Pulse oximetry is accepted as a standard of care in multiple settings. One of the primary limitations of pulse oximetry documented in the literature is motion artifact. It fails to provide valid results when the signal-to-noise ratio is low. The AARC’s Clinical Practice Guideline published in 1992, “Exercise Testing for Evaluation of Hypoxemia and/or Desaturation,” expands on the explanation of these limitations. Both at rest and with exercise, motion artifact may cause the measurements to read falsely low or falsely high.

The guideline states that only a limited number of pulse oximeters have been validated under exercise conditions with concurrent arterial blood gas analysis in diseased subjects. Despite this knowledge, oxygen continues to be prescribed on the basis of pulse oximetry results with exercise.

Subsequent to this guideline, research has continued to better define equipment limitations and suggest possible guidelines to improve the application of the results. In addition, new technology has emerged that may improve the impact of motion artifact on the measurements.

**Identifying motion artifact**

It is important to identify motion artifact during pulse oximetry measurements. The most reliable method is visual analysis of the individual pulse waveforms; but it is also the most tedious, requiring constant vigilance for longer studies. Computer algorithms have been tested comparing pulse and heart rate for motion artifact. One study tested a computer algorithm in 10 preterm infants. The data was analyzed for sensitivity and specificity. Of the data analyzed, 31 percent of the segments exhibited motion artifact. The computer algorithm was able to identify 95 percent +/- 3 percent of the artifacts, while the pulse oximeter identified 18 percent, +/- 11 percent. A significant amount of the tracing identified hypoxemia that was really the result of poor measurement conditions.

Prescribing oxygen flowrates during exercise for patients with chronic obstructive pulmonary disease (COPD) is commonly based on pulse oximetry measurements. The impact of prescribing long-term oxygen therapy for a patient carries multiple implications related to cost, morbidity, and psychosocial issues. It should be undertaken with caution and based on valid measurements. Understanding the correlation between the pulse oximetry measurements...
and CO-oximetry is critical for respiratory therapists responsible for performing and reporting these test results.

In a study reported in 1997, 20 COPD patients were evaluated during exercise on two separate days. A series of six-minute walking treadmill tests were performed until an oxygen flowrate that resulted in a SpO₂ (oxygen saturation as measured by pulse oximetry) greater than 90 percent was achieved for each individual tested. The exercise tests were repeated on the next day, but both SpO₂ and SaO₂ (oxygen saturation of the hemoglobin of arterial blood) results were required to be greater than 90 percent. On the average, the SpO₂ was found to be significantly less than the SaO₂. SpO₂ reproducibility was good between the two days of exercise. The oxygen prescriptions based on invasive and noninvasive results agreed in only one half of the patients.

In six subjects, pulse oximetry overestimated the required flowrate and in four subjects underestimated the flowrate. If the SpO₂ target had been raised to 93 percent, there would have been fewer underestimations of SaO₂. The authors suggested that the target value should be 93 percent with pulse oximetry to avoid improperly prescribed oxygen flowrates during activities of daily living.²

This data confirms an earlier study in 1996 performed to assess the accuracy and precision of pulse oximetry during exercise. Only eight male subjects with COPD were studied, but the authors concluded that the SpO₂ was not sufficiently accurate to replace SaO₂ as the gold standard for oxygen saturation in COPD.³

New technology emerges
Recent studies have evaluated a newer technology that uses a new method for oximeter signal processing. This technology appears to offer a significant advance in low signal-to-noise performance. Conventional technologies cannot differentiate between arterial and venous blood at the measurement site. Signal Extraction Technology (SET®) identifies the venous blood signal and isolates it. Then, using adaptive filters, SET cancels it — allowing the measurement to reflect an arterial oxygen saturation.

A 1997 study compared the impact of motion artifact on pulse oximeter measurements for two devices with conventional technology and a device with SET on 10 healthy volunteers. One hand was used as a stationary control while the other hand had sensors on three digits and was placed on a mechanical motion table. The inspired oxygen concentration was varied from 100 percent to 75 percent.

The sensors were connected both before and during motion.
The 

\[ \text{SpO}_2 \] errors increased when the sensors were applied during motion, with a deviation of greater than 7 percent from the stationary control being calculated as an error. Alarm thresholds were also evaluated. The true alarms to total alarms were 73 percent and 81 percent in current technology and 100 percent with SET.\(^6\)

**False alarms in various settings**

The incidence of false alarms is an area of concern with pulse oximetry. A large number of alarms observed in intensive care units are generated by pulse oximeters. One source states 94 percent of these oximeter alarms are not significant.\(^5\) Desensitizing health care providers to alarms may carry a risk of potential delays in responding to a severe event.

A study of preterm infants compared conventional technology to SET to assess the frequency of false alarms. Alarm limits were set at 85 percent and 100 percent. The newer technology generated 93 percent fewer alarms than conventional technology.\(^3\) This demonstrates potential to decrease the frequency of false alarms and decrease the noise generated in these units.

False alarms have also been studied in the recovery room under conditions of gross arm movement, shivering or Parkinsonian tremors, and fist clenching. The conventional technology was compared with SET. A seven-fold decrease in audible false alarms was observed in the newer technology.\(^6\)

Patient transport presents another challenge for pulse oximetry measurements where poor perfusion and site motion are inevitable. The degree of monitoring error can be so great as to delete the benefits of the monitoring device under conditions where its need is the greatest. Helicopter transport of acutely ill individuals has been associated with failure of pulse oximetry measurements in various models of conventional oximeters. Comparing technologies during helicopter transport of five infants with documented cardiac shunting, researchers noted fewer failures with SET.\(^7\)

Although each of these studies included a small number of subjects, each study demonstrated the potential of improved validity of measurements with low perfusion states and motion artifact. The respiratory therapist is faced with the challenge of continuing evaluating...
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tion in the clinical setting to de-
termine the application and
benefits of new technologies.

Continual validation
necessary
The need to validate each in-
dividual pulse oximeter during
exercise continues to exist. The
literature suggests each type of
oximeter may correlate differ-
cently with CO-oximetry values.
Some read falsely high while
others read falsely low through-
out the exercise. The effect of
dyshemoglobins must also be
considered as it may affect the
results differently based on the
level of exercise.

The evaluation of each tech-
ology under conditions of mo-
tion artifact and low perfusion has
significant impact on patient care
decisions in multiple settings and
across age groups. Sensor tech-
nology will continue to change
and requires ongoing evaluation.
When considering equipment
purchase, a careful evaluation of
the intended uses and impact on
the validity of results should
always be completed.

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