Development of a Reflectance Fibre-Optic Pulse Oximetry Probe for Use in Abdominal Organs

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Background and purpose

The early detection of inadequate splanchnic tissue oxygenation would reduce the risk of hypoperfusion, severe ischaemia, and multiple organ failure [1]. None of the currently available methods provide continuous monitoring of splanchnic perfusion pre-operatively, operatively and post-operatively. In an attempt to overcome these limitations, a new fibre-optic probe utilizing the principle of reflectance pulse oximetry was developed. The separation distance between the source and detector fibres of the probe has a direct impact on the quality of the photoplethysmographic (PPG) signal and the accurate estimation of blood oxygen saturation (SpO_2) [2]. Prior to finalising the probe design, an investigation was conducted to establish the optimum source-detector separation.

Method

Figure 1 illustrates the configuration of the fibre optic pulse oximeter probe. A Y-piece was used to multiplex the red (650nm) and infrared (850nm) light into a single fibre. This fibre transmits the light to the tissue. Another fibre is used to detect the backscattered light and return it to a photodiode. A processing and data acquisition system was developed to drive the optical components of the probe and to detect, pre-process and digitise the red and infrared ac and dc PPG signals.

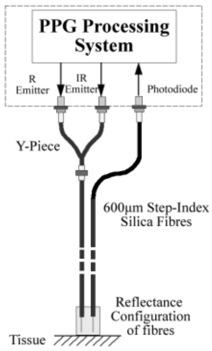

Fig. 1. Configuration of the fibre-optic probe.

To determine the optimum fibre separation distance, PPG signals were obtained from the finger at both wavelengths and recorded simultaneously while varying the separation between source and detector at 1 mm increments (range: 1-8 mm).

Results

PPG signals were recorded at all fibre separation distances (Figure 2). PPG signals at 1 and 2mm were problematic as at 1mm the ac PPGs were of large amplitude but of very poor quality and errstic with little resemblance of a conventional PPG signal, while the dc PPG signals at 1-2mm were unrealistic indicating a possible saturation of the photodetector. Signals over 6mm were of poor quality and very low amplitude.

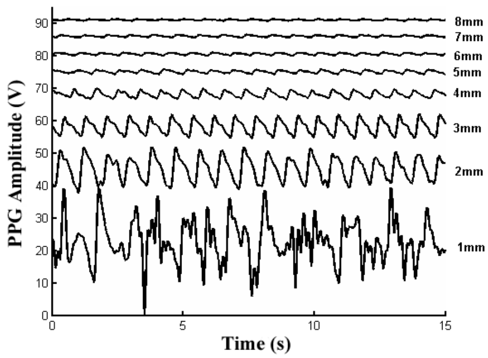

Fig. 2. PPGs from the finger at various separations

Figure 3 shows preliminary calculated SpO_2 values for all fibre separations, confirming the problems experienced at separations of 1-2mm and over 6mm, where the saturation values are either much higher or much lower than 100%.

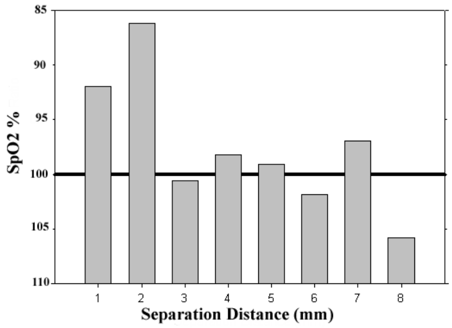

Fig. 3. SpO_2 values for all separation distances.

Conclusions

A new fibre-optic splanchnic perfusion probe and processing system has been successfully designed and developed. The optimum source-detector separation distance was found to be in the range 3mm-6mm. This separation range provided PPG signals of good amplitude and quality, and resulted in realistic SpO_2 calculation. These preliminary results have indicated that it may be feasible to develop a probe that can be used in the abdomen for continuous perfusion monitoring.

Acknowledgement

EPSRC

References

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[2] Jury of the Consensus, Tissue Hypoxia: How to detect, how to correct, how to prevent?, Intensive Care Med, 1996: 22, 1250-1257.