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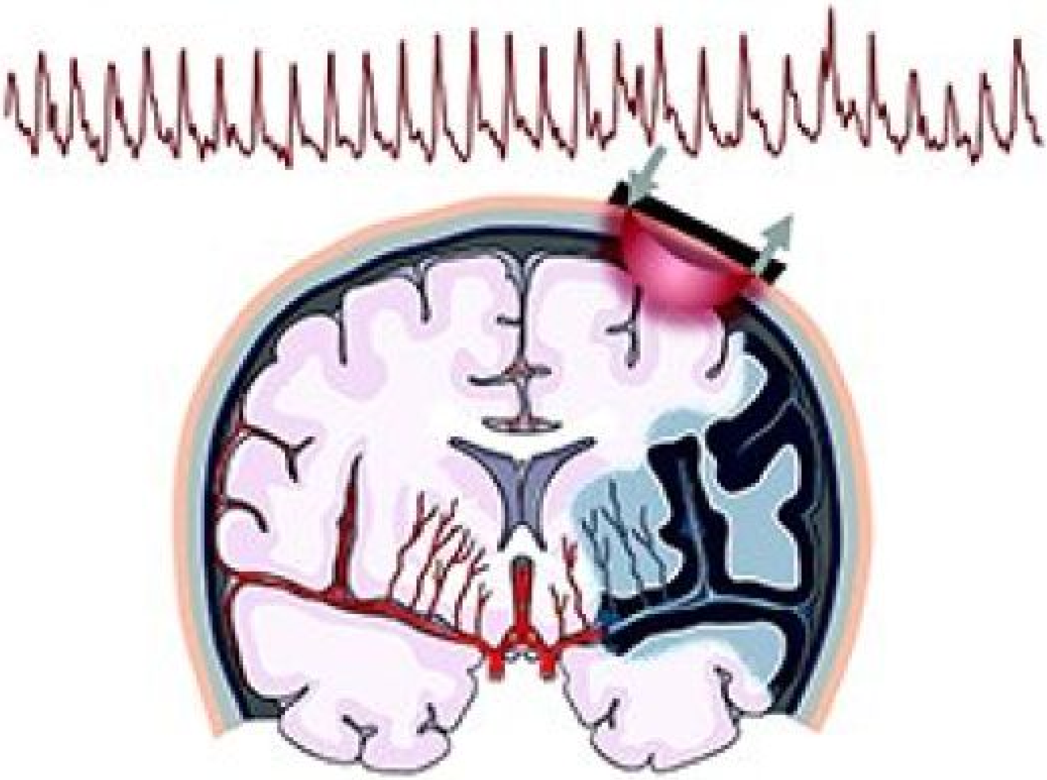


PhD THESIS DEFENSE: Transcranial Diffuse Optical Measurements of Pulsatility Derived Parameters for Neuromonitoring Applications

JONAS FISCHER

October 26, 2021
16:00 to 19:00
ICFO Auditorium and Online (Teams)

Diffuse optics are non-invasive and continuous techniques using near-infrared light which allow for comfortable bed-site monitoring of microvascular cerebral hemodynamics, oxygenation and metabolism. Here, diffuse correlation spectroscopy (DCS) to measure microvascular cerebral blood flow (CBF) and time-resolved near-infrared spectroscopy (TR-NIRS) to measure microvascular blood oxygenation are at the center stage. In particular, this work has contributed to the development of fast CBF measurements (?10 Hz) resolving the pulsatile fluctuations due to the cardiac cycle. These signals were exploited to calculate various parameters related to intracranial pressure (ICP), vascular properties and cerebral autoregulation (CA) which are posed as novel new biomarkers for different pathologies.

New devices that I have developed set new standards in the group and were replicated several times paving the way for future multi-center studies using same devices. I have utilized said devices employed for neuro-monitoring traumatic brain injury (TBI) and acute ischemic stroke patients at collaborating hospitals.

In case of TBI patients and patients with other complex neuropathologies, invasive (probe implanted in the brain tissue through a burr hole in the skull) ICP monitoring is an important tool for patient management. Its invasiveness limits its utility and, here, I present a new approach using new machine learning based on pulsatile CBF to measure ICP non-invasively. My pilot studies show that that method can be both accurate (bias ~0 mmHg) and precise (limits of agreement:

Furthermore, pulsatile CBF allowed me to derive ICP surrogate variables that reflect the health of the cerebral vasculature such as the pulsatility index (PI), the critical closing pressure (CrCP) and the resistance area product (RAP). New algorithms were developed and applied to different populations. An exploratory study on acute ischemic stroke patients revealed that these parameters may serve as potential biomarkers for disease and may help to better understand and explain the physiology.

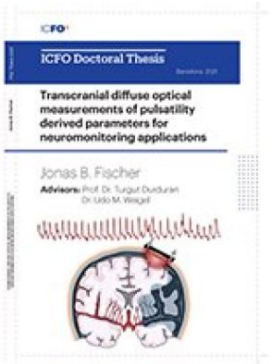
Another aspect, targeted in this thesis is related to CA, a mechanism to protect the brain by keeping CBF constant despite changes in the pressure. However, this mechanism may be impaired in TBI and stroke and put the brain at risk of ischemia. Ideally, a non-invasive method monitoring its status is desired. For this purpose, the DCS autoregulation index (CBFx) was introduced and validated in the TBI patients. This index was also applied to the stroke population and compared to healthy subjects confirming impaired CA in TBI and stroke on a group level. If this is taken to the level of an individual this may have implications for personalized treatment of the patients.

As a side note, COVID-19 and widespread face mask wearing posed questions and challenges for us which I have addressed by a study of cerebral and systemic physiological response to mask wearing showing that while there are significant changes, they are well within the changes during daily activities demonstrating its safety while highlighting the need for care in special scenarios (patient groups, neuroimaging studies).

Taken all together, my contributions in this thesis have provided the hardware and algorithmic basis for new neuromonitoring tools and methods while my studies have shown that these parameters may be useful in personalized treatment of the patients and improve their outcome.

Thesis Director: Prof. Dr. Turgut Durduran and Dr. Udo M. Weigel

Hosted by: Turgut Durduran



Jonas Fischer's Thesis Cover