AAS Guide to Pulse Oximetry

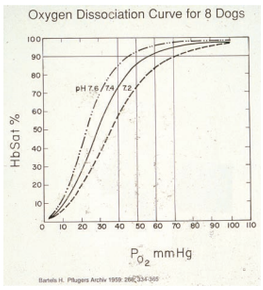
Pulse oximeters have revolutionised anesthesia monitoring because of their ease of use, rapidity of application, reliability as continuous, peripheral pulse monitors and their ability to non-invasively measure haemoglobin (Hb) saturation with O_2 (SpO_2). Pulse oximeters can detect problems in two main areas. First is hypoxia (lack of oxygen delivery to tissue), which is the most common cause of anesthetic mortality; second are changes in pulse strength and regularity - commonly caused by lack of blood flow, bradycardia and dysrhythmias.

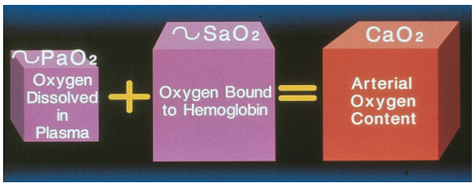
Basic Understanding

Physiology

Tissue O_2 Delivery = Blood Flow x Content of O_2

Blood O_2 Content = Hb concentration x SpO_2 % + O_2 dissolved in plasma



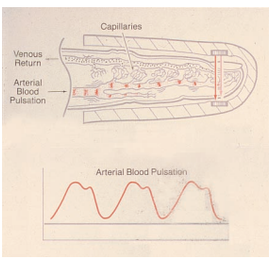


Over 97% of the O_2 is carried on haemoglobin (Hb). Halving the PCV (40 to 20) halves the blood O_2 content but SpO_2 won't change!

O_2 binds to Hb in a sigmoidal relationship so arterial blood SaO_2 should be over 90% to stay above the steep decline on this curve, corresponding to a PO_2 > 60 to 65 mm Hg in dogs. Venous blood SvO_2 is typically 70 to 85%.

Methodology

Pulse oximetry is the continuous non-invasive monitoring of peripheral capillary bed SpO_2 via absorption of infrared light. The absorption characteristics of haemoglobin vary with oxygen saturation.

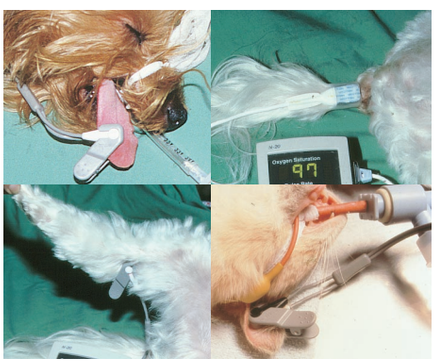


The infrared light must be transmitted through skin or mucosa, subcutaneous tissue, bone and the blood volume filling the capillary bed (the total sum of which = "background absorption"), as well as the arterial pulsatile blood volume (used to determine SpO_2). Pulse oximeter SpO_2 readings decrease because of low Hb O_2 saturation (hypoxemia) or the background light absorption changes (lower blood flow).

SpO_2 Interpretation and Trouble shooting

Sensors application sites

The most useful sites for application of clip type sensors in dogs & cats are the tongue, the lip and the ear in non-pigmented skin. Other useful sites include the paw of cats, across the individual toes of dogs and the thin skin fold above the hock caudal to the tibia. Clipping a small area of hair at the application site (e.g. ear, hock) will improve sensor performance.



Handle tissue (tongue, ear etc) gently when positioning sensors to avoid vasoconstriction which alters SpO_2 readings. In cats and other small patients, folding a surgical swab over the tongue underneath the probe improves performance because this eliminates some light, "damping the signal." Motion artifacts (sensor movement or shivering) and extraneous light reduce pulse oximeter performance.

Black skin absorbs IR light

Dark, pigmented skin absorbs most of the infrared light so pulse oximetry won't work.

Interpretation of SpO_2 readings

SpO_2 and pulse rate normal ranges measured with pulse oximeters

	SpO_2 (%)	Heart Rate (bpm)
Small Dog	87-100	70-150
Large Dog	87-100	55-140
Cat	87-100	100-200
Horse	85-100	20-50

Alarm Settings

SpO_2 measured by a pulse oximeter is generally 2-3% lower than SaO_2 because it reads capillary blood through skin/mucosa. We aim to maintain arterial Hb O_2 over 90% so alarms are typically set at 85% to 87%.

Troubleshooting low SpO_2 readings

1. Look at the patient

- Is there a pulse?
- Is there breathing?
- What is the mucous membrane colour?
- What is happening in surgery? (e.g. pain causes vasoconstriction)

2. Problem management Low Perfusion

- Decrease in capillary blood volume (flow) altering background light absorption:
  - vasoconstriction from painful stimulation
    - consider analgesia
  - poor perfusion caused by deep anesthesia
    - decrease anesthesia
    - increase IV fluids
    - consider inotropes (e.g. dopamine or dobutamine)

Reposition the sensor if there are no signs of hypoxia (below). This will cause the monitor to "re-set" itself using the new blood flow so the SpO_2 reading should improve to what it was prior to the change.

3. Problem management - Hypoxia

- Poor pulmonary dysfunction
  - signs of hypoxia: cyanosis, high HR & RR
  - ensure adequate ventilation: minimum 1 breaths/30 sec (O_2 95%)
  - increase inspired oxygen level
  - improve pulmonary blood flow
- PCV below 15 - 20%: consider transfusion

O_2 by mask

- tight fitting
- 95% from anesthesia breathing circuits
- flow 100 to 200 ml/kg/min.

Test-drive a pulse oximeter

- Does it work effectively on cats?
- Does it recognise alarm states?
  - take probe off patient: see how long until it alarms
  - cardiac arrest: test on a euthanasia patient
- Is it user-friendly?
- Probes wear out & are damaged:
  - how much is a new one?
  - what is the warranty?
- Consider the power supply