Investigation of oesophageal pulse oximetry in burns patients

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Background and purpose

Pulse oximetry is widely used in anaesthesia and intensive care monitoring. It is a valuable, non-invasive optical monitoring technique used for continuous measurement of arterial blood oxygen saturation (SpO_2). Sites for pulse oximeter sensors are frequently difficult to find in patients with major thermal injury. Standard sites such as fingers or toes may be affected by the burn, unsuitable due to the use of tourniquets during surgery, or in some cases absent. Therefore blood oxygen saturation readings are often unobtainable at just the time when they would be most valuable.

An oesophageal SpO_2 probe has been designed to record reliable photoplethysmographic (PPG) signals and SpO_2 values from the oesophagus of burns patients.

Method

A reflectance oesophageal pulse oximetry sensor has been constructed comprising miniature electro-optical devices [1 2]. An electrically isolated PPG processing system was developed to detect and pre-process simultaneously the red and infrared AC and DC PPG output signals. Oesophageal AC and DC PPG traces (obtained at red and infrared wavelengths) were digitised by a 16-bit data acquisition card. The digitised PPG signals were further analysed by a *Virtual Instrument* implemented in *LabVIEW*. Oesophageal PPG signals were displayed simultaneously on a laptop computer. The design of the *Virtual Instrument* incorporated algorithms allowing the online estimation of oesophageal SpO_2.

Seven patients with major burns admitted to burns intensive care were recruited for the study. The five men and two women ranged in age between 26 and 52 years. The total body surface area burnt ranged between 28% and 90%. A nasogastric tube containing the reflectance pulse oximetry sensor was placed in each patient's oesophagus. The PPG signals were recorded at various depths in the oesophagus. Arterial blood samples were taken for estimation of oxygen saturation using a CO-oximeter. Linear Regression analysis was used to compare the blood oxygen saturation results from the oesophageal pulse oximeter with those from CO-oximetry.

Results

Measurable PPG traces were obtained from the oesophagus in all patients. The oesophageal PPG signals recorded from all patients were of good quality and large amplitude. The optimal monitoring oesophageal depth ranged from 13 cm to 20 cm, measured from the upper lip (mean $\pm$ SD: 15.6 $\pm$ 1.8 cm).

A plot of SpO_2 readings obtained from the reflectance oesophageal pulse oximeter (OES SpO_2) against the SaO_2 values from the CO-oximeter is shown in Figure 1. The equation of the best fit linear regression line is: (OES SpO_2) = 33.278 + 0.666 (CO-ox SaO_2) (the solid line in Figure 1); $r^2 = 0.49$; Standard Error of Estimate (SEE) = 0.64; $p<0.001$. The dashed line represents the line of identity.

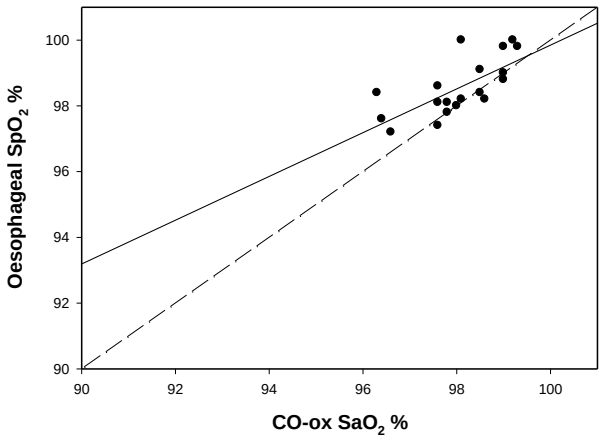

Figure 1: Plot of SpO_2 measurements obtained from the oesophageal pulse oximeter against SaO_2 from the CO-oximetry for 7 patients.

Conclusions

The aim of this investigation was to evaluate the reliability of oesophageal pulse oximetry in major burns patients. Good quality oesophageal PPG signals with large amplitudes were measured from various depths within the oesophagus. The optimal monitoring oesophageal depth ranged from 13 cm to 20 cm, measured from the upper lip. It was found that the oesophageal pulse oximeter saturation results were in good agreement with those from the CO-oximeter (see Figure 1). In summary, the data suggest that oesophageal reflectance pulse oximetry may be a reliable and useful alternative method for monitoring continuous oxygen saturation in major burns patients.

References

[1] Kyriacou P A, Powell S, Langford R M, and Jones D P. Oesophageal pulse oximetry utilizing reflectance photoplethysmography IEEE Trans. on Biomed. Eng., 2002: 49(11): 1360-1368.

[2] Kyriacou P A, Powell S, Langford R M, and Jones D P. Evaluation of oesophageal pulse oximetry in patients undergoing cardiothoracic surgery. Anaesthesia, 2003: 58: 422–427.