It’s curious how we tend to take everyday conveniences for granted. Technology that was considered “miraculous” just a decade ago is assigned a role or task in the workplace and becomes just another element in a routine. We expect a device to perform and give accurate results, sometimes not understanding how it does what it does, or what the results really contribute to the assessment of a patient. This is the case with the pulse oximeter, a handy clinical device introduced in the late 1980s that facilitates rapid assessment of oxygenation status of a patient without have to break the skin and/or analyze whole blood.

The non-invasive nature of the oximeter was a revolution for the times, as we were all dealing with Universal Precautions, and seeking ways to avoid contact with human blood or other potentially infectious materials. The other advent of the oximeter was its speed. Results could be obtained at the point of care in a matter of seconds. Another clinical innovation of the times that facilitated the oximeter’s rapid success was the clot-buster drug Streptokinase. This clot-dissolving drug was being used cautiously to break down thromboemboli in heart attack and stroke victims. There was much trepidation about causing bleeding in patients receiving this therapy by blood sampling, so the oximeter offered a safe, non-invasive assessment of oxygenation that was a vital part of their care and management.

Pulse oximetry was accepted and integrated into health care culture very rapidly. So rapidly, in fact, that few took time to understand what was actually being measured, or what limitations were inherent to the technology. Because the oximeter made sampling so easy, few questioned the accuracy of its results.

This unconditional acceptance of the new technology has led to current practice standards in both in and out-patient care: whatever the number is on the meter is accepted as accurate and representative of the patient’s condition. Luckily, as manufacturers have competed with one another for market share, they have improved the accuracy of the device as a competitive feature. This makes use of it a “no brainer.” However, there are still basic principles to understand when using the pulse oximeter that ensure more accurate results. Here are some application points presented to improve the use and results of the pulse oximeter:

1) The pulse oximeter is a light meter (photometer). The unit comes with two light emitting diodes (LEDs) and a photodetector in the clip that attaches to the patient’s finger. The diodes emit light at two different wavelengths (one visible, one infrared); the photodetector receives the light after it has passed through the finger. The light wavelengths are specific to oxyhemoglobin and deoxyhemoglobin (i.e., hemoglobin loaded to capacity with oxygen, and hemoglobin not loaded to capacity with oxygen, respectively). That is, *each substance absorbs light at one particular light wavelength.* As the light waves pass through the finger, they encounter a bed of arterioles that are pulsating with blood. All of the tissues in the finger absorb light at a fairly constant rate with one exception: the blood pulsing through the network. *The blood’s ability to absorb light changes with the amount of oxygen being carried by the red blood cells.* So, oxygen saturation is calculated based on the ratio of different absorption rates of these two hemoglobin states (i.e., loaded with oxygen vs. partially loaded with oxygen). Whatever light makes it through the finger is measured by the *photodetector* on the other side of the finger clip.

In principle, oximetry is a little math story-problem. Suppose you know nothing about money. But every day, Mom gives you a five-dollar bill and sends you to the store to buy milk. You select a gallon of milk as instructed and give the clerk the bill. He gives you three dollars back. You quickly learn to expect three dollars back. The three dollars in change represents 100% of your expectation (that is, you come to expect three dollars back in every transaction). Receiving anything less than three dollars is less than 100%. Apply this concept to the oximeter; the wavelengths of light emitted by the diodes and received by the *photodetector* represent the five dollars given the clerk, and three dollars received in change (respectively) in the math story. Determining the correct wavelengths to send through the finger, and learning how much light will be absorbed, are merely the tip of the iceberg in terms of research and technology behind the development of the instrument. The required technology, knowledge and experimentation behind the little light emitting diodes in the finger clip of the oximeter represent a colossal advancement of applied science. We should be awestruck each time we turn the unit on!
Pulse oximetry has proven to be reasonably accurate — with nearly thirty years of clinical trials, it's pretty well established that the oximeter is accurate in a range from 80% saturation to 100% (1).

2) The light frequencies in the oximeter are specific for measuring the absorption of it by blood and tissue. Thus, when attaching the oximeter to a finger, it is essential that blood is pumping well through the finger (i.e., the finger is perfused). This concept defines the use of the term pulse in pulse oximetry — there must be an adequate supply of blood pulsing through the finger. On larger oximeters, the pulse rate is usually represented by a flashing bar that indicates the strength of the pulse signal being picked up by the meter. This pulsing bar signal is much like the bar signal on a cell phone that indicates how strong the satellite signal might be in a particular calling area (2).

So, the criteria for selecting a finger for assessment should be the same as selecting a finger for a finger-stick capillary puncture. It should be warm to the touch; it should be rich with color; it should blanch when squeezed, then refill with blood quickly (all indicate adequate perfusion of the finger being selected).

Do not attach the pulse oximeter and try to get a reading on an arm with an inflated blood pressure cuff. This is disrupting the blood flow to the finger and will alter oximetry results (remember: the oximeter will almost always display a result, accurate or not!). Also, if the hands are cold, try to warm them up (establish better perfusion) before accepting the oximeter’s result. Lastly, make sure that the pulse signal bar is the highest (best pulse) signal you can find. (Evaluate the signal from several fingers before deciding on the best signal.)

3) Remember that pulse oximetry is a simple screening — don’t bet your life (or someone else’s) on it. The pulse oximeter is reporting this result: how much light is being absorbed by the oxygen carried in each little red blood cell as it passes through an arteriole beneath the diode in the finger clip. If the little red cell is fully saturated with oxygen, the oximeter will report around 97% to 100%. There is a method of estimating what this means in terms of how much oxygen pressure (PaO2) is in the blood.

Without an actual analysis of whole blood, the best one can do with the oximeter’s result is estimate the adequacy of oxygen in the blood. That is because there are many physiologic variables that can confound the accuracy of the estimation. For example, the pulse oximeter’s result reflects how saturated with oxygen each red cell passing through the arteriole is at the time of measurement. However, it says nothing of how many red cells exist, or how capable they are of carrying oxygen. Thus, it is a good practice to have a current hemoglobin level when evaluating pulse oximetry results.

Also, there are chemical elements in the blood that affect the loading and unloading of oxygen from hemoglobin. These elements can make a dramatic difference in what the oximeter’s result means to the individual. A pulse oximetry saturation of 96% for one person with normal body temperature, normal blood concentration of Hydrogen ions (pH), normal carbon dioxide levels and an adequate level of an enzyme that helps unload oxygen from hemoglobin (2,3, diphosphoglycerate) means something entirely different from someone who has abnormal levels of these elements. Also, smokers, who have elevated levels of blood carbon monoxide may have normal or near-normal oxygen saturation levels on the meter, but still be in need of oxygen at the cellular level.

4) The use of the oximeter is not foolproof. As with all technology, the quality of the result reflects the quality of the assessment. One’s selection of a monitoring site, and accepting a result as accurate, is as important as the correct application of the result to the patient’s care.

There is evidence to suggest that the accuracy of the oximeter’s reading can be affected by the following:

- **Skin pigmentation**: Melanin concentration in skin will affect light conductance through it.
- **Nail polish**: Despite great improvements in the light-technology over the years, dark nail polish should still be removed for more accurate results.
- **Perfusion**: As previously described, the oximeter requires a strong pulse signal for accurate measurement.
- **Anemia**: Hemoglobin levels in the blood dictate how much oxygen is being carried to cells and tissues; this volume of oxygen is NOT represented by the saturation reported by the oximeter (this volume can be calculated if an accurate hemoglobin level is known).
- **Carbon monoxide in blood**: Carbon monoxide attached to hemoglobin interferes with its ability to both carry and release oxygen at the cellular levels. (If you encounter a patient suspected of CO2 poisoning, the pulse oximeter is NOT the diagnostic tool for assessment of his/her blood oxygenation.)
- **High intensity ambient light**: Light pollution can affect oximetry results. Make sure that the oximeter’s diodes are flush to the skin and covered.
- **Motion of the extremity used for assessment**: The extremity should remain relaxed and still for as long as possible. (Evaluate the signal from several fingers before deciding on the best signal.)

**Summary**

The pulse oximeter is a wonderful tool with many relevant applications in ambulatory care. The lesson to be learned here is that the results from the oximeter are as good as the techniques used to acquire them. Moreover, the oximeter’s report is always an estimate
of the patient’s oxygenation status at the time of assessment. It is a screening to indicate whether a more precise, whole blood measurement (arterial blood gases) is indicated.

References


---

Chris Christian Receives 2007 Cuviello Excellence in Education Award

C. E. “Chris” Christian, MT, Sayre, Oklahoma, has been awarded the 2007 Cuviello Excellence in Education Award. This annual honor is bestowed on an individual nominated by members of the AMT Board of Directors, Council, AMTIE Trustees, state societies or members at large, and voted by the AMTIE Board of Trustees.

Mr. Christian founded the Medical Technology Program on the Southwestern Oklahoma State University-Sayre campus branch in 1967. The Medical Technicians program at Sayre was the first such program west of the Mississippi, and one of the first three collegiate-approved programs in the United States. He was an instructor at the college for over 20 years and was named director emeritus of the SWOSU-Sayre Med Tech program in 1989 when he retired from the classroom. Today, Mr. Christian has at least two former students from the program working in labs in all 50 of the United States. The program continues to be nationally respected for its leadership in producing solid med techs.

After retiring from the classroom in 1989, he served as a Bayer Corp. national representative, making public speaking presentations nationwide to medical professionals at least once a month. He is a three-time past president of the Oklahoma AMT state society and a recipient of AMT’s highest honor for medical technologists — the Order of the Golden Microscope.
of the patient’s oxygenation status at the time of assessment. It is a screening to indicate whether a more precise, whole blood measurement (arterial blood gases) is indicated.

References


Chris Christian Receives 2007 Cuviello Excellence in Education Award

C. E. “Chris” Christian, MT, Sayre, Oklahoma, has been awarded the 2007 Cuviello Excellence in Education Award. This annual honor is bestowed on an individual nominated by members of the AMT Board of Directors, Council, AMTIE Trustees, state societies or members at large, and voted by the AMTIE Board of Trustees.

Mr. Christian founded the Medical Technology Program on the Southwestern Oklahoma State University-Sayre campus branch in 1967. The Medical Technicians program at Sayre was the first such program west of the Mississippi, and one of the first three collegiate-approved programs in the United States. He was an instructor at the college for over 20 years and was named director emeritus of the SWOSU-Sayre Med Tech program in 1989 when he retired from the classroom. Today, Mr. Christian has at least two former students from the program working in labs in all 50 of the United States. The program continues to be nationally respected for its leadership in producing solid med techs.

After retiring from the classroom in 1989, he served as a Bayer Corp. national representative, making public speaking presentations nationwide to medical professionals at least once a month. He is a three-time past president of the Oklahoma AMT state society and a recipient of AMT’s highest honor for medical technologists — the Order of the Golden Microscope.