Summary of Clinical Reference
Pulse Oximetry

Summary

Pulse oximetry is a well-established , widely-used and sensitive method of monitoring, detecting and quantifying hypoxemia in intensive care, operative, and post-operative environments.

Accuracy
The accuracy of pulse oximetry is reported to be $< \pm 3\%$ at Sao2 $>70\%$. This level of accuracy is considered to be more than sufficient for most clinical purposes.

Limitations
There are several limitations of pulse oximetry that may affect the accuracy of measurements or the ability to obtain oximetry readings.

- Incidence of failure (defined as the inability to obtain any pulse oximetry reading for a cumulative period of 30 minutes or greater after all mechanical problems have been eliminated and all possible sites had been tried) has been found to be approximately 1% in two large prospective and retrospective studies.

- Low Signal to Noise Ratio
  A low signal to noise ratio may be caused by any of the following issues. A further discussion of the individual issues is described further in this document.

  Decreased Signal
  - Low perfusion state
  - Improper probe placement

  Increased Noise
  - Motion
  - Ambient light
  - Venous pressure waves

- Vasoconstrictors / Low Perfusion
  Cold vasoconstriction combined with low pulse pressure (e.g. after cardiac bypass) or an increase in venous pressure often precludes detection of Spo2 from fingers or at lease delays the detection of hypoxemia.

- Probe Position
  Finger probes when withdrawn partially beyond the fingertip often cause a false low reading before failure occurs.

- Motion Artifact
  When patients are awake, movement is the most common cause of failure and false alarm. Probe motion may cause either absent or incorrect readings.

- Ambient Light
  Strong ambient light, or light flickering at frequencies similar to the harmonics of the probe LED may interfere with the rate and saturation measurements. Opaque covering of the probe is helpful in minimizing the effects of ambient light.

- Venous pressure waves
  When the arterial pulsation decreases below some fraction of the total transmitted light, some oximeter units judge the signal unacceptable and display a low quality signal error message. Instruments that continue to display Spo2 at lower pulse pressures may be more prone to providing erroneous data at low signal levels.

- Abnormal Pulses
  Abnormal pulses caused by a large dicrotic notch, tricuspid insufficiency or ischemic cardiomyopathy have been responsible for low of absent Spo2 readings.

- Ventilator Induced Pulse Interference
  The cycling venous and arterial pressures when using positive pressure ventilation may cause continuous searching for an optimal signal.

- Response Times
  Slow finger circulation due to cold vasoconstriction may delay response by more than 1 minute at normal blood pressure and by much longer periods during severe hypotension. This issue has not been noted when probes are used on the ear, forehead, nose or lips.

- Alternative Sites
  Most pulse oximeters use the finger, except when peripheral vasoconstriction or hypotension limits finger perfusion. At very low saturations, the ear has shown both faster response and greater accuracy that the finger. The overall performance of probes in other sites was worse than that of finger probes.

- Skin Pigments, Dyes, Nail Polish
  Dark skin pigmentation and nail polish have been shown to provide erroneous readings and a higher incidence of signal detection failure.

- Carboxyhemoglobin and Methemoglobin
  When clinically significant levels of carboxyhemoglobin or methemoglobin are suspected or known, in vitro blood gas analysis and oximetry are needed to supplement pulse oximetry. Not only because dyshemoglobins interfere with pulse oximetry but also because they decrease the oxygen-carrying capacity of blood.

Risks

- Skin burns
  Skin burns have been reported in connection with pulse oximetry during MRI due to induced skin current beneath looped pulse oximeter cables acting as antennae. Burns have also been caused by using probes with defects or defective designs or connecting an incompatible probes and oximeters.

- Pressure Necrosis
  Pressure necrosis may occur from probes being left on a single site too long.

Conclusions

Pulse oximeters are considered more than sufficiently precise and accurate for most clinical purposes. The described risks and limitations on accuracy appear minor in comparison for requirements for effective patient monitoring. The device's ability to detect an unfavorable trend in oxygenation can be at least as important as its accuracy.

Several large clinical studies have demonstrated that pulse oximetry improves patient safety through the detection of clinically unapparant episodes of desaturation and can allow a reduction in the number of bloody gas analyses utilized without adverse effects to the patient. The mortality rate from anesthesia in healthy patients since the introduction of pulse oximetry has decreased 10-fold, of which a portion of this reduction can be attributed to the introduction and wide-spread use of pulse oximetry.

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Lynne Aronson
Senior Consultant
Morningstar Consulting Group, Inc.

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