Development of a Perfusion System for MR Microscopy of Small Samples

Flint, J.J. (UF, Neuroscience); Mennon, K. (UF, Biomedical Engineering); Hansen, B. (Aarhus, Denmark); Forder, J. (UF, Radiology) and Blackband, S.J. (UF, Neuroscience, NHMFL)

Introduction
Recent studies demonstrated the feasibility of imaging mammalian neural tissue at cellular resolutions using new microsurface rf coils (1). Our long-term goal is to image similar tissue while live, using a controlled perfusion system, so that tissue can be studied in its native state and undergoing a variety of perturbations to simulate disease processes. These data can then be used to make working models of tissues and provide a better understanding of clinical MRI. Attempts to use existing perfusion systems external to the magnet bore, used for perfused organs and cell chambers, failed. The flow rate to the tiny perfusion chamber is so slow that perfusate regulation (O₂ concentration, temperature and pH) could not be adequately controlled, even using special tubing designed to minimize O₂ loss. Here we describe a new perfusion system that overcomes these limitations.

Experimental
The solution to the problem was to construct a miniaturized perfusion system that fit inside the magnet bore, thus minimizing the distance from O₂ infusion to the sample chamber. Fig.1a,b,c shows three views of the microcoil holder and sample chamber (black arrows in Fig.1b). Fig.1d shows the oxygenator consisting of oxygen permeable tubing wrapped around the perfusion tube. The perfusate exits from the bottom of the oxygenator and enters the perfusion chamber cover that goes over the microcoil. Experiments were conducted on isolated rat brain tissue using the 600MHz microimaging system in AMRIS at UF.

Results and Discussion
Fig.2. shows a time course measurement of the MR signal in diffusion weighted images over 15 hours. The non-perfused cortex clearly demonstrates a large signal change indicating tissue instability. However perfused tissue, similar to fixed tissue, showed a constant and stable MR signal indicating tissue stability.

Conclusions
These data demonstrate that stable tissue perfusion is achieved for 12 hours or more for MR microscopy on small live samples. These data have recently been published (2).

Acknowledgements
Funded by the NIH (1R01EB012874) and an NHMFL UGCP award, and performed at the NHMFL, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490 and the State of Florida.

References