TITLE: **FOREHEAD REFLECTANCE PULSE OXIMETRY -- TIME RESPONSE TO RAPID SATURATION CHANGE**

AUTHORS: S.J. Barker, Ph.D., M.D., J. Hyatt, T. Long
AFFILIATION: Dept. of Anes., University of California, Irvine, Orange, CA 92668

Conventional pulse oximeters measure light transmitted through tissue. The sensors consist of light sources on one side of the tissue and a detector on the other side. The newer reflectance pulse oximeter measures reflected light using sources and detectors located adjacent to one another. Transmission pulse oximeters are limited to sensor locations where the light source and detector can be on opposite sides of tissue, such as finger or ear. Reflectance pulse oximeters do not share this limitation. Previous studies have shown that ear probes respond to rapid desaturation or resaturation earlier than finger probes (1,2). We present a comparison of forehead reflectance pulse oximetry with finger and ear sensors during rapid recovery from an SaO2 value of 75%.

Twenty healthy volunteers, aged 23 - 42 years, were monitored with radial artery cannulas, ECG, mass spectrometer, and pulse oximeters with sensors on the earlobe (Nellcor N-100), index finger (Nellcor N-100, Sentinel 2000), and forehead (Sentinel 2000). The Sentinel 2000 is a reflectance pulse oximeter, while the Nellcor N-100 is a conventional transmission oximeter. Subjects breathed a controlled mixture of oxygen and nitrogen through a sealed mask. Inspired oxygen fraction (FIO2) was gradually lowered to 11%, yielding steady-state SaO2 values of 70-74%. These baseline SaO2 values were determined by arterial blood sampling and IL-282 Co-oximeter. FIO2 was then abruptly changed to 100% and pulse oximeter saturation (SpO2) was recorded digitally until steady-state was again reached. The SpO2 from each pulse oximeter was recorded at every heartbeat by means of digital data outputs. The time to 50% resaturation (i.e., time to SpO2 = 87%) was determined for each pulse oximeter for each subject. The mean differences between these resaturation times were computed to compare time lags between finger, ear, and forehead sensors.

The difference between ear sensor and finger sensor resaturation time ranged from 5.5 to 28 seconds. The mean and S.D. were 15.1 $\pm$ 6.6 seconds. The forehead to finger time difference ranged from 7 to 25 seconds, with a mean and S.D. of 15.8 $\pm$ 6.3 seconds. Both the ear-finger and the forehead-finger time lags are significant to a P-value less than 0.005. The difference between the ear-finger and forehead-finger time lags is not significant.

The new forehead reflectance pulse oximeter provides data on rapid changes in saturation with the same time lag as the conventional ear sensor, which is significantly faster than the finger sensor. The average 15 second time difference between ear or forehead and finger sensors in these healthy subjects may be much longer in critically ill patients. This study differs from previous experiments in that the low SaO2 values prior to resaturation were steady-state rather than transient.

References

1. Anesthesiology 67:551-558, 1987.
2. Anesthesiology 66:376-380, 1987.