Cerebral Oximetry Neglects Variability of Cerebral Perfusion During Cardiac Surgery

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Introduction

• Cerebral oxygenation and perfusion are important clinical parameters, since hypoxia is the primary cause of neurological injuries [1].
• These parameters may help guide intraoperative monitoring during procedures associated with neurological complications [2,3].
• While stroke and cognitive dysfunction are complications of many surgical procedures, the incidence following cardiac surgery remains highest [4,5]. Consequently, prompt identification of cerebral hypoxia before irreversible trauma occurs is paramount.
• Devices currently approved by the Food and Drug Administration (FDA) provide non-invasive monitoring of cerebral oxygen saturation based on low-density configurations of transmitters and sensors [6-8].

Methods

• Data from six participants in an intraoperative cerebral monitoring study were analyzed (Table 1).
• Optodes were attached to a headgear and arranged in arrays covering 4 sites (Fig 1).
• Optical recordings and a record of intraoperative events were taken during surgery using a Near-Infrared Spectroscopic (NIRS) imaging system (INRy DYNOTcompact). The data were examined retrospectively to identify clinically significant events.
• An anesthesiologist (Dräger-Narkomed 6000) was used during surgery to simultaneously measure physiological parameters such as mean systemic arterial and pulmonary arterial pressures.
• A global estimate of light-source intensity variability and superficial hemodynamic fluctuations was computed, and near-infrared linear regression was used to subtract the contribution of the global factor from each raw data time series [10].
• The normalized difference method [11] was used to recover time series of volumetric images from the pre-processed data (see Fig. 2).
• Analysis of hemoglobin (Hb) levels was performed using a modified Beer-Lambert law (MBL) [12] algorithm to calculate the composite time series of oxy, deoxy, and total Hb (HbO2, Hbdeoxy, Hbtotal) for all channels.
• Superficial-signal correction was carried out for each channel as depicted in Fig 3. Channels labeled S1D4 and S4D1 are a reciprocal pair, with the roles of S and D interchanged.
• The signals measured correspond to the cerebral and overlying tissue components. In contrast, channels S1D3 and S4D2 consist largely of signals from overlying tissue. This would appear to allow for selective removal of the superficial-tissue component of the data recorded by the S1D4 and S4D1 channels [13].

Conclusions

• While subjects were under general anesthesia, their intraoperative cerebral perfusion remained relatively stable.
• Minor changes in source-detector pair location result in notably differing signal recordings.
• FDA-approved non-invasive cerebral oximetry devices, based on low-density arrays, are unlikely to yield accurate representation of complex heterogeneous cerebral perfusion.
• In contrast, a tomographic imaging method with a rich array of optodes would retain the possibility to capture time-varying heterogeneous spatial maps of cerebral perfusion.

References

[8] Nonin: www.nonin.com/RegionalOximetry

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