The clinical implications of pulse oximeter sensor accuracy in the sleep laboratory

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Introduction

Pulse oximetry is a core monitoring modality in medicine. Aoyagi first described its use in 1974(1) and since then it has become widely accepted as a standard of care monitor in hospital medicine. However, recent clinical observations of large differences in pulse oximetry readings on the same patient with different sensors has raised questions of accuracy.(2)

Background

Children with sleep-disordered breathing often undergo a sleep study to help establish a diagnosis and determine therapeutic options which may range from supplemental oxygen therapy, non-invasive respiratory support and ventilation, to tonsillectomy. A sleep study involves multi-modality monitoring and a key component of this monitoring is pulse oximetry. The sleep laboratory at Children's Hospital Colorado (CHC) uses two different pulse oximeter sensors to measure peripheral oxygen saturations (SpO_2). Often, these sensors will provide different readings that make it very difficult to interpret the sleep study data. An example is shown below in a patient with Down syndrome on non-invasive ventilation at night. The selection of ventilator settings changes depending on which pulse-oximeter is used.

Masimo Sensor

OXYGEN SATURATION EPOX	W	NR	R	TST
Mean SpO2%:	94.0%	92.3%	92.9%	92.5%
Min. SpO2%:	84.2%	87.4%	82.2%	82.2%
% Sleep Time in Range ("bad data" excluded)				
< 95%:			97.7%	
< 92%:			35.4%	
< 90%:			0.9%	
< 88%:			0.2%	
< 80%:			0.0%	
< 70%:			0.0%	

Nellcor Sensor

OXYGEN SATURATION	W	NR	R	TST
Mean SpO2%:	94.2%	93.5%	93.3%	93.4%
Min. SpO2%:	90.1%	88.2%	83.5%	83.5%
% Sleep Time in Range ("bad data" excluded)				
< 95%:			96.4%	
< 92%:			7.7%	
< 90%:			0.7%	
< 88%:			0.2%	
< 80%:			0.0%	
< 70%:			0.0%	

W Wake, **NR** Non-REM sleep, **R** REM sleep, **TST** Total Sleep Time

Testing the accuracy of the pulse oximeter

One source of inaccuracy is related to the pulse oximeter sensor itself. Pulse oximeter sensors use two light emitting diodes (LEDs) of specific and differing wavelength (660 and 940 nm) to measure the combined absorption by a mixture of oxyhemoglobin and deoxyhemoglobin of red and infrared light measured using a photodiode. The photodiode measures the variation in the intensity of light falling upon it, and converts this into an electrical voltage. The ratio of absorption at these two wavelengths is called the R-value, and is compared with R-values stored in the pulse oximeter monitor. Should the wavelength of the light emitted by one or both LEDs alter, the degree of absorption will alter and the R-value will change. The mathematical algorithm contained within the pulse oximeter software for the estimation of SpO_2 will then receive incorrect information and an inaccurate SpO_2 will be displayed on the monitor. At lower saturations, the SpO_2 error will be greater as the absorption of reduced hemoglobin is much more sensitive to wavelength errors. So just when increased accuracy is needed the pulse oximeter becomes less accurate. The Lightman® (The Electrode Co. Ltd, Monmouthshire, UK) is a portable micro spectrophotometer that uses an internal diode-array spectrophotometer to measure the exact emission spectra of the LEDs in pulse oximeter sensors. (3)

Hypothesis

The pulse oximeter sensors being used for sleep studies have varying accuracy due to the quality of the LEDs.

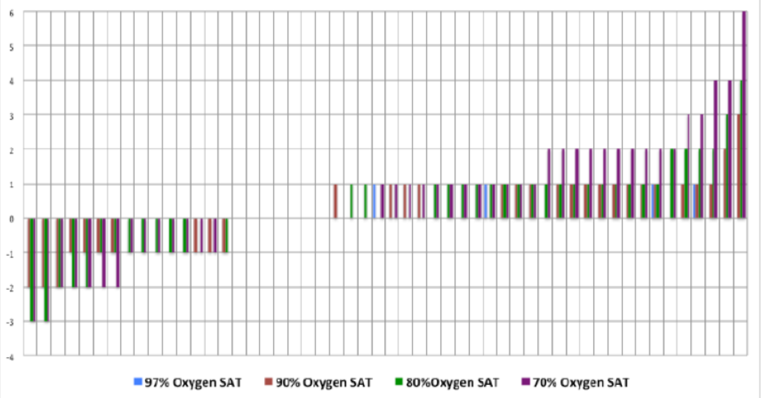
Method

This IRB approved, prospective study collected 50 paired sensors (Nellcor and Masimo) after they had been used for a sleep study. The sensors were then analyzed using The Lightman®, to determine their accuracy and the bias of every sensor at differing SpO_2 values (97%, 90%, 80% and 70%).

Results

The results below show the considerable range in the accuracy of the sensors analyzed.

Differences between the paired Masimo and Nellcor sensors per patient tested at different oxygen saturations



Conclusion

The data presented here shows that pulse oximetry may not always be an accurate measure of SpO_2 and this could lead to inappropriate therapeutic decisions being made. Further study is needed to understand the extent of this issue.

References

1. Severinghaus JW. Aoyagi T. Discovery of pulse oximetry. Anesth Analg. 2007;105

2. Ross PA et al. Accuracy of pulse oximetry in children. Pediatrics. 2014;133:22-9.

3. Milner QJ, Mathews GR. An assessment of the accuracy of pulse oximeters. Anaesthesia. 2012;67:396-401.