Presurgical assessment of the feeding vasculature in extra-axial tumors with superselective arterial spin labeling

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Introduction

Many tumors of the central nervous system have uniform feeding vessels. However, certain tumors, in particular large meningiomas, can present a variable vascular architecture, supplying different compartments of the tumor. A detailed knowledge of the feeding vasculature may be helpful for an optimal diagnosis and for an optimized treatment strategy. MR-angiography provides information on the vascular enlargement but without detailed information on the supplied area. Digital subtraction angiography (DSA) can provide this information after selective intra-arterial contrast agent injection. However, the procedure is invasive and it bears the risk of severe complications. Moreover, to visualize all tumor-feeding vessels DSA requires an invasive, selective multi-vessel approach which increases the dosage of ionizing radiation as well as the amount of exogenous contrast agent. Recently, a new method named superselective ASL has been introduced that overcomes these limitations and enables the selective labeling of the smallest intracranial arteries even distal to the Circle of Willis in a complete non-invasive way [1]. In this study, superselective ASL has been used to identify the individual feeding vasculature of meningioma patients in order to differentiate between single and multiple vascular compartmental supply of the tumor which is considered helpful preoperative information by neurosurgeons.

Material and Methods

In 6 patients (all female, age range 44-71) suffering from meningiomas superselective ASL was performed to image the perfusion territories of the major brain feeding arteries, namely both internal carotid arteries (ICAs), the basilar artery (BA) and of the external carotid arteries (ECAs) or their distal branches, respectively.
For all cases, scanning and tagging parameters were as follows: Philips 3T Achieva scanner; field of view 220x220mm, voxel size of 2.7x2.7x6 mm, gradient echo planar read-out. Labeling duration 1.65 s, postlabeling delay 1.525 s with background suppression, 15 slices and 20 averages of label and control images. Scan time was approximately 2:40 min per vessel. The perfusion-weighted images were combined into a color-encoded frame and subsequently compared to contrast-enhanced T1-weighted images.

Results

Superselective ASL has been successfully applied in all six patients. In three patients the measurements revealed a blood supply of the meningioma by the ipsilateral ICA and the ECA and consisted of more than one compartment. In three patients the tumor was exclusively supplied by the ipsilateral ECA or ICA (see table 1).
Figure 1 shows the tagged arteries in time-of-flight images of a 49 year-old patient with a 3-by-5 cm typical convexity meningeoma (right temporal). Three representative slices of the associated perfusion territories and corresponding contrast-enhanced T1 weighted images show that the tumor is exclusively supplied by the medial menigeal artery, a distal branch of the ECA.
Figure 2 demonstrates the labeled arteries of a 69 year-old patient with a 4-by-4 cm atypical meningeal tumor left parieto-occipital and a smaller lesion parietal. The corresponding flow territory maps show that the parieto-occipital location of the tumor consisted of two compartments from which one segment was supplied by intracranial arteries fed by the left ICA (green) and the other segment was supplied exclusively by the ECA (magenta). The superselectively labeled occipital artery did not contribute to the tumor perfusion (but labeled blood that remained intra-arterial could still be seen in the perfusion weighted images (yellow arrows)).

Discussion and Conclusions

At present, patients need a DSA examination to reveal a reliable estimate of the vascular architecture of a tumor. However, for various reasons, this has become an option rather than a prerequisite. Therefore, surgeons are limited to preconceived knowledge of standard vascular supply to a tumor which has to be verified during surgery. Previous studies already showed the potential of ASL measurements for evaluating the vascular supply to a tumor, but suffered from limited selectivity so that they were not able to provide surgically relevant information [2]. In this study, however, it was demonstrated that superselective ASL makes it possible to identify all supplying arteries to a tumor and to define different compartments in a complete non-invasive way. This information can potentially be crucial for the surgeon as a basis for planning the approach, and reacting to intraoperative bleeding. The depiction of feeding arteries may also help to distinguish between intra- and extra-axial tumors since a differentiation on conventional MR imaging alone can be difficult. Furthermore, this information can be used as a basis for decision making in preoperative embolization. This adjuvant therapy can be useful in mitigating blood loss during surgical resection, in particular, if the major suppliant artery can only be reached at a later surgical stage. In addition, superselective ASL makes it possible to differentiate between tumor feeding vessels and en-passent feeders which also supply brain tissues, thereby estimating possible complications from devascularization of the tissues. Further clinical investigation by comparing the results from superselective ASL and DSA is needed to evaluate the results and clarify the usefulness of this application.

Age	Gender	Type / Localization of tumor	Blood-supply of tumor
44	Female	Sphenoid wing M. / right	ICA right + ECA right
49	Female	Convexity M. / right temporal	ECA right
55	Female	Sphenoid wing M. / right	ICA left + ECA left
66	Female	Planum sphenoidale M. / -	ICA right
69	Female	Convexity M. / left parieto-occipital	ICA left + ECA left
71	Female	Sphenoid wing M. (with osseous infiltration) / left	ECA left

Table 1: Summarized results from patient measurements with superselective ASL.

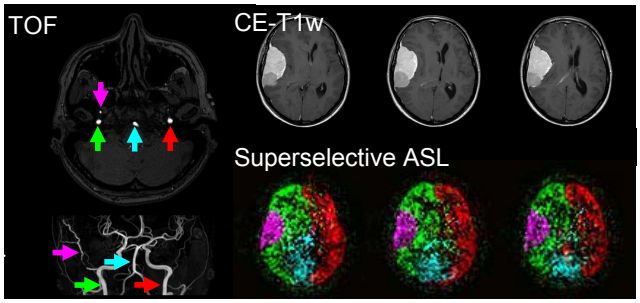

Figure 1: TOF images show the tagged arteries of a 49 yo patient with a meningial tumor. Corresponding flow territory maps revealed an exclusive tumor supply by the ipsilateral ECA (magenta).

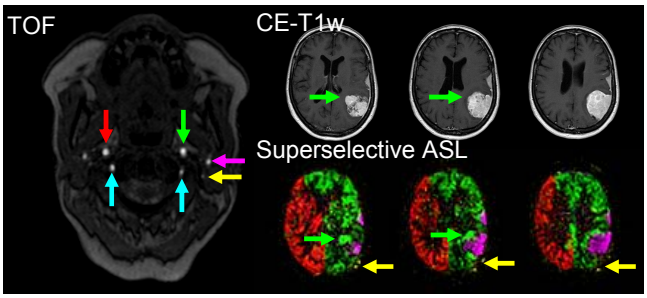

Figure 2: TOF images show the tagged arteries of a 69 yo patient with a meningial tumor. Corresponding flow territory maps revealed two compartments of the tumor in which one segment was supplied by intracranial arteries fed by the ipsilateral ICA (green, arrows) and the other segment was supplied by the ECA (magenta). The separately labeled occipital artery did not contribute to the tumor perfusion, but labeled blood that remained intra-arterial could still be seen (yellow arrows).

References: [1] Helle et al, Magn Reson Med 2010;64:777-786; [2] Sasao et al, AJNR 2010;31:554-558