THESIS DEFENSE: Application and development of diffuse optical methods for the non-invasive bedside assessment of cerebral hemodynamics in the stroke unit

LISA CHRISTINA KOBAYASHI FRISK

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The brain is an organ with a large energy budget compared to its volume and weight and constantly requires oxygen-rich blood to meet its metabolic needs. Given this fact, a tool that enables the continuous non-invasive monitoring of cerebral hemodynamics would be an important addition to a clinician's toolbox. In this thesis, I focus on stroke, a disease in which cerebral blood flow is impaired in different regions of the brain.

Hybrid diffuse optical techniques are capable of the non-invasive measurement of regional cerebral hemodynamics. The main objectives of this PhD thesis were to demonstrate th potential utility of diffuse optical techniques in stroke patients as well as to advance th technology to become more portable and less expensive with the capability of measurin hemodynamics with a greater precision and accuracy

In the first part of the thesis, I report on data from a randomized controlled trial whic monitored the cerebral hemodynamics in one hundred-and-six stroke patients during firs mobilization using two optical techniques: time-resolved near-infrared spectroscopy (TRS and diffuse correlation spectroscopy (DCS). The aim of the clinical trial was to determin whether cerebral hemodynamics measured during mobilization could be used as biomarker for individualizing mobilization therapies

In the first set of results, the cerebral hemodynamic response to mobilization and postur change was characterized. In the second set of results, cerebral autoregulation was assesse during first mobilization and was found to be associated with neurological deterioration These results suggest that patients with impaired cerebral autoregulation during mobilizatio should perhaps avoid further mobilization in the early hours post-stroke. In the third set o results, the safety and efficacy of standard and intensive mobilization therapy wa compared. No differences were found, and cerebral autoregulation status was n t associated with neither safety nor efficacy outcome variable

. The clinical portion of the thesis is an example of the potential application and demonstrat s the value of non-invasive measurements of cerebral hemodynamics at the bed-sid

. However, a major disadvantage of current diffuse optical technologies is the difficulty n acquiring data with a high signal to noise ratio (SNR) in areas with higher probability f absorption, e.g. in regions covered by hair. In the context of stroke patients, this limi s measurements to anterior hemodynamics irrespective of the location of the strok . The second part of the thesis consists of the development of another diffuse optic l technique (speckle contrast optical spectroscopy/tomography (SCOS/SCOT)) that may e able to overcome this limitation. As a first step, a simulation model was developed to mod l the generation and acquisition of the speckle contrast signal. This model allowed for t e study of the properties of the speckle contrast signal both in terms of detection nd measured tissue parameters. In addition, the simulation model allows for the definition of certain measurement goals to achieve a predetermined acquisition accuracy and precisi n. Then, a prototype device was built that is not only cheaper and more portable than m re standard diffuse optical technologies, but also has a high SNR. The device was characteriz d, and the measurement goals for accuracy were established. Finally, I developed an anal sis method for extracting blood flow data from SCOS signals. This method allows fo the simplification of system designs and/or protocols and can also increase data acquis tion frequen
ies. This thesis covers a range of topics from clinical research to simulation models and s stem design. However, the overall contribution of this work is to demonstrate the clinical utili y of these techniques as well as to propel the technology further to achieve a more com lete picture of cerebral he

Thesis Director: Prof Dr. Turgut Durduran