Brain Magnetic Resonance Imaging
CO₂ Stress Testing
in Adolescent Post-Concussion Syndrome

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MRI Stress Testing Potential

- Can be quantified by voxel counts
- Comparisons between and within subjects by warping into MNI space
- Repeatable with Model-based Prospective End-Tidal Targeting (MPET) technology for gas control
- Permits longitudinal assessment
- Hard to ‘sandbag’ if test completed
- Comparison between centres with established atlases
- If established - a potential means to determine ‘return-to-play’
RespirAct™ Breathing Sequence
SPM Preprocessing and Analysis

Image time-series → Spatial filter → Design matrix → Statistical Parametric Map

- Realignment
- Normalisation
- Anatomical reference
- Parameter estimates
- Statistical Inference

General Linear Model → t-test

p < 0.001
2\textsuperscript{nd} Level Comparisons to Control Atlas $p = 0.005$

A

PCSS=0
>\text{Voxels}=0
<\text{Voxels}=0

B

PCSS=73
>\text{Voxels}=349
<\text{Voxels}=868

C

PCSS=42
>\text{Voxels}=6109
<\text{Voxels}=134
BOLD 2nd Level at p = 0.001 ROC Curve

A
Voxel Counts > Control Group

B
Voxel Counts < Control Group
Control subject vs Atlas – 18 months apart
PCS Patient – Before and After Exercise Test
Conclusions

• MRI CVR provides usable biomarkers to indicate altered brain CV physiology in PCS patients
• Potential for diagnosis with the acute syndrome and aid in prognosis
• Repeatability permits longitudinal assessment
• No reason to assume same approach cannot be used to assess TBI patients – potentially across the full spectrum of condition
Acknowledgements

- Kleysen Institute for Advanced Medicine
- Pan Am Concussion Clinic
- Mike Ellis, Lawrence Ryner, Marco Essig, Paul Barrette, Ruth Graham, Jeff Leiter, Vincent Wourms, Dean Cordingley, Kelly Russell
- Subjects
- Department of Anesthesia, Research Office, Dean’s Office
- Most importantly our patients
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Limitations

- Cost and Availability
- MRI contra-indications
- Available expertise to utilize MPET technology
- Need to establish atlas of control subjects
Blood oxygen level-dependent (BOLD) MRI signal

Deoxyhemoglobin is paramagnetic

Oxyhemoglobin is diamagnetic

Assuming constant $O_2$ extraction by tissues, BOLD signal varies with CBF
**BOLD imaging Influences**

**Influences on BOLD signal output**

*neuronal activation not a requirement for CO₂ stress testing*