Review Article

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Pulse Oximetry

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Abstract

Pulse oximetry is probably the most commonly employed monitoring tool in the emergency department. It is a simple, noninvasive and affordable medical tool that enables monitoring of oxygenation continuously. Like any other medical instrument, it has its own pitfalls and therefore, knowledge of these as well as the correct method of using this device is important for accurate interpretation of results. In this review, we have briefly covered the practical aspects of use of this important monitoring tool.

Key words: Pulse oximeter; Oxyhemoglobin dissociation curve; Oxygenation; Saturation probe.

Introduction

Pulse oximetry is a simple, non-invasive, portable and inexpensive method of continuously monitoring oxygen saturation and heart rate in sick children.

Principle of working of pulse oximetry

The principle of pulse oximetry is based on Beer Lambert's law which states that concentration of an unknown solute in a solvent can be determined by light absorption i.e.

L (out)= L (in) –(D*C*a) where-

L=intensity of light

C=concentration of solution

D= distance the light travels through the solution

a= absorption coefficient of solute

Normally there are two solutes of hemoglobin (Hb) *i.e.* oxyhemoglobin and reduced hemoglobin which absorb light at wavelengths of 940 nm (infra-red) and 660 nm (red) respectively. Pulse oximetry uses these two wavelengths of light to measure oxygen saturation.[1]

The pulse oximeter probe consists of two diodes which emit equal intensities of red and infrared light sequentially into pulsatile tissue bed. The oxygen saturation is calculated by measuring the pulsatile change in light transmission through living tissue with the presumption that this change in light transmission is due to change in intervening blood volume alone. A photo detector placed on the opposite side senses the ratio of red and infrared light based on which the proportion of oxygenated and reduced hemoglobin is estimated.[1]

Pulse oximeters (figure 1) measure

1. The oxygen saturation of haemoglobin in arterial blood – SpO_2
2. The pulse rate - in beats per minute, averaged over 5 to 20 seconds.
3. In some models, a graphical display of the blood flow past the probe.
4. Correlation with PaO_2
5. This can be explained by the oxyhemoglobin dissociation curve. The PaO_2 at any given saturation is a

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Figure 1: Pulse oximeter

function of the oxyhemoglobin dissociation curve. At PaO_2 of 27 mmHg about 50% of the hemoglobin is saturated with oxygen (also known as P_{50}). The PaO_2 varies with the SpO_2 till the curve flattens. After this point further increases in PaO_2 cause little change in saturation (figure 2).[1,2]

To estimate PaO_2 from SpO_2 one may use the 4-5-6 7-8-9 rule.

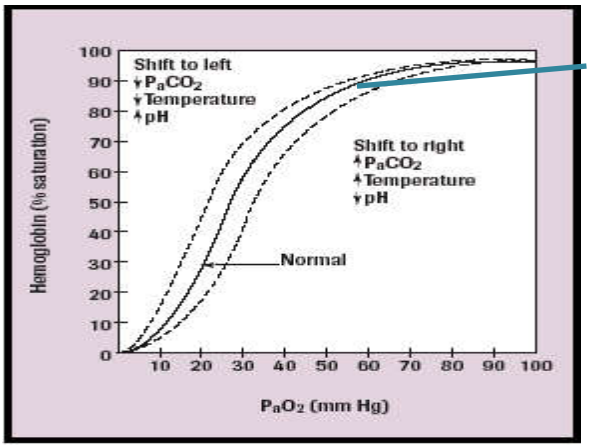
SpO_2= 70 corresponds to PaO_2 of 40 mm Hg

SpO_2= 80 corresponds to PaO_2 of 50 mm Hg and

SpO_2 =90 corresponds to PaO_2 of 60 mmHg 50%

Factors which shift the curve to right include acidosis, high $PaCO_2$, increased temperature, high 2,3- DPG concentration and adult hemoglobin. This results in less oxygen saturation at a given PaO_2 or decreased oxygen affinity. The corresponding changes in the same factors as mentioned above in the opposite direction such as alkalosis, low $PaCO_2$, decreased temperature, low 2-3 DPG concentration and fetal hemoglobin shift the curve to the left thereby increasing affinity of hemoglobin to oxygen or higher oxygen saturations at a given PaO.[1,2]

Figure 2: Oxyhemoglobin dissociation curve



Uses of pulse oximetry[1,2,3]

- Measurement of SpO_2 is considered as the fifth vital parameter in an acutely ill child.
- Used to monitor response to oxygen therapy, resuscitation.
- May be used as an apnoea monitor.
- Used in titration of oxygen therapy.
- Useful for monitoring of vital parameters during transport.
- It may be useful in addition to Allens test to detect ulnar artery patency.

Indications for use

- To measure oxygenation in cases of hypoxia, apnoea, cardiorespiratory diseases etc.
- To monitor response to therapy during resuscitation
- Monitoring side effects of therapy like suctioning, laryngoscopy.

Steps involved in setting up of pulse oximeter

1. Assemble all necessary equipment.
2. If a reusable probe is used then cleanse it with alcohol.
3. Turn monitor on.
4. Apply probe to a site that is well perfused.
5. Ensure both sides of probe are directly opposite to each other.
6. Secure probe in place and avoid bruised or edematous sites.
7. Set high and low alarm limits for saturation and heart rate (usually 2% above and below desired limits.

8. Check correlation of depicted heart rate on monitor and actual heart rate by auscultation.
9. Record heart rate, respiratory rate, SpO_2 and FiO_2 hourly or more frequently.
10. Change the site of application at least once per shift or as when required

Various sites of application of probe

Probe can be positioned on the fingers, toes, hand, foot, wrist or ear.

Pitfalls of pulse oximetry[3,4]

- Pulse oximetry is accurate when oxygen saturation is between 80 – 95.
- Movement by the patient may lead to disrupted signals and artefacts.
- If probe doesn't fit properly light can be shunted from the LEDs directly to photodetector leading to false readings.
- It is not reliable in conditions of severe hypotension(an ear probe might be more reliable).
- It only reflects the state of oxygenation and has no value in estimation of adequqcy of ventilation.

Precautions to be taken while using the pulse oximeter

1. Interference from other light sources can be avoided by covering it with an opaque material.
2. Avoid compromising blood flow to the limb to which the probe is attached e.g. by inflating a B.P cuff.
3. Pulse-oximeters cannot distinguish between different types of hemoglobins e.g. in the presence of carboxyhemoglobin readings may be falsely elevated thus masking hypoxia.
4. Probe should be cleansed and dried before using on another child.

Complications

These are rare and include finger burns and pressure necrosis due to prolonged contact with probe.

Newer technologies in pulse oximetry- Signal extraction technology (Masimo)[3]

Masimo signal extraction technology (SET) enables accuracy of Spo_2 measurement during low perfusion states and movement. While conventional pulse oximetery employs one or two algorithms to attempt to measure patient arterial saturation, Masimo SET employs five algorithms using adaptive filters, working in parallel to ensure accurate measurement in difficult situations like motion or low perfusion.

Common brands available in India

Make	Dealers
Pacetex Model 520 Series 300	Medex
Novamatrix Model 511, 515 C Oxypleth	Rustagi Surgicals
Oxypal Nihon Khoden	Shibumi Medical System
Pulsesense	Meditrin, Mediserve
Nellcor N-180, 185	Instromedix
Dolphin Medical 2100	Rohanika
Ohmeda Biox - 3700, 3800	Phoenix Medical System
Minolta	Draeger, Phoenix Medical System
APACHE, Erkadi	Moolaa Technologies
Invivo	Instrument and Machine
EMCO	EMCO Meditex
Simed	Oticare
Pulseox	Methodex
Criticare 503, 507 series	Criticare India Ltd.
Masimo	Innovative intex Pvt. Ltd.

Key points

1. Pulse oximetry is a simple, non-invasive, portable and inexpensive method of continuously monitoring oxygen saturation and heart rate in sick children.
2. Desired oxygen saturation will vary according to patients' condition.
3. Alarm limits are kept 2% higher and lower than the desired saturation range.
4. Inaccurate readings may be due to poor peripheral perfusion, exposure of probe to light sources, excessive movement of limb, electrical interference from other equipment, any obstruction to blood in that limb (inflated BP cuff) and cool extremities.

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