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# A NEW SYSTEM FOR ESTIMATING HUMAN SPLANCHNIC OXYGEN SATURATION

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**Abstract:** Adequate splanchnic oxygen saturation ( $SpO_2$ ) is essential for maintaining organ viability during and after surgery. There is a need for reliable continuous monitoring of organ oxygen saturation. A new photoplethysmographic (PPG) probe and signal processing system were developed. PPG signals from abdominal organs (bowel, liver, kidney) and the finger were obtained from 12 anaesthetised patients. The amplitudes of the abdominal organ PPGs were, on average, approximately the same as those obtained simultaneously from the finger. Preliminary  $SpO_2$  values from abdominal organs showed good agreement with those obtained simultaneously from a commercial finger pulse oximeter.

## Introduction

Measurement of  $SpO_2$  from an extremity such as the finger may not accurately reflect abdominal organ oxygen saturation values. Adequate splanchnic oxygen saturation is essential for maintaining organ viability and may prevent multiple organ failure during and after surgery. Therefore, there is a need for reliable continuous monitoring of organ oxygen saturation. Animal studies have shown that pulse oximetry could be used to monitor intestinal oxygen saturation [1]. The technique of pulse oximetry relies on the presence of adequate arterial pulsations, which are detected as AC photoplethysmographic (PPG) signals. As a preliminary to developing a suitable pulse oximeter for estimating organ  $SpO_2$ , a system to investigate the morphology and quality of PPG signals from various human abdominal organs, such as the bowel, liver and kidney, has been designed and is described.

## Materials and Methods

A reflectance PPG probe comprising miniature infrared and red emitters and a photodetector has been constructed. The PPG probe fits into a disposable transparent stomach tube, 20 French gauge [2]. An electrically isolated signal processing system has been developed. The output was digitised and further analysed by a virtual instrument implemented in Labview on a laptop computer. Infrared and red PPG traces from the abdominal organs, together with PPG traces from an identical finger probe, were obtained simultaneously and displayed on the laptop screen. Twelve adult patients were studied during laparotomy under general anaesthesia. PPG traces from the surface of the bowel, liver and kidney were

recorded for each patient for a total of approximately 8 minutes.

## Results

Measurable PPG signals with similar amplitudes and reasonably high signal-to-noise ratios were obtained from all investigated abdominal organs. Typical PPG traces obtained from the bowel and the finger at both wavelengths are shown in Figure 1. The mean PPG amplitudes ( $\pm$ SD) for the infrared wavelength for the bowel, liver, kidney and finger were:  $1.0\pm 0.4V$ ,  $0.8\pm 0.3V$ ,  $1.0\pm 0.6V$  and  $1.4\pm 0.7V$ , respectively. The corresponding values for the red wavelength were:  $0.4\pm 0.2V$ ,  $0.4\pm 0.1V$ ,  $0.4\pm 0.1V$  and  $0.5\pm 0.2V$ .

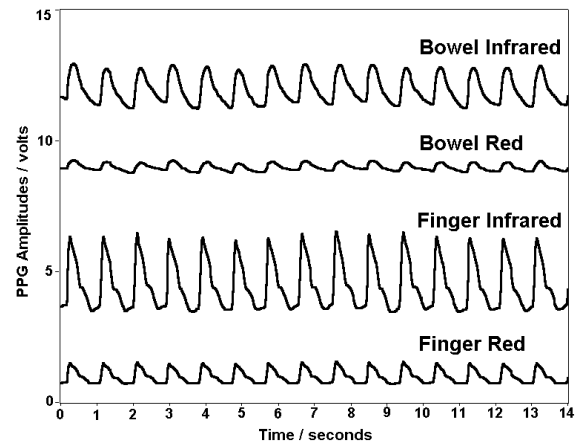


Figure 1: PPG traces from the bowel and the finger

Paired t-tests showed that there were no statistically significant differences between the PPG amplitudes recorded from the abdominal organs and those from the finger. Preliminary  $SpO_2$  values obtained from the abdominal organs showed good agreement with  $SpO_2$  values obtained simultaneously from a commercial finger pulse oximeter.

## Conclusions and Discussion

Abdominal organ PPG signals have been obtained with adequate signal-to-noise ratio. This appears to be the first report of PPG signals from human abdominal organs. The amplitudes of the abdominal organ PPGs are, on average, approximately the same as those obtained simultaneously from a finger for both wavelengths, although there is considerable variability. Preliminary  $SpO_2$  results support the hypothesis that pulse oximetry may be used as a monitoring technique, for abdominal organs such as the bowel, liver and kidney. Further work needs to be carried out to validate this hypothesis.

## Acknowledgements

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