

Pulse Oximetry – The Basics...

Introduction:

Is it not amazing how pulse oximeters have evolved over the past several years? I can recall the early days of my career where our pulse oximeters were bigger than most portable transport ventilators are nowadays.

With ongoing technology, we have become spoiled for choice from a wide range of units that seem to be getting smaller and smaller. It is an extremely competitive market with companies investing millions of Rands into research and development, in an attempt to produce models that provide superiorly accurate results.

There is no doubt that pulse oximetry plays a crucial part in patient monitoring, however it must be said that one should not use it without considering important factors such as, patient medical history, clinical examination findings and if there are any other factors that could influence the readings presented by the pulse oximeter.

In this article, I would like to focus on the basics of pulse oximetry and some of the pros and cons associated with its use.

History of Pulse Oximetry:

In 1935 Karl Matthes from Leipzig, Germany, built the first device to continuously measure blood oxygen saturation by transilluminating tissue on the ear. He used two wavelengths of light, one of which was sensitive to changes in oxygen saturation and the other, which was in the infra-red range, to compensate for the variances of tissue thickness, haemoglobin content and light intensity. This device was groundbreaking in being able to monitor saturation trends; however, it was extremely difficult to calibrate, not very portable and was not able to produce absolute values. In comparison to today's unit, it was also frightfully expensive.

The “modern day” pulse oximeter was developed in 1974 by Takuo Aoyagi and Michio Kishi, who were bioengineers at Nihon Kohden. It was first tested on a patient by a surgeon named Susumu Nakajima. His findings were published in 1975. The first commercially available pulse oximeter was launched by Biox in 1981.

Over the years the technology has evolved into the current ‘cost-effective’ units which can be found being widely used across the healthcare fraternity. Pulse oximetry has proved to be one of the most important advances in respiratory monitoring.



Definition:

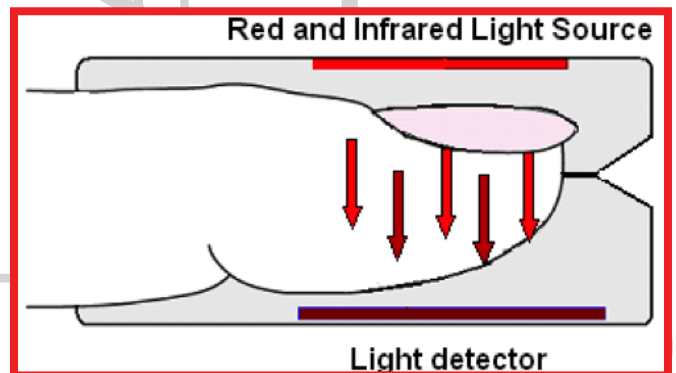
Pulse oximetry (SpO₂) is a non-invasive (non-skin penetrating) monitoring technique that enables Healthcare Professionals to rapidly measure oxygen saturation of haemoglobin in arterial blood. This is achieved by making use of a device called a pulse oximeter which provides a reading as a percentage, i.e. percentage of available haemoglobin saturated with oxygen (or other gas).

How a Pulse Oximeter Works:

Oxygenated blood absorbs light at 660nm (red light), whereas deoxygenated blood absorbs light preferentially at 940nm (infra-red). One nanometer (nm) is equal to 1 billionth of a meter.

A pulse oximeter probe consists of a light source (red – 660nm and infrared – 940nm) at one end and a light detector at the other end. When the probe is placed on a finger the red and infrared light from the source passes through the finger towards the light detector.

Much of the light is absorbed by structures within the finger, i.e. tissue, bone and venous blood; however a portion of it reaches the light detector. Oxygenated haemoglobin (oxyhaemoglobin or O₂Hb) absorbs more infrared light than red light. Deoxygenated haemoglobin (Hb) absorbs more red light than infrared light. By comparing the amounts of red and infrared light received at the light detector, the pulse oximeter calculates the oxygen saturation and displays it on a screen as a percentage.



Benefits of Pulse Oximetry:


One of the major benefits of pulse oximetry is that it provides continuous non-invasive monitoring of oxygen saturation. Prior to the availability of pulse oximetry, arterial blood gas (ABG) analysis was been used to determine haemoglobin saturation.



This involves taking an arterial blood sample (usually from the radial artery) running it through an ABG machine and waiting for results. The results of numerous surveys conducted have indicated a downward trend in oxygen saturation related lab tests since the wide scale introduction of pulse oximeters.

This has two spin-offs. Firstly it reduces the costs associated with unnecessary lab testing on patients that are otherwise deemed to be 'relatively' stable.

Secondly, because it is non-invasive, it reduces patient exposure to pain and complications associated with taking samples for testing. I have firsthand experience of the joys of having arterial samples taken and it wasn't a pleasant experience by any means.



Furthermore, relying on physical hypoxic signs in a patient, such as cyanosis, is dangerous, as it is usually picked up at a very late stage. Pulse oximetry desaturation will occur significantly sooner thereby prompting healthcare providers to reassess the patient clinically and take the necessary action. Low saturation alarms found on all machines provide valuable warning.

It is however important to note that pulse oximetry does not provide the additional information that is obtained from arterial blood gas analysis. pH, partial pressure of oxygen (PO₂), carbon dioxide (PCO₂), standard bicarb, base excess and oxygen saturation are all obtained from ABG's and provide crucial information when treating patients with acid-base disturbances related to a compromised respiratory system

Limitations of Pulse Oximetry:

There are several limitations to pulse oximetry that may produce inaccurate or false readings. We'll discuss a few.

Carbon Monoxide poisoning

Once carbon monoxide has been absorbed it forms a strong bond with the iron atoms in the haemoglobin (called carboxyhaemoglobin, or HbCO), which is the principle oxygen carrying component of blood. Carbon monoxide has a much higher (more than 200 times) affinity for haemoglobin than oxygen. It is therefore able to bond quicker and stronger with haemoglobin, thereby reducing haemoglobin oxygen transport.

Pulse oximetry only reads the percentage of bound haemoglobin; it cannot determine what gas has actually bonded to the haemoglobin. As such, a patient with carbon monoxide poisoning may exhibit normal pulse oximetry readings despite inadequate oxygen transport. This may significantly delay the recognition of hypoxemia in these patients. The events leading up to the emergency that is being treated becomes crucial information in interpreting the pulse oximetry results.

Anaemia


Anaemia, one of the most common blood disorders, is a disease that is characterised by a decrease in the number of red blood cells or a less than normal amount of haemoglobin. As mentioned earlier, pulse oximetry reads the percentage of bound haemoglobin. In anaemic patients, the less than normal available haemoglobin may indeed be saturated with oxygen, thus showing a normal pulse oximetry reading even though the patient has very poor tissue oxygen delivery.

Peripherally vasoconstricted patients

In order to provide a reading, pulse oximeter probes require pulsatile blood flow through the structure to which it is attached. In patients who are peripherally vasoconstricted, either as a compensatory response to shock, or due to hypothermia or as a result of the administration of vasopressor agents (drugs used to cause constriction of the blood vessels) have poor peripheral blood flow through structures such as fingers, toes and ears. As a result, the pulse oximeter probe will likely fail to deliver a reading, or if it does, it is generally unreliable.

Nail polish and dirt under the finger nails

Certain shades of nail polish (mainly hues of black, blue and green) have been shown to cause significantly lower oxygen saturation readings. Dirt under the finger nails has also been reported to cause difficulty in obtaining reliable readings.



One of the ways that poor readings through nail polish can be overcome is to move the probe so that it transmits light from one side of the finger to the other, rather than through the nail bed. Alternatively, use another site such as an ear or toe.

Bright external light source

Bright external light may overwhelm the light sensor in the oxygen saturation probe and give erratic or erroneous readings. This can be overcome by simply placing the patient's hand under a blanket or covering the probe with material, thereby blotting out external light.

Failure to detect hypoventilation

Hypoventilation and hypercarbia (abnormally high level of CO₂ in circulating blood) may occur without a decrease in haemoglobin oxygen saturation. This is especially true if the patient is receiving supplemental oxygen. A pulse oximeter should thus not be relied upon to assess the adequacy of ventilation, oxygen source disconnections or misplaced endotracheal tubes into the oesophagus.

A combination pulse oximeter/ capnograph provides a far better range of monitoring. A capnograph measures CO₂ in exhaled air and is thus the monitor of choice to pick up acute events such as a dislodged endotracheal tube. A pulse oximeter will only pick up the consequences of an acute event (hypoxia) and may result in significant time delay before healthcare providers may respond and correct the problem.

In conclusion:

Pulse oximetry provides extremely valuable information when monitoring acutely ill patients. The cost effectiveness of modern day pulse oximeters has seen them being widely utilised in both in-hospital and pre-hospital medicine.

The limitations associated with pulse oximetry should always be considered when evaluating results. Failure to do so may paint a confusing picture of the patient.

With the large amounts of money being invested in pulse oximetry research and technology we will no doubt see a continued improvement in the quality and accuracy of data being produced by future designs of the pulse oximeter.

Be Safe Paramedical markets and sells a range of excellent quality pulse oximeters. These include the small finger type to the technologically superior oxygen saturation/ capnograph combination monitor.

Give us a call or drop us an email at info@be-safe.co.za for further information on our range of products.

Written by: Gavin Sutton

www.be-safe.co.za

