Cerebral Blood Flow Measured by Diffuse Correlation Spectroscopy for Monitoring Depth of Anesthesia in Piglets

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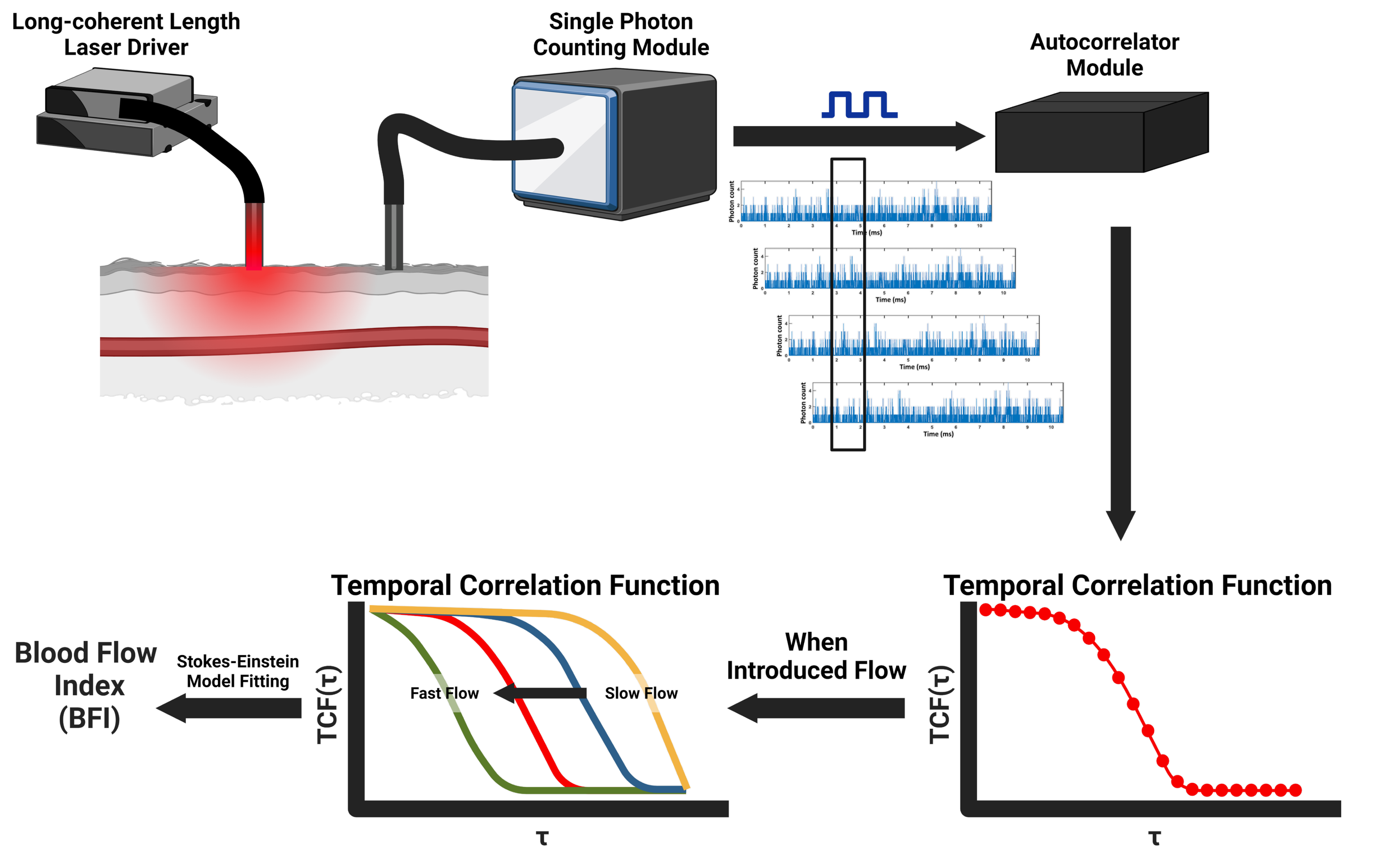
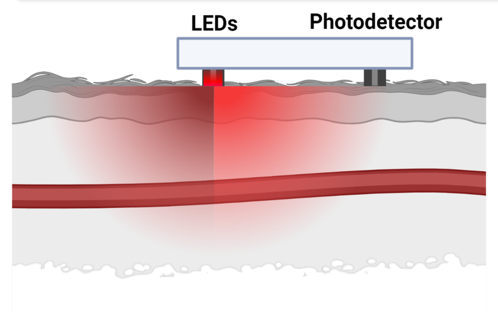
Introduction

- Monitoring depth of anesthesia during surgery is critical with **risks of under-dose and over-sedation** as well as **unintended emergence**.
- **Cerebral blood volume (CBV)** and **cerebral blood flow (CBF)** are **associated with changes in anesthesia states** [1].
- **Diffuse Correlation Spectroscopy (DCS)** is an optical **cerebral blood flow (CBF)** measurement technique [2].

Methods: Optical Imaging Modalities

- **Diffuse Correlation Spectroscopy (DCS)** quantifies **cerebral blood flow** by analyzing temporal fluctuations in backscattered photons from the tissue.
  - Near-infrared light is delivered to tissue via a continuous **785 nm** wavelength **laser**.
  - Intensities of **scattered light**, caused by the tissue (static scatter) and red blood cells (dynamic scatter), are collected by a photon counter.
  - Temporal intensity fluctuations are analyzed using **autocorrelation**
  - **Blood Flow Index** (**BFI**) is a relative biomarker that is calculated by fitting on a correlation diffusion model.





- **Near Infrared Spectroscopy (NIRS)** reports chromophore concentrations (HbO, HbR) by processing absorption.

  *[Cerebral blood volume (**CBV**)] = [**HbO**] + [**HbR**]*

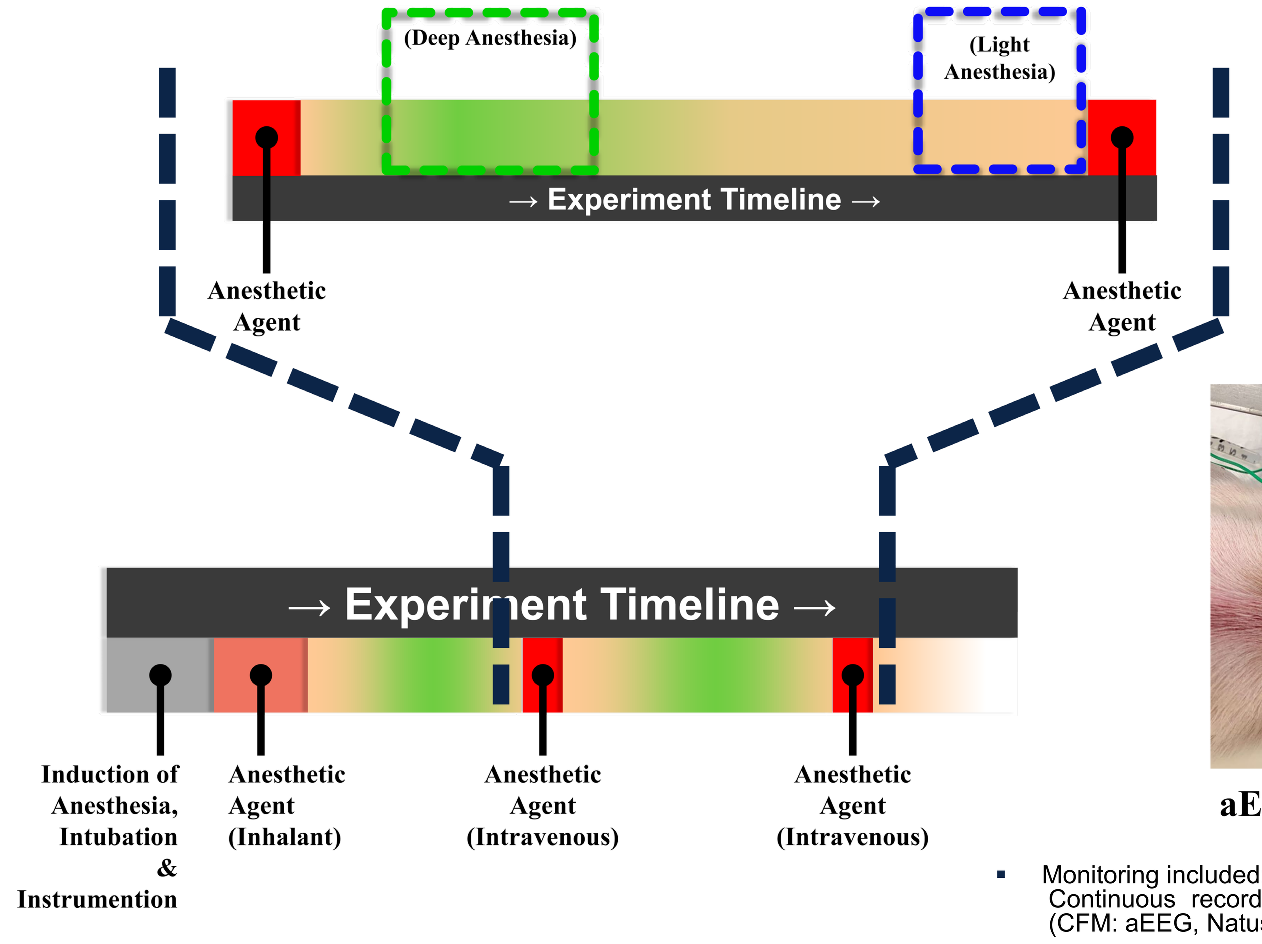
- NIRS is used as verification for CBF measures from DCS.

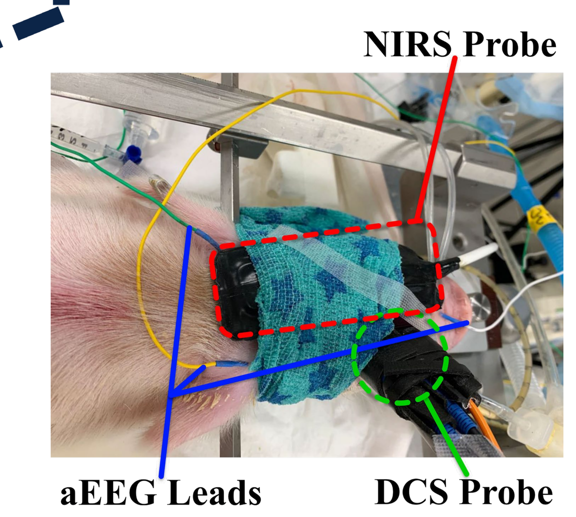
Objective

- To test the ability of **DCS** monitoring to **assess** emergence from **deep to light anesthesia,** with CBF by DCS verified with CBV measures by NIRS.

Methods: Experimental Protocol

- **Piglets (n=2)** were ventilated at normal oxygen and administered inhalational agents **Isoflurane, Nitrous Oxide**, and an intravenous agent **Ketamine**.

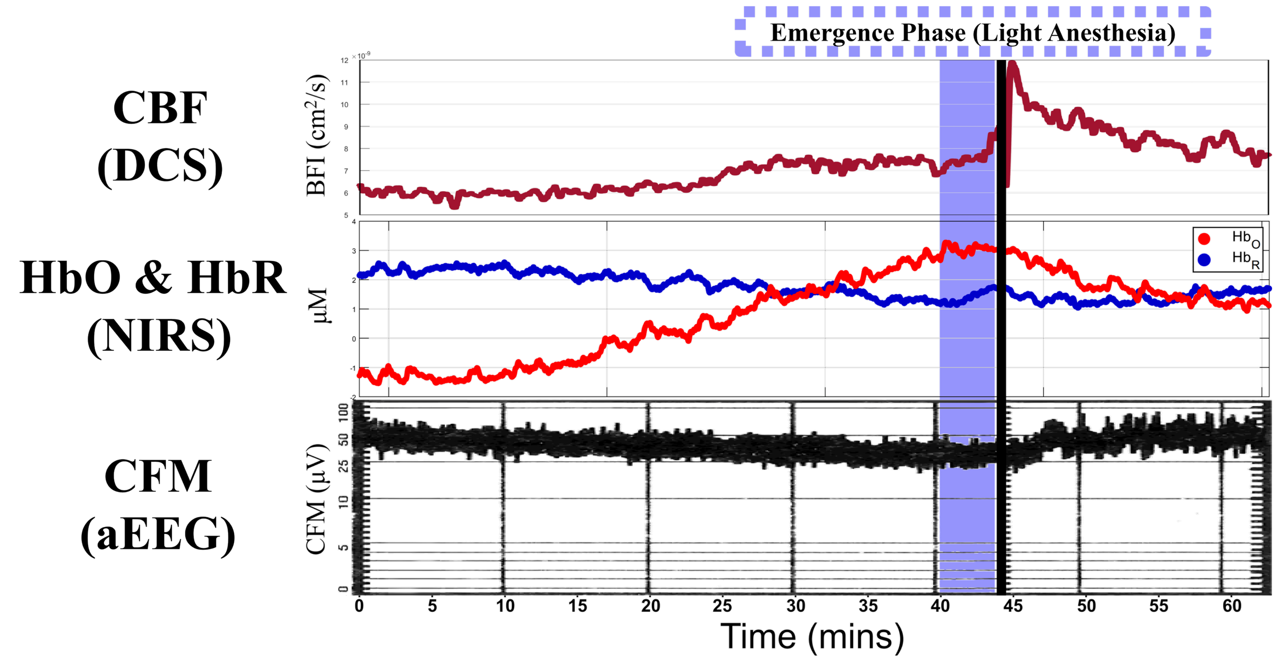




- Monitoring included: Continuous recording of vital signs; **Cerebral Function Monitor** (CFM: aEEG, Natus 6000); **NIRS**; and **DCS** systems.
- Animal procedures in accordance with protocols approved by the IACUC at Drexel University.

Results

- **CBF, HbO** simultaneously **increase** towards lighter state of anesthesia.
- CFM, collected from aEEG is following this trend with a delay.

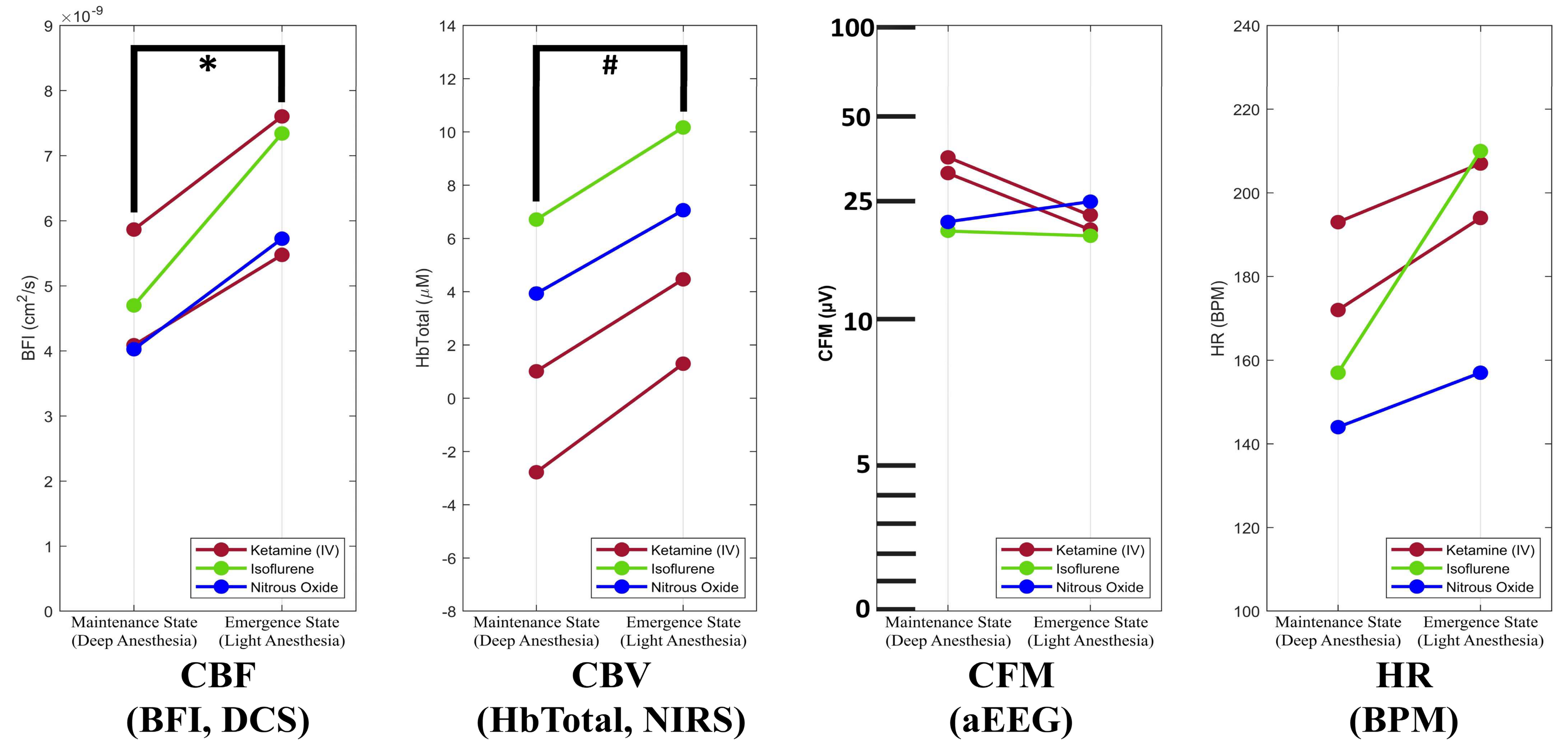


- **Example** anesthesia session from intravenous **Ketamine** from one animal.
- Animal is past the induction phase of the drug and is at the **maintenance phase**.

Results

- This pilot study reports **four sessions** of **emergence** from deep anesthesia to light anesthesia from two piglets.

*: p<0.01, t(3)=-6.91, #: p<0.01, t(3)=-17.81, (Paired t-test)



- The results show a significant **increase in CBF and CBV (HbO + HbR) during the emergence** from deep to light anesthesia considering all drugs administered.

Discussion & Conclusion

- This proof-of-concept study shows **consistency in CBF and CBV** measures quantified by **DCS and NIRS** across **all anesthetic agents** administered.
- Ongoing experiments to further investigate anesthetic **agent specific monitoring** and **individualized dosing**.
- We conclude that, DCS can be a monitoring tool to **prevent unintended emergence** from deep anesthesia especially with nonverbal subjects such as infants, or patients under paralytic agents.

References

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2. [2] G. Hernandez-Meza, M. Izzetoglu, M. Osbakken, M. Green, H. Abubakar, and K. Izzetoglu, "Investigation of optical neuro-monitoring technique for detection of maintenance and emergence states during general anesthesia," J Clin Monit Comput, vol. 32, no. 1, pp. 147–163, Feb. 2018, doi: 10.1007/s10877-017-9998-x.

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