Evolution of Cerebral Hemodynamics with Migraine Onset and Progression

Hannah Alderson, Nastaren Abad, MS & Samuel C. Grant, PhD

Introduction

Migraine

- Recurrent disabling neurological disorder
- Afflicting more than 38 million people in the USA
- Fundamental understanding of the physiology behind migraine is lacking

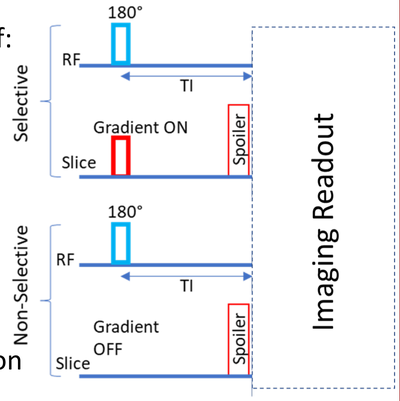
Arterial Spin Labeling (ASL) at 21.1 T

- Noninvasive MRI used to measure quantitatively tissue perfusion by magnetically tagging blood
- Pulsed ASL variant employing flow alternating inversion recovery (FAIR) with EPI readout
  ⇨High signal-to-noise ratio & fast acquisition

Methods

- 8 animal subjects – Sprague-Dawley rats
  - N=5 – injected with nitroglycerin (NTG)
  - N=3 – injected with saline
  - All anesthetized & loaded into 21.1-T magnet

FAIR EPI consists of:



1. M_0 image with a FISP readout
2. ASL FISP with non-selective, global inversion
3. ASL FISP with selective inversion

For all three protocols, the readout parameters were identical. T_1 maps of each slice were acquired using 8 TIs (0.1-1 s).

- Baseline ASL acquired for 30 min – ***Pre-injection***
- ASL acquired for up to 2 h – ***Post injection***
- Cerebral blood flow (CBF) using a custom Matlab® script calculated by[1]:

$$\mathrm{CBF} = \frac{\Delta M \lambda \left(\frac{1}{T_{1blood}} - \frac{1}{T_{1app}}\right)}{2M_o \left(e^{\frac{-TI}{T_{1app}}} - e^{\frac{-TI}{T_{1blood}}}\right)}$$

ΔM – *change in magnetization*
M_o – *tissue magnetization*
λ – *blood-tissue water partition coefficient*
CBF – *blood flow*
TI – *inversion time*
T_{1app} – *flow dependent tissue relaxation time*
T_{1blood} – *blood relaxation time*

Acknowledgements

Funding provided by the:

- NIH (2R01NS072497-06A1)
- NSF and National High Magnetic Field Laboratory (DMR-1644779)
- Maglab REU program

[1] Kwong, K. K., et al. "MR Perfusion Studies with T1-Weighted Echo Planar Imaging." *Magn Reson Med*, 34(6): 878–887, 1995.

Aberrant cerebral perfusion does not cause **acute migraine** but potentially results as a **response** to enhanced neural excitability

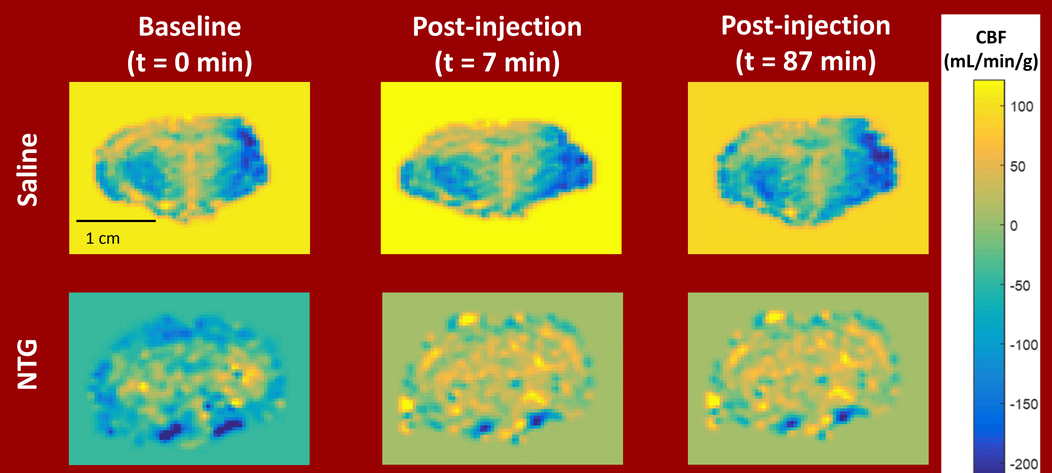


Figure 1 – *in vivo* CBF maps prior to and following injection

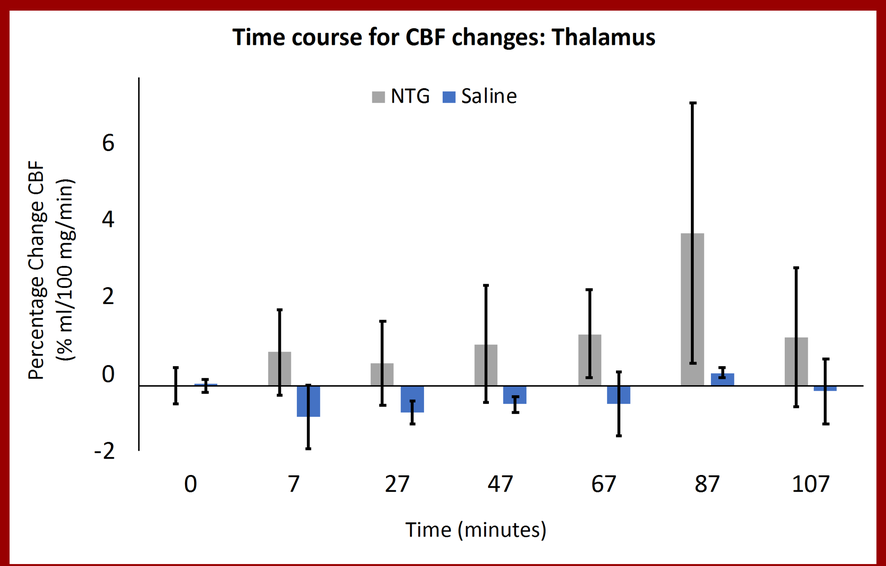


Figure 2 – Percent CBF change in the thalamus over the time course

Results

Calculations

- Left and right lobes of the thalamus were measured separately
  - ✓ These values were averaged to give an overall value for the whole thalamus
  - ✓ The averaged values were normalized to baseline for each subject
- CBF values for each time point were averaged across all subjects
- Percent change (mean ± SD) was calculated in reference to mean baseline

Trends

- There is a slight discrepancy between left & right lobes of the thalamus
  - Evident for both NTG and saline subjects
  - Displayed in Figures 3 & 4

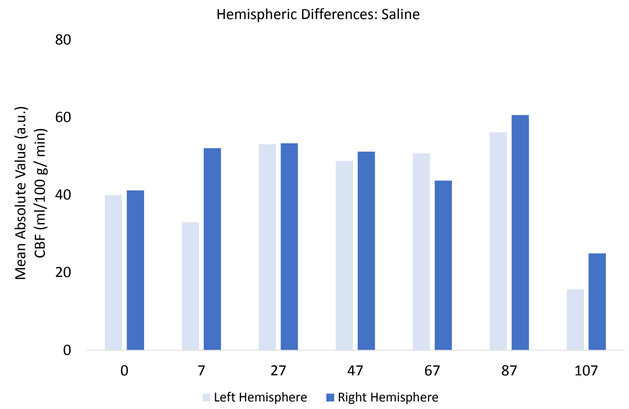


Figure 3 – *in vivo* mean absolute CBF values in Saline cohorts demonstrating hemispheric differences

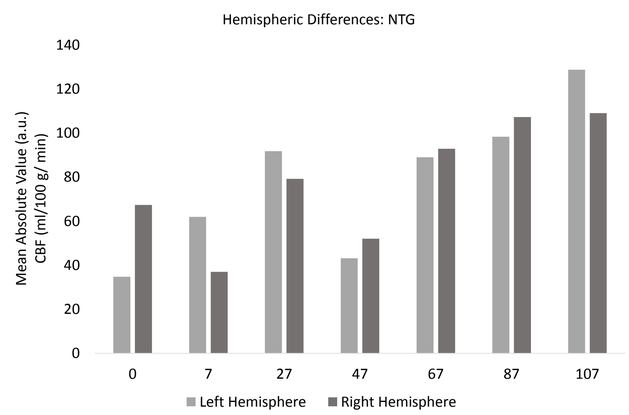


Figure 4 – *in vivo* mean absolute CBF values in NTG cohorts demonstrating hemispheric differences

Discussion

- Figures 1 and 2 show the CBF maps & associated time course for migraine onset and progression
  - ✓ *Control data* – no significance in terms of perfusion or anesthesia impacts
  - ✓ *Migraine data* – increasing trend towards significance around 1.5 h post-injection
    - ➢ Return to baseline > 1.5 h post-injection

⇨ No recruitment of capillary perfusion preceding behavioral migraine onset (45 min post-injection)

Future work

- Expand to include more subjects
- Explore other regions of the brain
- Evaluate the impact of migraine drugs on CBF

FAMU-FSU College of Engineering
Chemical & Biomedical Engineering