Intraarterial Perfusion to Monitor Endovascular Procedures in MR

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Introduction

The increased monitoring capabilities of MR give it the potential to displace x-ray for some endovascular procedures.[1] Intraarterial (IA) thrombolysis for ischemic stroke may benefit from the increased monitoring capability of MR. Real-time, MR catheter guiding systems are being developed and tested, including successful real-time catheter visualization in the carotid arteries of canines.[2] Here, we propose a *monitoring* strategy based on local perfusion maps using selective IA contrast agent injections. Local perfusion maps may monitor local perfusion changes such that reperfusion can be easily, accurately and quickly detected and the thrombolytic dose minimized and tailored to individuals. Here, we monitor the progression of ischemia using MR perfusion-weighted imaging with local (internal carotid artery, ICA) and systemic (left ventricle, LV) contrast agent injections. (LV contrast agent injections are conceptually the same as intravenous injections.)

Methods

Using x-ray guidance, catheters were placed in the LV and the ICA (randomized to right or left) of 6 dogs. The dog was then moved to the MR suite. Stroke was induced by injecting autologous clot into the ICA as previously described.[3] T2*-weighted single-shot gradient-echo echo-planar acquisitions (final parameters: TR/TE/flip = 1500 ms/24 ms/30°, 144 × 144 acquisition matrix, 24 cm field of view) were preformed serially for IA and LV injections of contrast agent, pre-stroke and post-stroke. The contrast agent (Magnevist Gd-DTPA, Berlex, Wayne, NJ) was diluted with saline to compensate for the local administration giving 1:1 ratio for the LV and 1:4 ratio for the IA injection.[4] Cerebral blood flow (CBF) maps for the LV contrast agent injections (LV-CBF maps) were constructed (using PerfTool[5]) by selecting an arterial input function (AIF) on the middle cerebral artery. IA-CBF maps were generated using a box function with a duration of 5 s for the AIF to approximate the local IA injection characteristics (*i.e.,* no cardiovascular dispersion).

Results

The semi-quantitative IA-CBF maps, as performed here, are reliable and objective. The IA- and LV-CBF maps contain similar information (examples from 2 dogs in Figs 1 and 2); although, there are differences between these two maps. Three perfusion patterns are apparent after stroke on the IA-CBF maps: (a) reduced perfusion (Fig 1), (b) no perfusion (Fig 2), and (c) contrast agent reflux (*i.e.,* contrast agent being shunted to other vascular territories) (Fig 2). A combination of these patterns can occur in different regions of the same dog (Fig 2); however, they are not always obvious on the LV-CBF maps.

Discussion

Stroke progression was monitored using IA- and LV-CBF maps. The IA-CBF maps were sensitive to perfusion changes that occur with stroke, as there were specific characteristics seen on the IA-CBF maps that were not obvious on the LV-CBF maps. For example, the post-stroke IA-CBF map in Fig 1 shows contrast agent can access the anterior left hemisphere, but this is not obvious on the LV-CBF map. This implies that the ischemia is due to a partial occlusion or there is collateral flow, which is important for therapy decisions. IA-CBF maps are comparable to the local injections of contrast agent performed during x-ray road-mapping; however, the IA-CBF maps are depicting local perfusion, so are more comparable to the x-ray blush not the bulk flow. Three altered perfusion patterns were seen on IA-CBF maps. With incomplete occlusions and/or collateral flow, reductions in CBF occur. Reflux occurs as a result of an obstruction causing an increase in vascular resistance so the contrast agent cannot pass and it refluxes to other vascular territories. More severely, no perfusion resulted when cerebral tissue could not accommodate the contrast agent in any region. When interpreting the IA-CBF maps, it is important to consider the local physiology and pathology that alters the resistance and compliance of cerebral tissue, which in turn affects perfusion. Additionally, the IA-CBF maps lack the contralateral control. The IA-CBF maps may be useful for monitoring thrombolysis, as tissue perfusion can be monitored in addition to arterial blood flow. As shown here, the development of monitoring techniques such as local perfusion maps shows that MR has the potential to improve endovascular procedures.

References

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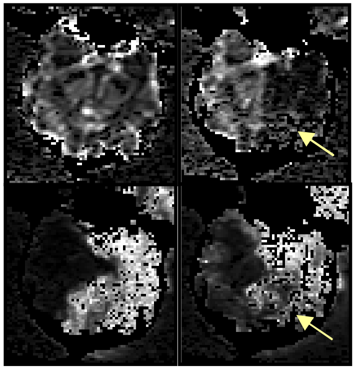

Fig 1. LV-CBF maps (top) and IA-CBF maps (bottom) before (left) and after (right) stroke. There is reduced perfusion in the posterior portion of the brain on both LV-CBF and IA-CBF maps (arrows).

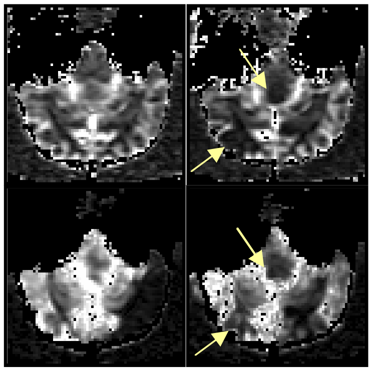

Fig 2. LV-CBF maps (top) and IA-CBF maps (bottom) before (left) and after (right) stroke. Reflux to the contralateral hemisphere is seen on the IA-CBF maps and areas of no perfusion (arrows) are apparent after stroke on both the IA- and the LV-CBF maps.