Preliminary evaluation of a fiber optic cerebral oximetry system in patients undergoing neurosurgery.

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Introduction

A serious concern in the treatment of patients after major neurosurgical procedures and particularly in the days after traumatic head injury is to prevent secondary damage from raised intracranial pressure (ICP) due to swelling of the brain [1]. For many years, management of patients at serious risk of raised intracranial pressure has included intracranial pressure monitoring via a cranial bolt inserted into a burr hole drilled through the skull [2]. We have developed an optical fiber probe which may be inserted via a cranial bolt, allowing oxygen saturation measurements to be made directly from the brain tissue. A preliminary study was undertaken to determine whether or not it is possible to obtain photoplethysmographic (PPG) signals from the brain tissue and to verify the effectiveness of the type of fibers used and the chosen 'depth of penetration' of the fibers.

Materials and method

The probe consists of two silica optical fibers with a core diameter of 400 μm and a numerical aperture (NA) of 0.39. Each fiber is terminated at one end with an SMA connector and the other end is cut and polished flat. The instrumentation is housed in a metal box containing: red (660 nm) and infrared (850 nm) emitters, a PIN photodiode photodetector, a battery power supply and a simple signal processing circuit. The signals for each of the two wavelengths are recorded and stored on a notebook computer using a LabVIEW-based data acquisition system.

This study was fully approved by the local research ethics committee and the patients' consent was sought prior to recruitment to the study. Patients undergoing elective neurosurgery who required cranial bolts as part of their routine care were recruited. After induction of anaesthesia, the cranial bolt was inserted by the neurosurgeon. The fibers were inserted into the bolt and PPG signals were recorded for a period of four minutes. The fibers were then removed and the surgery resumed.

Results

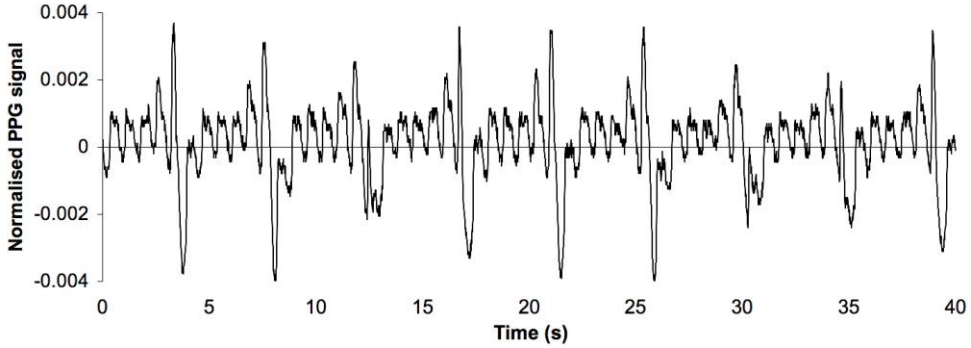

Figure 1. infrared ac-filtered normalized PPG signals recorded from the brain tissue via a cranial bolt.

At the time of writing, four patients have been recruited to the study. Signals were successfully obtained at both wavelengths for all four patients. Figure 1 shows a sample of the infrared ac PPG waveform recorded from one patient. The PPG signals consisted of variations in intensity synchronised with the cardiac frequency, modulated by a periodic signal of very large amplitude occurring at the respiratory frequency. This signal was thought to be caused by ventilator induced pressure changes in the cerebral circulation and was present in the recordings from all patients with varying amplitude relative to the cardiac PPG.

4. Discussion

We have shown that good quality red and near-infrared PPG signals could be obtained from human brain tissue using a fiber optic probe. These results confirm that the optical fiber system can be used to effectively obtain pulsatile and non-pulsatile reflected PPG signals from the brain tissue. Furthermore the type of optical fibers used and the depth of penetration are appropriate for successful signal acquisition.

Following this study a more extensive trial will be performed in patients recovering from head injuries. It is hoped that it will be possible to collect data for 24-48 hours, and that oxygen saturation will be calculated and compared with other modalities such as ICP and arterial oxygen saturation measured peripherally using a finger or ear probe.

References

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