Pilot study in neonatal and paediatric oesophageal pulse oximetry

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Purpose of the study

The primary objective of this proof-of-concept pilot study was to investigate the feasibility of detecting photoplethysmographic (PPG) signals and estimating blood oxygen saturation (SpO_2) values from the oesophagus of children and neonates. This vital measurement can be impossible to obtain at times when it is most needed during septic shock, circulatory collapse or cardiac arrest.

Methods

Instrumentation: A miniaturised reflectance oesophageal pulse oximeter probe was constructed comprising one infrared and one red surface mount emitter (880 nm and 655 nm) and a surface mount photodetector mounted between the emitters (figure 1). The probe was designed to be small enough to slide down the lumen of a plastic transparent disposable size 12 French (external diameter of 3.8 mm) nasogastric tube. A processing system was constructed to pre-process, record and display oesophageal PPG signals and estimate SpO_2 values on a laptop computer. PPG signals were analyzed by a *Virtual Instrument (VI)* implemented in *LabView*. Algorithms[1] were also developed in the *VI* for the online estimation of oesophageal SpO_2.

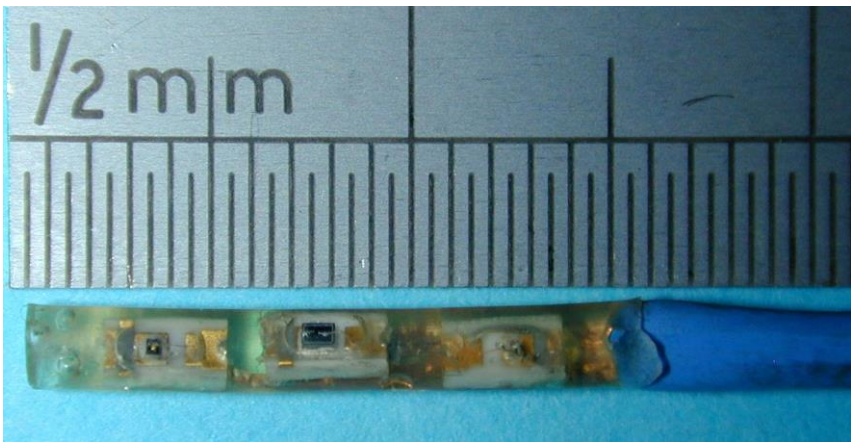

Figure 1: Photograph of the paediatric/neonatal oesophageal pulse oximetry probe

Patients and Measurements: Local research ethics committee approval was obtained for this proof-of-concept pilot study. Five neonates (3M, 2F) were studied on the neonatal and paediatric intensive care units. The age range (days), ± SD was (5 to 1398, ± 606) and the weight range (kg), ± SD was (1.9 to 10.0, ± 3.3). The oesophageal probe was advanced gently through the mouth to a maximum depth of 15 cm from the lips. The babies were all mechanically ventilated and adequately sedated. The probe was withdrawn slowly until PPG signals with high signal-to-noise ratio could be obtained. The probe was then left at this depth for the duration of the study for approximately ten minutes and PPG traces and derived SpO_2 values were recorded. During the oesophageal measurements, SpO_2 values from a commercial toe pulse oximeter (Philips, Merlin CMS Monitors, Reigate, UK) were also recorded for comparison.

Results

Good quality PPG signals from the oesophagus were recorded in all patients. The measured effective signal-to-noise ratio was always better than 40dB at the output of the system. A total of 48 pairs of SpO_2 values from the 5 patients were used to compare the oesophageal and the commercial toe pulse oximeters. The limits of agreement between the oesophageal SpO_2 results and those from the commercial toe pulse oximeter, were calculated using the *between-method differences* analysis outlined by Bland and Altman[2]. The bias, estimated by the mean difference (d) was –0.34% and the standard deviation (s) was 0.67%. The limits of agreement for the SpO_2 data (commercial toe and oesophageal) were:

$$d - 2s = -0.34 - (2*-0.67) = 1.0\ \%$$
$$d + 2s = -0.34 + (2*-0.67) = -1.70\ \%$$

Conclusions

A new reflectance oesophageal pulse oximetry probe and an isolated processing system have been developed which allow measurements to be made within the oesophagus of neonates and children. In this preliminary study it has been shown that good quality oesophageal PPG signals with large amplitudes can be measured within the oesophagus of neonates. This appears to be the first report of PPG signals from the oesophagus of neonates. In a direct comparison between the oesophageal and commercial pulse oximeters, using Bland and Altman analysis, the preliminary SpO_2 results from the two instruments were in good agreement. This study suggests that the oesophagus can be used as an alternative site for SpO_2 monitoring in neonatal and paediatric patients and encourages more extensive and rigorous clinical trials.

References

1. Kyriacou P A, Powell S, Langford R M and Jones D P 2002 Esophageal Pulse Oximetry Utilizing Reflectance Photoplethysmography *IEEE Transactions of Biomedical Engineering* **49** 1360-1368
2. Bland J M, and Altman D G 1986 Statistical Methods for Assessing Agreement Between Two Methods of Clinical Measurement *Lancet* **1** 307-310