WHITEPAPER

Measure Oxyhaemoglobin Saturation vs. Calculated Saturation Values

INTRODUCTION:

Despite the large body of evidence supporting the accuracy of pulse oximeters, individual institutions often desire to conduct accuracy verification trials prior to purchasing new pulse oximeters. When conducting these trials using blood samples as point in time standards for verification purposes, it is critical that these samples have the SaO_2 measured via CO-Oximetry. The use of calculated oxyhaemoglobin saturation values from a blood gas machine introduces errors that cannot be accounted for, thereby making the verification invalid.

TERMINOLOGY:

Calculated SaO2 - Oxyhaemoglobin saturation calculated based upon one of a variety of nomograms. Variables used in the calculation include PaO_2, $PaCO_2$, pH, and patient temperature. Certain assumptions are made that the levels of 2,3 DPG, Carboxyhaemoglobin, methaemoglobin, and other factors affecting the oxyhaemoglobin dissociation curve are all normal. Blood gas analysers such as the ones listed in Table 1, only produce a calculated SaO_2.

Measured SaO2 - Oxyhaemoglobin saturation directly measured via spectrophotometric principles (shining light through the sample) by a device called a CO-Oximeter. Spectrophotometry is presently the only method capable of directly measuring SaO_2. These devices utilize numerous wavelengths of light and directly measure the concentrations of oxyhaemoglobin and the various dyshaemoglobins, including carboxyhaemoglobin and methaemoglobin. Various CO-Oximeters, capable of directly measuring SaO_2, are listed in Table 1.

The CO-Oximetry method has been validated against the classical Van Slyke method over a wide physiological range.[1] The ASTM / ISO standard for pulse oximetry calls for CO-Oximetry as the only method for verification.[2] Calculated SaO_2 is based upon the PaO_2, $PaCO_2$ and pH values and assumes a normal oxyhaemoglobin dissociation curve. Gothgen et al. showed that the actual measured SaO_2 for a given PaO_2 can vary considerably.[3] For a PaO_2 of 60 ± 4 mmHg (8.0 ± 0.5 kPa), the associated measured SaO_2 was from 69.7% to 99.4%. This wide range of values could easily affect the results of a pulse oximeter verification test, if the calculated SaO_2 was used.

Chiappini et al. evaluated the accuracy of indirect estimates of oxyhaemoglobin saturation.[4] In patients with respiratory failure the authors found that calculated SaO_2 (compared with measured SaO_2) is not homogeneously accurate and that this might be "especially dangerous in monitoring patients with severe respiratory failure." In 20% of the blood samples evaluated the difference between calculated and measured SaO_2 was more than 5% and in 9% of the samples the difference was greater than 10%.

SUMMARY

When comparing SpO_2 (from a pulse oximeter) with SaO_2 (from blood) only a measured SaO_2 from a CO-Oximeter can be used.

Calculated SaO_2 (Blood gas analyzers)	Measured SaO_2 (CO-Oximeters)
I-Stat portable*	
IL Gem Premier*	
AVL Opti 1*, 3*	
Bayer 400*	Bayer 405*
AVOXimeter 1000E*	AVOXimeter 4000*
AVL Compact 2, 3, AVL 995, AVL Omni 1, 2, 4, 5	AVL Omni 3, 6
Bayer 248, 278, 280, 288, 348, 840, 850, 860, 1200	Bayer 845, 855, 865, 1205
IL 1630, 1640, 1650, 1660, 1710, 1720, 1730, 1740	IL 682, 1715, 1725, 1735, 1745
Radiometer ABL 330	Radiometer OSM, OSM3
Radiometer 5, 50, 500, 505, 555, 600	Radiometer ABL 520, 620, 625, 700 & 800 series

* point-of-care testing devices.

Table 1. Various blood gas machines (calculated SaO_2) and CO-Oximeters (measured SaO_2). This is not an exhaustive list. If your particular device is not listed here, check the users manual to determine if the SaO_2 parameter is calculated or measured.

REFERENCES

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2. ANS/ISO 9919; Medical electrical equipment - Particular requirements for the basic safety and essential performance of pulse oximeter equipment for medical use. 2005.
3. Gothgen, IH, Siggaard-Andersen O, Kokholm G. Variations in the hemoglobin-oxygen dissociation curve in 10079 arterial blood samples. *Scand J Clin Lab Invest Suppl*. 1990. 203: 87-90.
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Masimo Americas
tel 1-877-462-7466
info-america@masimo.com

Masimo International
tel +41-32-720-1111
info-international@masimo.com

Masimo UK
tel +44-(0)-1256-479988
uksales@masimo.com

Masimo Asia-Pacific
tel+65-6392-4085
info-asia@masimo.com

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