Pulse oximetry is sometimes referred to as the fifth vital sign; it is a quick and non-invasive monitoring technique that measures the oxygen saturation in the blood by shining light at specific wavelengths through tissue, most commonly the fingernail bed. Deoxygenated and oxygenated hemoglobin absorb light at different wavelengths, 660 nm, and 940 nm, respectively.

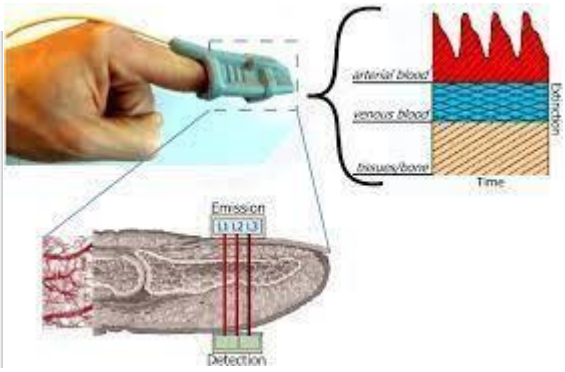
The ***spectrophotometry technique*** is used to determine the peripheral arterial blood oxygen saturation (SpO2) as a marker for the oxygenation of tissues using the Beer-Lambert Law. Pulse oximeter probes have two light emitters and one light detector or sensor aligned to capture the light on the other side of the tissue bed or the reflection of light from a site such as the forehead. Pulse oximeter probes come in single-use adhesive probes or multi-use clips.

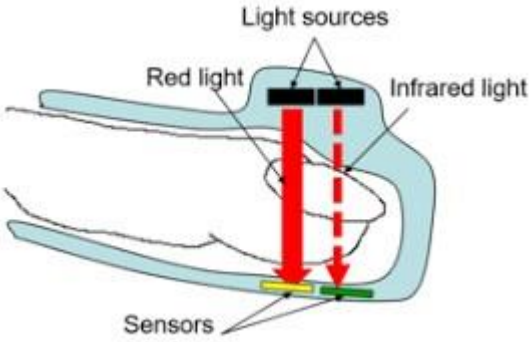
Oxygen saturation levels between 96% and 100% are considered normal at sea level. Healthy individuals living at higher elevations may have lower oxygen saturation levels. Pulse oximeters are usually calibrated to a range of saturation from 70% to 100% with an accuracy of between 2% and 4%, indicating a pulse oximeter reading lower than 70% may not be accurately compared to the gold standard invasive blood gas measurement.

Components

1. A probe is positioned on the finger, toe, ear lobe or nose. Two light-emitting diodes (**LEDs**) produce beams at red and infrared frequencies (*660 nm and 940 nm* respectively) on one side and there is a sensitive photodetector on the other side.
2. The case houses the microprocessor. There is a display of the oxygen saturation, pulse rate and a plethysmographic waveform of the pulse. Alarm limits can be set for a low saturation value and for both high and low pulse rates.







Mechanism of action

1. The oxygen saturation is estimated by measuring the transmission of light, through a pulsatile vascular tissue bed (e.g. finger). This is based on **Beer's law** (the relation between the light absorbed and the concentration of solute in the solution) and **Lambert's law** (relation between absorption of light and the thickness of the absorbing layer).
2. The amount of light transmitted depends on many factors. The light absorbed by non-pulsatile tissues (e.g. skin, soft tissues, bone and venous blood) is constant (DC). The non-constant absorption (AC) is the result of arterial blood pulsations. The sensitive photodetector generates a voltage proportional to the transmitted light.

3. The microprocessor is programmed to mathematically analyze both the DC and AC components at 660 and 940 nm calculating the ratio of absorption at these two frequencies (R/IR ratio).

The result is related to the arterial saturation. The absorption of oxyhemoglobin and deoxyhemoglobin at these two wavelengths is very different.

4. A variable pitch beep provides an audible signal of changes in saturation.

Problems in practice and safety features

1. It is accurate (±2%) in the **70–100%** range. Below the saturation of 70%, readings are extrapolated.
2. The absolute measurement of oxygen saturation may vary from one probe to another but with accurate trends.
3. Carbon monoxide poisoning (including smoking), colored nail varnish, intravenous injections of certain dyes (e.g. methylene blue, indocyanine green) and drugs responsible for the production of methemoglobinemia are all ***sources of error.***
4. Hypoperfusion and severe peripheral vasoconstriction affect the performance of the pulse oximeter.
5. The device monitors the ***oxygen saturation*** with no direct information regarding oxygen delivery to the tissues.
6. Pulse oximeters average their readings every 10–20 s. They cannot detect acute desaturation. *The response time to desaturation is longer with the finger probe (more than 60 s) whereas the ear probe has a response time of 10–15 s*.
7. Excessive movement or malposition of the probe is a source of error.
8. Inaccurate measurement can be caused by venous pulsation.
9. The site of the application should be checked at regular intervals as the probe can cause pressure sores with continuous use.
10. Pulse oximetry only gives information about a patient's oxygenation. It does not give any indication of a patient's ability to eliminate carbon dioxide.

Pulse oximetry - sources of error

MetHb	false low reading
CoHb	false high reading
bilirubin	not a problem
dark skin	not a problem
methylane blue	false low reading
indocyanine green	false low reading
nail vanish	false low reading