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Oesophageal Pulse Oximetry in Neonatal and Paediatric Patients

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Background and purpose

Pulse Oximetry has been established as one of the most significant technological advances in clinical monitoring since its introduction in the early 1980s. The oximeter provides non-invasive continuous monitoring of arterial blood oxygen saturation. This technique relies on the presence of adequate peripheral arterial pulsations, which are detected as photoplethysmographic signals (PPG). When peripheral perfusion is poor, as in states of hypovolaemia, hypothermia, vasoconstriction, and low cardiac output, seen typically in meningococcal septicaemia, oxygenation readings become extremely unreliable or cease. These clinical situations also commonly occur in children and neonates undergoing prolonged surgical procedures such as cardiac surgery. Pulse Oximeters fail because the sensors are usually placed on the most peripheral parts of the body such as the finger or toe where pulsatile flow is most easily compromised. It is proposed to use the oesophagus as an alternative central monitoring site on the hypothesis that its perfusion should be preferentially preserved. Studies have shown that PPG signals and SpO₂ values can be recorded in the oesophagus of adult patients [1]. A new paediatric/neonatal oesophageal SpO₂ probe has been designed to record reliable PPG signals and SpO₂ values from the oesophagus of neonates.

Methods

A reflectance optical sensor has been constructed comprising miniature infrared and red emitters and a photodetector. The sensor was designed to fit into a conventional disposable transparent stomach tube, 12 French gauge. An electrically isolated data acquisition and processing system has been developed to detect, pre-process, sample, record and display simultaneously the red and infrared PPG signals and SpO₂ values. Five patients (3 male, 2 female) were studied on the intensive care unit. Age range (5 to 1398 days) and weight range (1.9 to 10.0 kg). The oesophageal SpO₂ probe was advanced through the mouth to a maximum depth of 15 cm from the lips. The probe was withdrawn slowly, and PPG signals were observed at various

depths to determine the optimal measuring site at which reliable signals with high signal-to-noise ratio were obtained. The probe was then left at this depth for the duration of the study for approximately ten minutes and PPG traces and SpO₂ values were recorded simultaneously. During the oesophageal measurements, values of blood oxygen saturation from a commercial foot pulse oximeter were also recorded.

Results

Measurable PPG traces of good quality were obtained in the oesophagus in all patients. Figure 1 depicts typical PPG signals from the oesophagus of a 3.2 kg, 5 day old neonate.

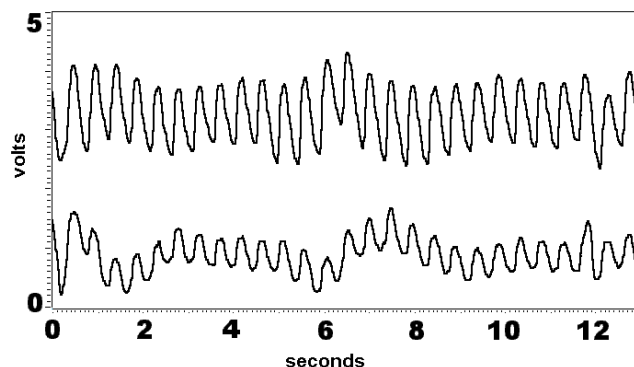


Figure 1: Typical PPG traces obtained from a neonatal human oesophagus at two wavelengths, infrared (top trace) and red (bottom trace)

A Bland and Altman [2] plot of the difference between blood oxygen saturation values from the commercial pulse oximeter and those from the oesophageal pulse oximeter against their mean showed that the bias and the limits of agreement between the oesophageal and toe pulse oximeters were -0.3% and -1.7% to 1.0% .

Conclusions

In this preliminary study it has been shown that good quality oesophageal PPG signals with large amplitudes can be measured from various depths within the oesophagus of neonates. Monitoring at the oesophageal depth of 10 cm (measured from the lips) proved to be the most appropriate for measuring blood oxygen saturation. In a direct comparison between the oesophageal and commercial pulse oximeters, using Bland and Altman analysis, the SpO₂ results from the two instruments were in good agreement. This study suggests that the oesophagus can be used as an alternative site for SpO₂ monitoring in neonatal and paediatric patients.

References

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