis is likely to result from not an actual physiological difference in CBF, but rather from the arterial transit time[1] differences and, for this reason, prefer to use the ''pseudo-asymmetry'' term. In dynamic contrast susceptibility-perfusion studies, it has been shown that unilateral fetal-type PCA led to left-right asymmetry due to macro-vascular transit effects[3], while CBF, mean transit time, or cerebral blood volume stay unaffected. In CT perfusion studies, unilateral fetal-origin PCA has also been shown to induce contralateral mean transit time and time-to-peak prolongation without CBF asymmetry.[4] This effect is likely due to higher blood flow velocities and volumes in the internal carotid arteries as compared to vertebral arteries. Thus, although the confounding effects of hemodynamic parameters on ASL signal are not perfectly understood yet, we believe that it is the transit time variations and blood velocities that mainly account for the ASL signal asymmetry.

Finally, in spite of the fact that the described-above findings create certain difficulties in the interpretation of ASL studies, they also give new opportunities for improving the ASL acquisition. Pseudo-continuous arterial spin labeling (pCASL) is considered to be the optimal default implementation of ASL for brain perfusion imaging due to its high label efficiency.[5] However, pCASL is known to be associated with a number of artifacts, in particular, with those induced by arterial transit time variations. It has been shown recently that the method of velocity-selective ASL, in which multiple velocity-selective saturation modules are used, can increase the signal-to-noise ratio and, theoretically, can be insensitive to transit delay effects.[6] In addition, the use of multiple inflow pulsed ASL may resolve some issues concerning the transit time effects since this method has been shown effective in characterizing ischemia by the combination of the arterial arrival time and CBF measurements.[7] Last but not least, vessel-encoded pseudo-continuous ASL may help overcome transit delay effects by improving the CBF accuracy since, in this method, each vascular component is treated separately.[8]

The discussed-above novel techniques will certainly allow better understanding the factors that influence the ASL signal, help to overcome the pseudo-asymmetry aspect in unilateral fetal-type circle of Willis, and increase the ASL reliability and diagnostic value.

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