Temporal MRI Contrast Agent Enhancement Patterns Differ Between Bolus and Step-Down Infusion Arterial Input: A Possible Indicator of Edema Formation?

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Background and Purpose: The development of edema following ischemic stroke and reperfusion is a critical factor in determining the severity of cerebral injury and predicting outcome. One potential method for assessing post-stroke edema formation is to use magnetic resonance imaging (MRI) to track the interaction of water molecules with a leaking MR contrast agent (MRCA). As the injury evolves, the blood-brain barrier often becomes damaged allowing the contrast agent to leak out of the vessels and interact with extravascular water molecules. For this study we compare the contrast enhancement patterns for a step-down infusion input versus a standard bolus.

Methods: Male Wistar rats (~300 g) were subjected to 3 h of suture occlusion of the middle cerebral artery followed by reperfusion via suture withdrawal. Groups of rats were studied following either a bolus injection (n=8) or step-down infusion (n=6) of MRCA. The MRCA was administered ~2.5 h post-reperfusion by either a step-down infusion[1] protocol, that rapidly increases the blood MRCA concentration to a elevated level and then maintains it at a relatively constant level for 20 minutes, or a bolus injection. Temporal measurements of the enhancing area were obtained at ~2.5 minute intervals using a Look-Locker (LL) sequence to produce T1-weighted images (T1WI). The enhancing areas were selected and measured by thresholding the image intensity of the post-contrast LL T1WI's to > 2 std. dev. of the pre-MRCA image. The number of enhancing pixels in each rat at each time point was normalized to the largest area measured and the results were averaged and are presented as mean ± std. dev. for both groups.

Results: The two input functions produced similar initial relative changes in area, indicating that a central source of increased pressure was forcing fluid outward, and presumably carrying MRCA with it. Whereas the enhancing region for the bolus input increased initially and then decreased over time, the area of the enhancing region for the step-down infusion increased for the first 15-20 minutes before reaching a relatively steady state (see Figure). These different temporal MRCA enhancement patterns were probably due to the continuing input of MRCA in the constant infusion experiment.

Conclusions: In conclusion, these observations indicate that the step-down input may provide a more accurate representation of the MRCA enhancing area (edema) than a standard bolus input. Thus, contrast enhanced MRI may be able to provide a useful method to assess the edema load in stroke.

References: 1. Nagaraja et al. Magn Reson Imaging. 2007;25(3):311-8.