Continuous Monitoring of Stroke Evolution Using Intraarterially Injected PWI in an Animal Model

L. Feng[1], R. Oklu[1], E. Lin[1], G. Gupta[1], S. Dashnaw[1], M. Baytion[1], T. Kim[1], R. DeLaPaz[1], J. Pile-Spellman[1]

[1]Radiology, Columbia University, New York, NY, United States

Introduction

Stroke is one of the leading causes of death and disability in the United States. Thrombolysis is the only effective therapy for acute ischemic stroke that has been validated by randomized clinical trials. PWI and DWI have been used to identify the ischemic penumbra that can be salvaged with thrombolytic therapy. Continuous monitoring of stroke evolution will offer tremendous advantages to acute stroke therapy, particularly by improving the efficacy and reducing the hemorrhagic risk for intra-arterial thrombolysis. Although DWI can be repeated over time easily, PWI using intravenous contrast injection cannot be reproduced more than once within 24 hours, due to contrast dose limitations and the presence of high background from previous contrast injections. However, with an arterial catheter already in place during intra-arterial thrombolysis, we hypothesize that PWI can be repeated in a short period of time with small boluses of intra-arterial contrast injection to allow continuous monitoring of tissue perfusion.

Materials and methods

Pigtail catheters were placed into the ascending aorta in four pigs under real-time MRI guidance. The catheter position was confirmed with IA contrast enhanced MRA (Figure 1). Following IV PWI with 0.3 mmol/kg Gd DTPA at 10 ml/s injection into a femoral vein, IA PWI was carried out with injection of 0.02 to 0.15 mmol/kg Gd DTPA at 0.5 to 8 ml/s. CBF and CBV were measured with GE Functool 2. IA PWI values were compared to the IV baseline values. To validate its ability to detect infarction and the ischemic penumbra, IA PWI was performed in a hemispheric ischemic stroke model.

Results

Reproducible CBF measurements can be obtained every 15 minutes using 0.04 to 0.15 mmol/kg at 2 to 4 ml/s injection rates (Figure 2). The cortical CBF values show no significant differences between IA and IV injections (195 ± 11 vs. 189 ± 20). Similar grey to white matter ratios were observed (1.73 ± 0.17 IA vs 1.46 ± 0.30 IV). The CBV values decreased over time as the baseline contrast concentration increased. IA PWI identifies ischemic regions in the hemispheric stroke model. Regions with over 50% CBF reduction developed permanent infarction, whereas regions with better perfusion values recovered after reperfusion (Figure 3).

Conclusion

PWI can be reproduced reliably with repeated IA injections of small contrast boluses. Our study demonstrates that continuous monitoring of stroke evolution can be performed with PWI during intra-arterial thrombolysis.

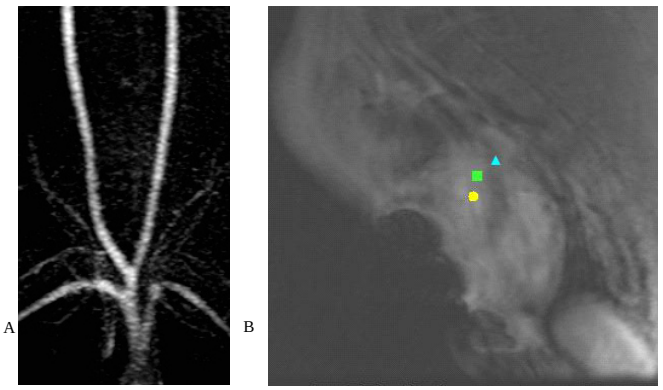


Figure 1. A) Coronal view IA contrast Enhanced MRA. B) Active Tracking Catheter in the ascending aorta on a sagittal oblique gradient echo roadmap.

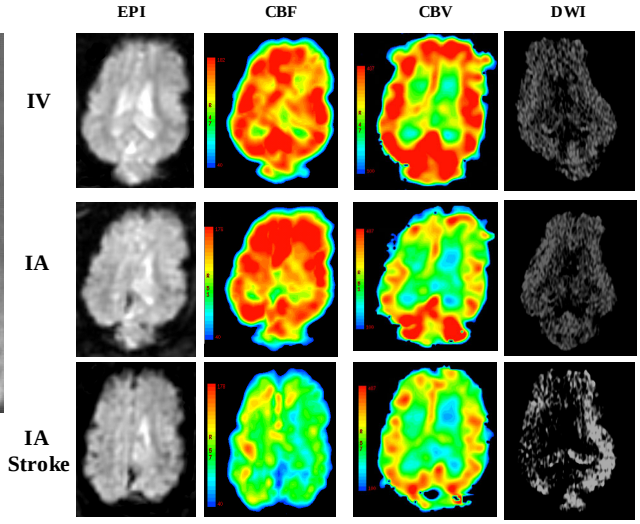
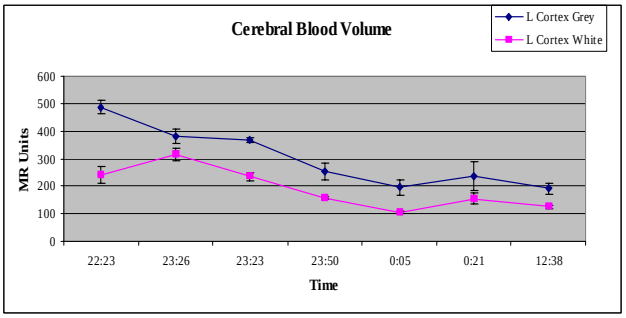
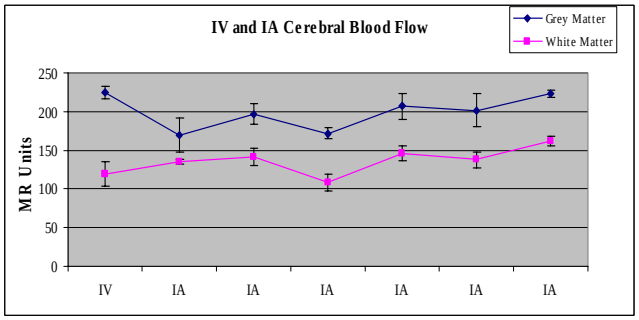


Figure 2. Representative EPI, CBF map, CBV map, and DWI images from IV, IA, and IA perfusion in a pig stroke model. CBF and CBV maps were obtained after processing with the GE Functool 2.

Figure 3.



Volume (mL)	15	3	4	3	2	4	3
Rate (mL/sec)	10	2	2.5	2	2	2	3



Volume (mL)	15	2	3	3	3	4	4
Rate (mL/sec)	10	2	2	2	3	2	2.5