Noninvasively Monitoring of Cerebral Blood Flow in Piglet Models of Graded Hemorrhage and Hypoxic Ischemic Brain Injury using Diffuse Correlation Spectroscopy and Near-Infrared Spectroscopy

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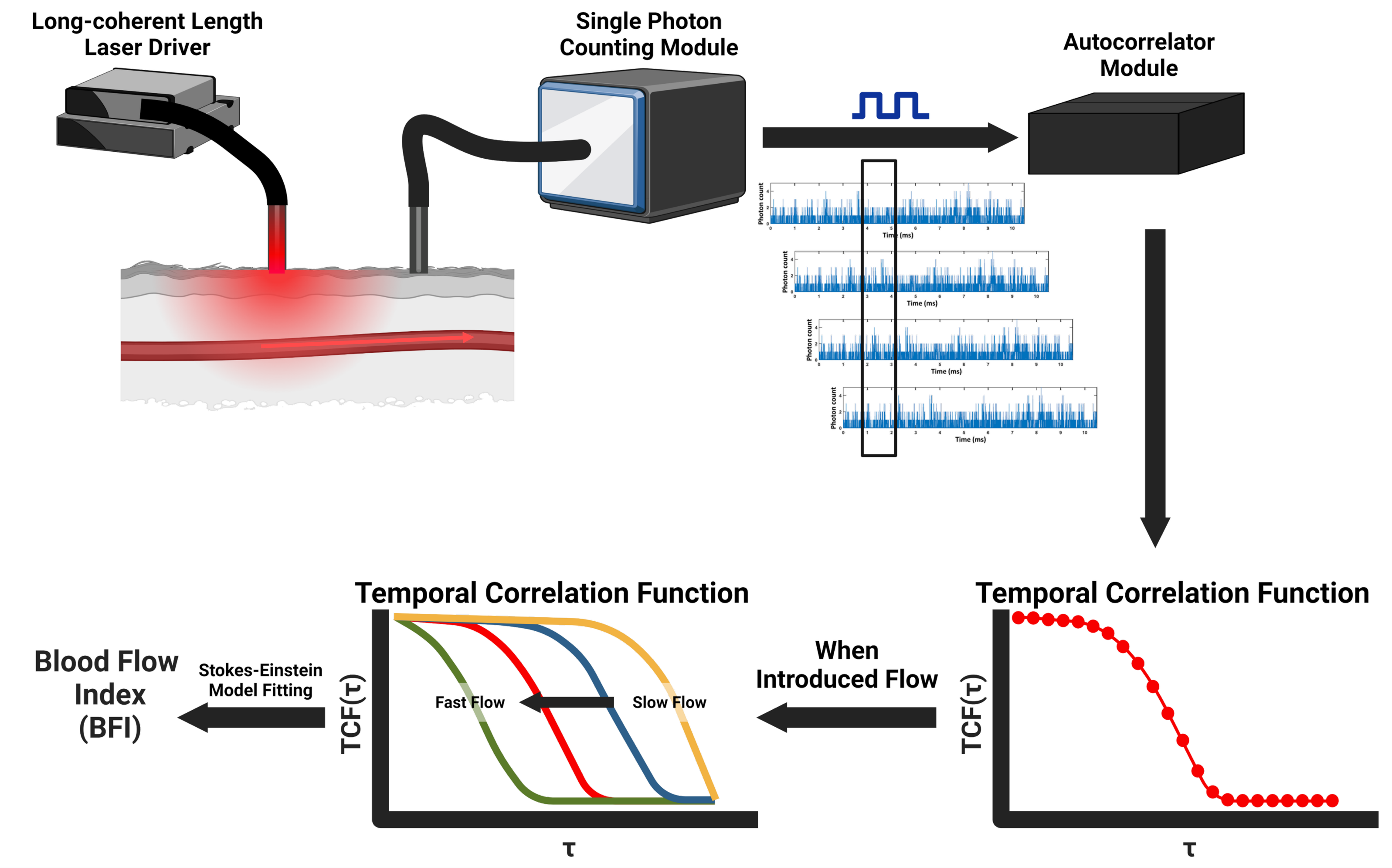
Introduction

- **Hypoxic-ischemic brain injury** and **hemorrhagic shock** are two conditions which negatively impact cerebral hemodynamics by reducing systemic blood pressure and blood oxygenation [1].
- Diffuse Correlation Spectroscopy (DCS) and Near-Infrared Spectroscopy (NIRS) **noninvasively measure cerebral blood flow (CBF)** and **cerebral blood volume (CBV)** of the local cerebral microvasculature, respectively [2, 3].

Methods: Optical Imaging Modalities

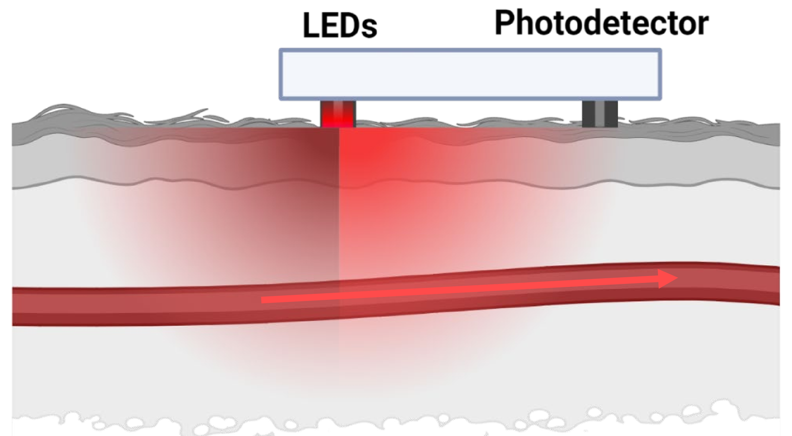
- **Diffuse Correlation Spectroscopy (DCS)** produces a **cerebral blood flow index (BFI)** by fitting a correlation diffusion model to decaying temporal autocorrelation functions generated from light scattered by moving red blood cells.

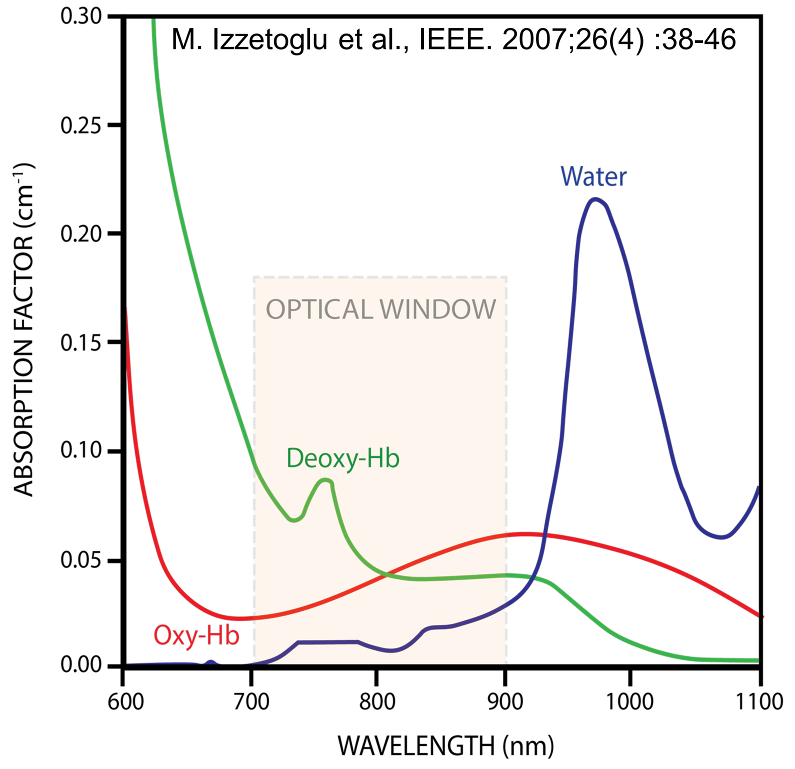


- **Near Infrared Spectroscopy (NIRS)** quantifies chromophore concentrations (**HbO, HbR**) from the attenuated light.

[Total Local Cerebral blood volume] =

[CBV] = [HbO] + [HbR]

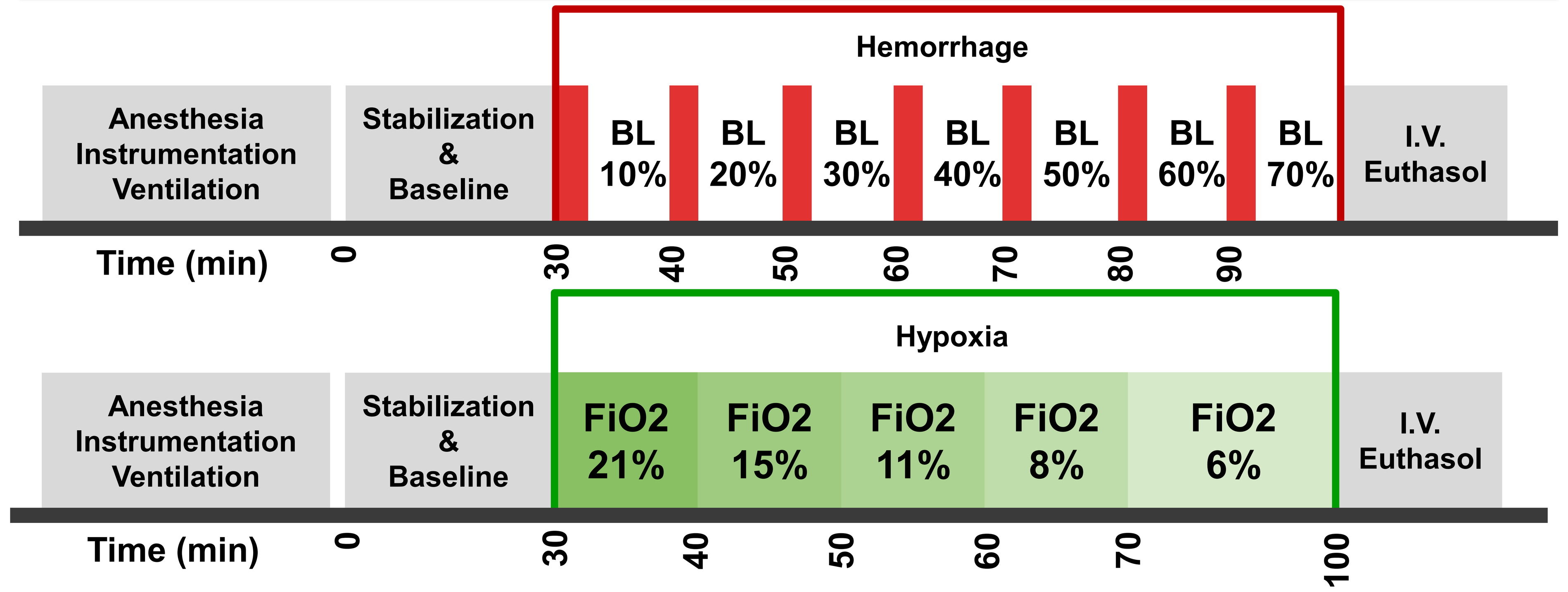


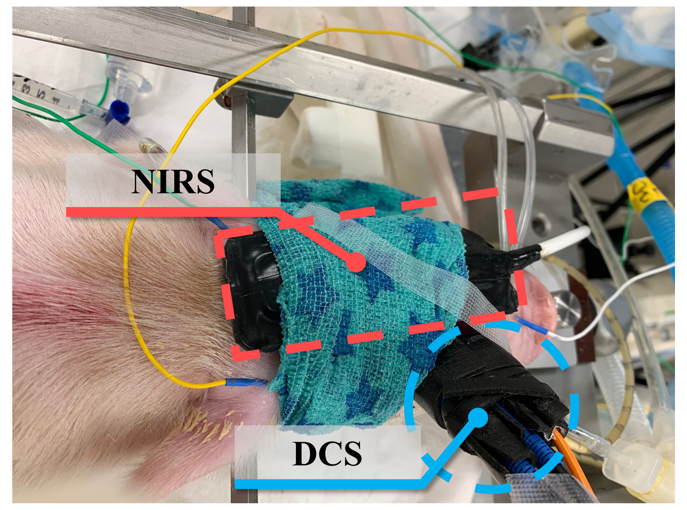


Objective

- **Detect changes in cerebral blood flow, blood volume and blood oxygenation via DCS and NIRS** during **hemorrhagic shock** and **hypoxia-induced brain injury.**

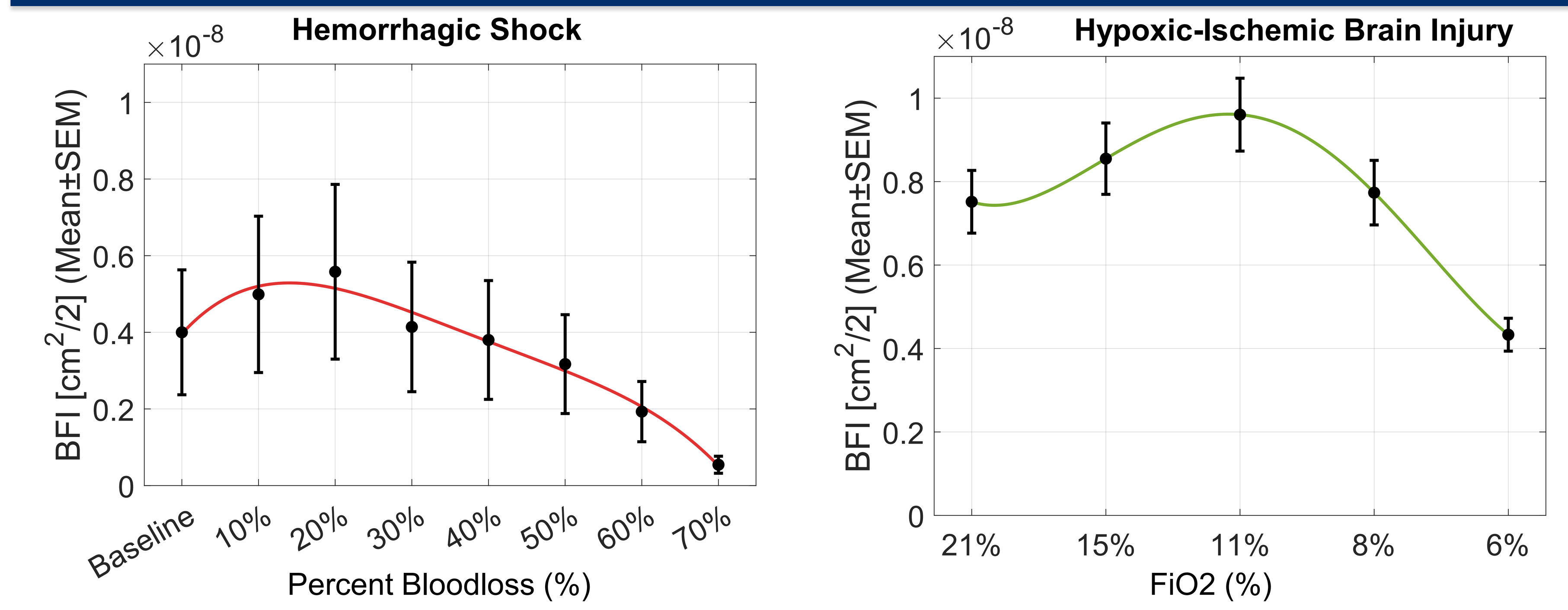
Methods: Experimental Protocol





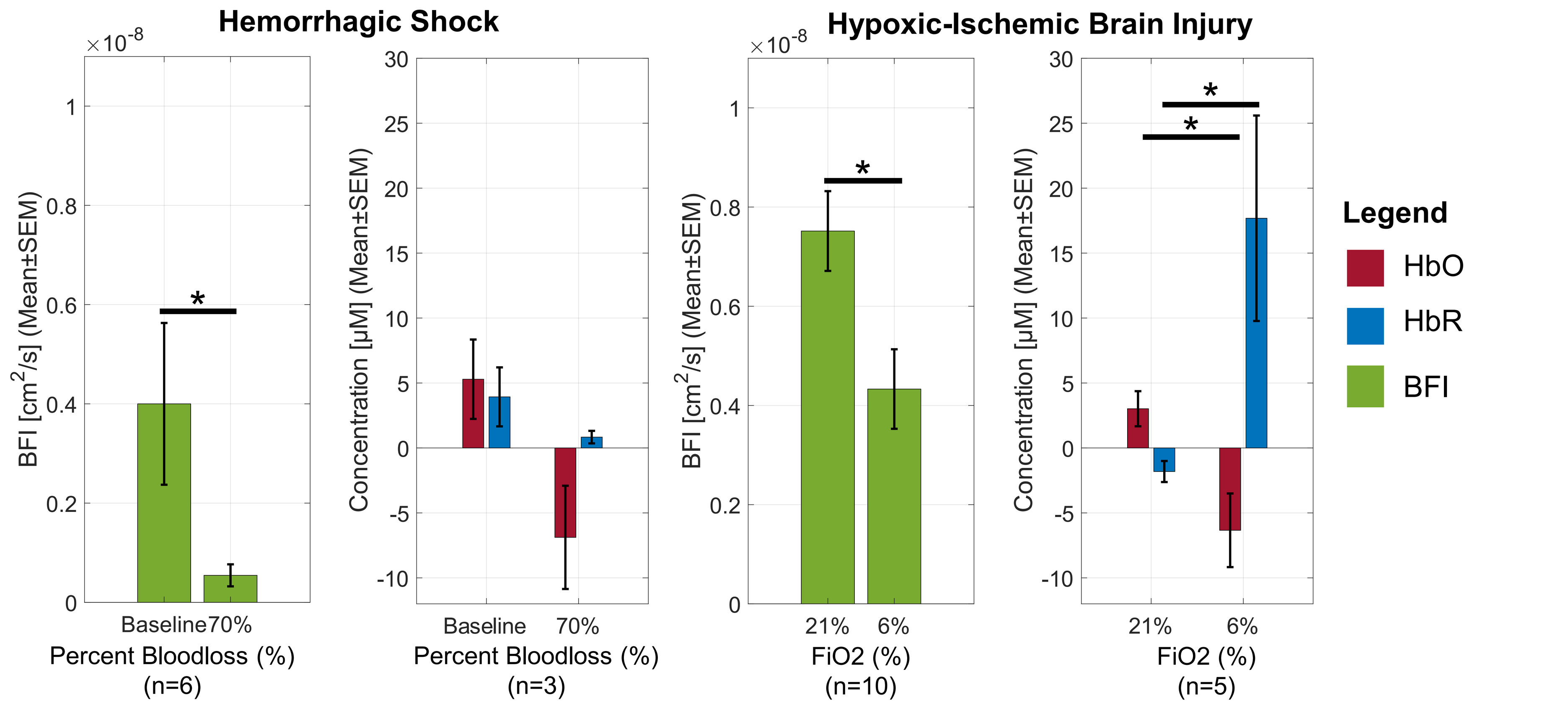
- Anesthesia induction with **isoflurane** and intramuscular **ketamine**, ventilation with balanced mixture of oxygen and **nitrous oxide**, administered inhalational agent **isoflurane**, and maintenance doses of intravenous **ketamine**.
- Injury protocols: controlled blood loss **(BL)** and graded fraction of inspired oxygen **(FiO2)**
- Animal procedures in accordance with protocols approved by the IACUC at Drexel University.

Results: BFI between Injury Models



- BFI changed during controlled blood loss (n=6) and reduction in FiO2 (n=11).

Results: No-Shock vs. Shock



- ***p<0.05**, Paired Two-Tailed t-test, α=0.05
- DCS-derived BFI **decreased between no-shock** and **shock** (baseline and 70% blood loss and 21% and 6% FiO2) conditions.
- Local total blood volume (HbO+HbR) decreased at 70% blood loss.
- HbO decreased, whereas HbR increased between 21% and 6% FiO2.

Discussion & Conclusion

- These studies demonstrate that **DCS** and **NIRS** can be used to monitor cerebral hemodynamics and to detector both hemorrhagic and hypoxic shock in-vivo.
- Integrating DCS and NIRS optical brain imaging modalities could provide a point-of-care, non-invasive cerebral monitoring and clinical triaging tool for patients with life threatening injuries, such as hemorrhagic shock or hypoxic-ischemic brain injury.

References

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