

GO Uganda Pulse Oximetry Project

INSTRUCTOR PACK



GO Uganda Oximetry Project

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Go Uganda Oximetry Project

Welcome to the GO Uganda oximetry project!

We are delighted to welcome you as a partner to the GO Uganda oximetry project.

Pulse oximetry is used routinely in anaesthesia practice in many countries in the world, but not commonly in Uganda. It is reliable technology which can detect low oxygen levels immediately and saves thousands of lives every year.

We would like to work with you in a one year project to test the TruSat Pulse oximeter in Uganda. We would like to see whether this equipment works effectively and reliably in your hospitals.

As an anaesthesia provider selected to help with the project, you will undertake a day of training on the use of the oximeter, take a short assessment and then be taught how to record the results from the oximeter in a logbook.

On successful completion of the project we will donate the oximeters to you for use in your hospital.

The project has been generously sponsored by GE Healthcare, the Association of Anaesthetists of Great Britain and Ireland and the World Federation of Societies of Anaesthesiologists.

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PRE COURSE Self Assessment Questions

Name _____ Hospital _____

Before the workshop starts, we would like to find out how much you know about pulse oximetry. Write your answers under the questions. If you do not know the answer, write "Don't know".

1. What two things does a pulse oximeter measure?
 - The pulse oximeter measures the peripheral oxygen saturation of arterial blood (%SpO₂) and pulse rate.
2. How is oxygen carried in the blood?
 - Oxygen is carried in blood combined to haemoglobin; 4 molecules of oxygen combine with each molecule of haemoglobin. A small amount of oxygen is dissolved in blood.
3. Name two factors that might make it difficult for an oximeter to work accurately?
 - Excessive ambient light, movement, inadequate pulse volume (vasoconstriction, shock), carbon monoxide poisoning, nail varnish.
4. What is the normal haemoglobin saturation level?
 - 95% -100%
5. What happens to the pulse oximetry reading when a patient stops breathing?
 - It will fall; there may be a short lag time of a few seconds
6. What happens to the pulse oximetry reading in a cardiac arrest?
 - The pulse oximeter will not pick up a signal
7. In theatre a patient undergoing Caesarean section under GA, has a SpO₂ (saturation) of 82%. Explain what you would do.
 - This is an emergency as the oxygen saturation is very low with serious hypoxia for both mother and baby. Check:
 - Airway? Position of the endotracheal tube?
 - Breathing? Is the patient too deep? Give high flow oxygen.
 - Circulation – check BP and pulse
 - Correct cause and recheck. Change probe position if all appears to be normal.
8. How much does a pulse oximeter cost? How much does the probe cost?
 - Currently, \$2000 for the oximeter, \$80 for the probe

PULSE OXIMETRY – THE BASICS

A pulse oximeter is an essential monitor for use during anaesthesia. It gives information about the patient's oxygen levels (oxygen saturation), and pulse (pulse monitor). It is important to understand how the pulse oximeter works to be able to use the monitor in a safe and effective way.

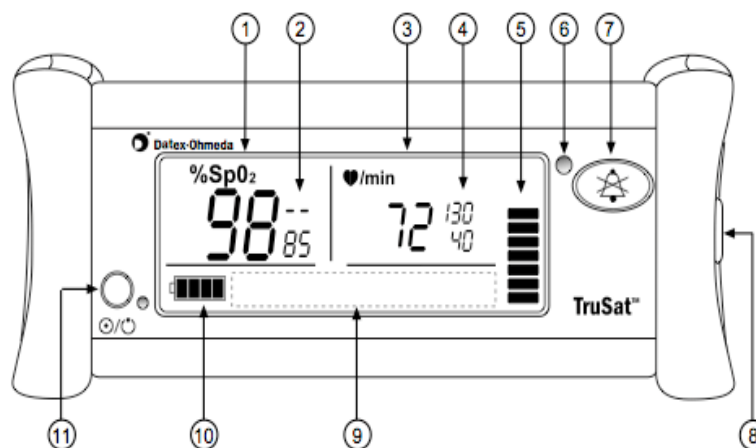
This photo shows the TruSat pulse oximeter in use in Uganda and Vietnam in the Global Oximetry Project.



Features of the TruSat monitor

The figure below shows the display of the TruSat monitor in use in the GO project.

NOTE: The monitor is shown without the handle.



Number	Monitor function
1.	Oxygen Saturation SpO ₂ value
2.	Low SpO ₂ alarm
3.	Pulse rate
4.	Pulse rate alarms
5.	Plethysmographic pulse bar (strength of signal = pulse volume)
6.	Alarm LED
7.	Alarm silence button
8.	Selector button
9.	Display area for on-screen control symbols
10.	Battery indicator
11.	Power Button and AC Power LED

There are TWO numerical values obtained from the pulse oximeter monitor:

- **The oxygen saturation of haemoglobin in arterial blood.** The value of the oxygen saturation is given together with an audible signal which varies in pitch depending on the oxygen saturation. A falling pitch indicates falling oxygen saturation; **this is a valuable clinical sign and should not be ignored.** Since the oximeter detects the saturation peripherally on a finger, toe or ear, the result is recorded as the peripheral oxygen saturation, % SpO₂.
- **The pulse rate** in beats per minute, averaged over 5 to 20 seconds.

In some oximeters there is a display to show the pulse volume detected by the probe. The better the pulse signal, the more accurate are the readings. On the TruSat model there is a pulse volume display (plethysmographic display or 'pleth' trace) which illustrates the strength of the flow being detected.

Basic physiology

Understanding oxygen saturation

Oxygen is carried in the blood bound to haemoglobin in red blood cells. During normal respiration, oxygen is exchanged for carbon dioxide in the alveoli, the terminal air spaces in the lungs. With each breath, oxygen in the inspired air passes across the alveolar membrane into the red blood cells in the lung capillaries to combine with haemoglobin. One molecule of haemoglobin can carry up to four molecules of oxygen after which it is described as "saturated" with oxygen. Most of the haemoglobin in blood combines with oxygen as it passes through the lungs and a healthy individual with normal lungs breathing air will have an arterial oxygen saturation of 95% – 100%.

Oxygen transport to the tissues

An adequate supply of oxygen is required by the tissues at all times for normal respiration and survival of the cells.

- In blood with a haemoglobin concentration of 13g/dl, each 100mls of blood carries 20mls of oxygen combined with haemoglobin. In addition, a very small quantity of oxygen is carried dissolved in the blood.
- The heart normally pumps 5000ml of blood to the tissues each minute which delivers 1000ml of oxygen to the tissues per minute.
- The cells in the tissues extract oxygen for metabolism, normally 250ml of oxygen per minute.
- Anaemic patients have lower levels of haemoglobin and carry less oxygen in their blood but their haemoglobin still combines with oxygen in the same way. Tissue oxygen delivery may be severely compromised with extreme anaemia (Hb<3g/dl)

Any interruption in the uptake of oxygen to the blood will result in reduced oxygen delivery to the tissues and a reduced oxygen saturation, which is called hypoxia.

Hypoxia can occur for a number of reasons under anaesthesia as described in table 1. Airway obstruction is probably the most common cause of hypoxia. The mnemonic ABLE is useful to remember the common causes of hypoxia during anaesthesia.

Table 1. Causes of hypoxia in theatre – ‘ABLE’

	CLINICAL EXAMPLE
A Airway	<ul style="list-style-type: none"> • Obstructed airway e.g. tongue, laryngospasm, secretions, displaced tracheal tube or LMA, oesophageal intubation
B Is the patient breathing adequately?	<ul style="list-style-type: none"> • Depression of respiration due to drugs • Inadequate respiration due to high spinal
L Are the lungs working normally?	<ul style="list-style-type: none"> • Problem interfering with the transfer of oxygen to the arterial blood (infection/pulmonary oedema/lung collapse/bronchospasm)
E Is the equipment working properly?	<ul style="list-style-type: none"> • Oxygen cylinder empty • Oxygen concentrator malfunction • Obstruction in breathing circuit

What does a pulse oximeter measure?

The pulse oximeter measures the oxygen saturation of haemoglobin in arterial blood. It gives an **early warning** of falling oxygen saturation and hypoxia. Severe hypoxia will lead to critical tissue oxygen deprivation and cardiac arrest.

Hypoxia can be detected clinically - the patient will have blue lips and tongue (central cyanosis) – but this may be difficult to see, for instance in poor lighting, or may not be obvious if the patient is very anaemic. **An oximeter therefore allows early detection of hypoxia and allows the anaesthetist to intervene early to prevent cardiac arrest.**

How does a pulse oximeter work?

A pulse oximeter consists of:

- a peripheral probe which is the sensing device
- a microprocessor unit
- a display device showing the oxygen saturation and pulse rate. In some models the display shows the pulse volume detected by the sensor (pleth trace).

Most oximeters also have an audible pulse tone, the pitch (note) of which relates to the oxygen saturation – the pitch falls as the saturation falls.

The oximeter probe consists of two parts, the light emitting diodes (LED's) and a photodetector. One LED is in the visible red spectrum (light wavelength 660nm) and the other in the infrared spectrum (light wavelength 940nm). The beams of light pass through the tissues to the photodetector. Some of the light is absorbed by the blood as it pulsates through the tissues, some by the non-pulsatile elements such as the venous or capillary blood or other tissue pigments.

The light absorbed by blood varies with the oxygen saturation of haemoglobin; this is the physical principle on which the oximeter works. The microprocessor unit compares the ratio of absorbance of the two wavelengths of light and subtracts the constant absorbance from the pulsatile element. The microprocessor compares the ratio of absorption at the two light wavelengths measured with these stored values, and then translates this into a value for the oxygen saturation (SpO₂) with a digital and an audible tone of varying pitch.

In order for the pulse oximeter to function correctly it must be placed where a pulse can be detected. There are several different designs of pulse oximeter probe, but in all cases, whether on finger, ear lobe or nose, the LED's must face the photodetector in order to detect the light as it passes through the tissues.

The pulse oximeter is prone to interference due to movement, shivering, or the effects of ambient light. Several recent advances in microprocessor technology have reduced the effects of interference on pulse oximeter function. Time division multiplexing, whereby the LED's are cycled: red on, then infrared on, then both off, many times per second, helps to eliminate background interference.

Saturation values are averaged out over 5 to 20 seconds. The pulse rate is also calculated from the number of LED cycles between successive pulsatile signals and averaged out over a similar variable period of time, depending on the particular monitor. The readings on the pulse oximeter may therefore lag behind the true values for oxygen saturation or pulse rate by 5 to 20 seconds. If in doubt, use your clinical judgement!

Factors interfering with the function of a pulse oximeter

The function of a pulse oximeter is affected by many variables, including:

- **Ambient light** – bright light directly on the probe may affect the reading. Remember to shield the probe from direct light.
- **Shivering** – movement may make it difficult for the probe to pick up a signal.
- **Pulse volume** – the oximeter depends on a pulsatile flow. When the blood pressure is low due to hypovolaemic shock, or the cardiac output is low or the patient has an arrhythmia, the pulse may be very weak and the oximeter will not be able to detect a signal.
- **Vasoconstriction** reduces blood flow to the peripheries and the oximeter often fails to detect a signal.
- **Carbon monoxide poisoning** (from patients who have been in fires). Carboxyhaemoglobin (haemoglobin combined with carbon monoxide, rather than oxygen), is interpreted by the oximeter as oxyhaemoglobin. The oximeter may read 100% even though the true oxygen saturation is very low and the patient may be very hypoxic.

What the pulse oximeter does not do:

The pulse oximeter does not give direct information on:

- The respiratory rate or tidal volume or the adequacy of carbon dioxide clearance.
- The cardiac output or blood pressure (although problems in detecting a pulse may indicate that the blood pressure is low)
- The overall oxygen content of the blood as this depends on the haemoglobin level in the blood. If a patient is severely anaemic, the oxygen saturation may be normal (95%-100%) but insufficient oxygen may be carried to the tissues as the haemoglobin is low.

Practical use of pulse oximeter

- The oximeter has a rechargeable battery. It should be plugged in to an electrical socket at all times if possible to maintain the charge on the batteries for when mains electricity fails.
- Turn the pulse oximeter on: it will go through calibration and check tests.
- Select the probe you require with particular attention to correct sizing and where it will go (usually finger, toe or ear). If used on a finger or toe, make sure the area is clean (remove any nail varnish).
- Position the probe carefully; make sure it fits easily and without too much pressure.
- Allow several seconds for the pulse oximeter to detect the pulse and calculate the oxygen saturation.
- Look for the pleth trace (or a displayed waveform in some models), indicating that the machine has detected a pulse. Without a detected pulse, any reading is meaningless. Choose a site for the oximeter probe that gives the best pleth trace.
- You can use the Perfusion Index ('Pir value') as a guide to find the best site for the probe: the higher the 'Pir', the better the signal
- Once the unit has detected a good pulse waveform, the oxygen saturation and pulse rate will be displayed.
- Like all machines, oximeters may **occasionally** give a false reading - if in doubt, rely on your clinical judgement, rather than the machine.
- Top tip: Systolic blood pressure can be estimated by noting the pressure at which the pleth trace reappears during deflation of a blood pressure cuff positioned on the same limb.

Setting the alarms on the pulse oximeter

Alarms are there to warn you of dangerously low oxygen saturations and abnormally high or low pulse rates. In a normal fit adult, the low oxygen saturation alarm should be set at SpO₂ 90% and heart rate alarm at less than 50 or greater than 120 beats / minute. Children require the same oximetry alarm settings, but the alarms for heart rate should be adjusted according to age.

Years of age	Normal Heart Rates for Children
Newborn -3 months	85 - 205
3 months – 2 years	100-180
2-10 years	60-140
>10 years	50-90

- If the **low oxygen saturation** alarm sounds, check the airway and make sure that the patient is breathing adequately. Lift the chin or apply other airway manoeuvres as appropriate. Give oxygen if necessary. Call for help. If everything appears fine, try changing the probe to a different finger.
- If the **no pulse signal** is picked up, or the pulse signal disappears, feel for a central pulse. If there is no pulse, call for help, start the procedures for Basic and Advanced Life Support. If there is a pulse, try repositioning the probe, or put the probe in a different place. If the patient is shocked, start resuscitation.
- On most pulse oximeters, the alarm limits for oxygen saturation and pulse rate can be altered according to your needs. However, do not alter an alarm just to stop it sounding - it could be telling you something important. The normal oxygen saturation should be 95%-100%.

Caring for your Pulse Oximeter

The TruSat pulse oximeter is a delicate and expensive piece of equipment and needs to be carefully looked after. The probes are particularly fragile and need special care.

- Remove dust, blood or dirt gently with warm slightly soapy water. Mild bleach is fine for blood stains. A 70% alcohol swab (like those used before blood sampling) is also acceptable.
- Do NOT allow the pulse oximeter or the probe to fall on the ground.
- Do NOT twist or yank the cable, and pay special attention to connecting and disconnecting the cable carefully.
- Do NOT autoclave or sterilize the probe.
- Do NOT expose the oximeter to excessive heat.

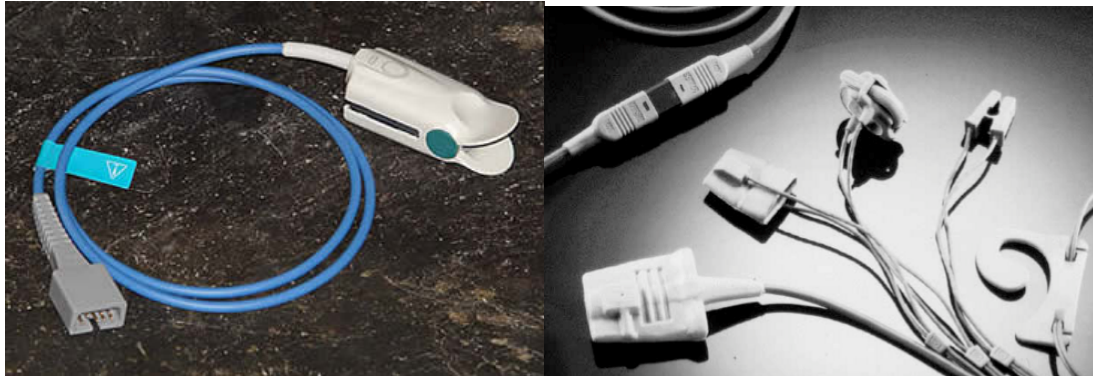
Answers to Self Assessment Questions

1. What does a pulse oximeter measure?
 - An oximeter measures the percentage of haemoglobin saturated with oxygen in peripheral blood = SpO₂.
2. Name two factors that might make it difficult for an oximeter to work accurately?
 - Poor blood flow under the probe (vasoconstriction due to cold or shock), bright lights shining on the probe, nail varnish and patient movement can all cause problems.
3. How should blood be cleaned off the probe?
 - Wash gently with soap and water, an alcohol swab or dilute bleach.
4. What happens to the pulse oximeter reading when a patient stops breathing?
 - Initially the saturation would be normal and would quickly fall as the patient becomes hypoxic. The alarm should sound as soon as the saturation drops below 90%.
5. What happens to the pulse oximeter reading in a cardiac arrest?
 - The pulse will disappear so the oximeter will stop detecting any flow and the no pulse detected alarm will sound.
6. In theatre a patient undergoing Caesarean section under GA, has a SpO₂ of 82%. Explain what you would do.
 - This is an emergency as the oxygen saturation is very low with serious hypoxia for both mother and baby. Check:
 - Airway? Position of the endotracheal tube?
 - Breathing? Is the patient too deep? Give high flow oxygen.
 - Circulation – check BP and pulse
 - Correct cause and recheck. Change probe position if all appears to be normal.

PULSE OXIMETRY - CLINICAL APPLICATION

The oximeter probe

The oximeter probe is the most delicate part of a pulse oximeter and is easily damaged. Take great care to handle the probe carefully and never leave it in a place where it could be dropped on the floor. The probe connects to the oximeter using a connector with a series of very fine pins that can be easily damaged – see photo. Always align the connector correctly before attempting to insert it. Never pull the probe from the machine by pulling on the cable; always grasp the connector firmly between finger and thumb.



Hinged finger probe showing connector sensor

Rubber finger probes and ear

that can only be connected one way by aligning the gap on the bottom with the oximeter lead

When not in use, the oximeter probe may be loosely coiled for storage or carrying, but should not be coiled too tightly as this will damage the wires inside the cable.

Probes are designed either for use on the finger or toe, or for the ear lobe. They are of different types as shown in the photo. Rubber probes are the most robust, but the wrap around type may constrict the blood flow through the finger if put on too tightly. Hinged probes are the most popular, but are easily damaged. Ear probes are lightweight and are useful in children or if the patient is very vasoconstricted. Small probes have been designed for children but an adult hinged probe may be used on the thumb or big toe of a child. The correct orientation finger or toe probes are marked by the manufacturer according to the position of the nail bed which is marked on the probe.

When in use the probe emits a red light; check that you can see this light to make sure the probe is working properly. The sensor is on the other part. The lens and sensor should be kept clean. Use slightly soapy water or an alcohol soaked swab to **gently** clean dust, dirt or blood from the probe.

In order to get a satisfactory reading the probe must detect adequate blood flow. If no signal is obtained on the oximeter after the probe has been placed on a finger, a number of factors should be excluded.

- Low perfusion – check for cold or hypotension (hypovolaemia, cardiac or septic problems). If the patient is cold, gentle rubbing of the digit or ear lobe may restore a signal. Resuscitation will improve the other situations.
- The probe is not on correctly. Try another location.
- If you are uncertain if the probe is working, put it on your own finger to check.

Does a pulse oximeter measure the same parameters as arterial blood gases?

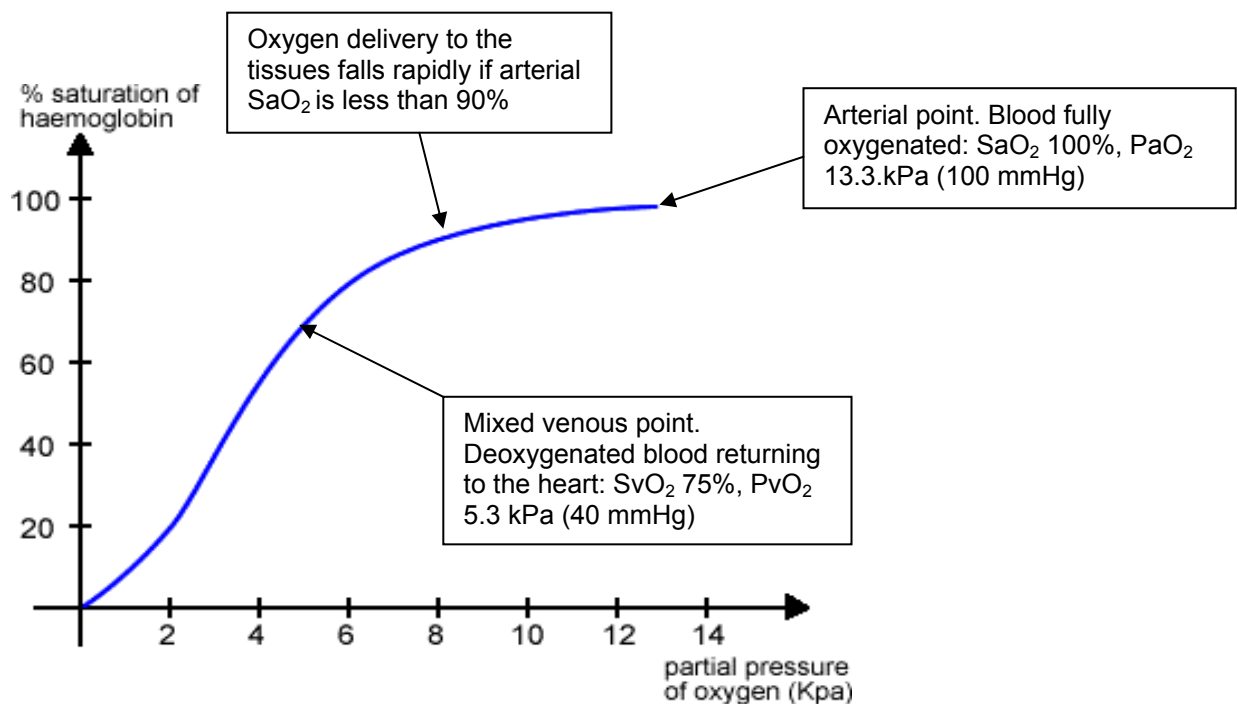
As previously explained, the pulse oximeter detects the oxygen saturation of haemoglobin in arterial blood. A blood gas analyser may be used to measure the oxygen content in a blood sample ('arterial blood gases'). The blood gas analyser describes the gas content as a partial pressure: it measures the partial pressure of oxygen (PaO_2) and carbon dioxide (PaCO_2), also the pH of the blood and the bicarbonate concentration.

What is partial pressure? – The atmosphere is made up of a mixture of gases at a pressure of one atmosphere, 101kPa or 760mmHg. Oxygen is 21% of the atmosphere and the partial pressure of oxygen in air is 21kPa or 150mmHg. When blood is exposed to gases, the gas crosses into the blood down the pressure gradient. The partial pressure of oxygen and carbon dioxide in blood can be measured by placing a sample of blood in a 'blood-gas machine' which is used to assess the efficiency of oxygenation and ventilation. Oxygen saturation measured with a pulse oximeter gives a more useful minute-to-minute measurement of oxygenation, but gives no information about CO_2 or pH.

The Oxygen Dissociation curve

The relationship between the partial pressure of oxygen and the oxygen saturation is shown by the oxygen dissociation curve. As the partial pressure of oxygen in blood increases, so does the oxygen saturation. The sigmoid shape of the oxygen dissociation curve reflects the cooperative interaction between haemoglobin and four oxygen molecules.

Some arterial gas analysers use the partial pressure of oxygen to estimate the haemoglobin saturation from a computer in the analyser, but this measurement is not as accurate as one measured by an oximeter.



Gas exchange occurs in the lungs. The lungs are reloaded with fresh oxygen with each breath. Oxygen at a high partial pressure (PaO_2 13kPa or 100 mmHg) drives oxygen on to the haemoglobin until 95 – 100% is saturated. Haemoglobin releases oxygen as the blood passes through the tissues. The partial pressure of oxygen in blood returning from the tissues (mixed venous blood) is much lower than in arterial blood (PaO_2 5.3 kPa or 40mmHg).

The oxygen dissociation curve is initially steep, and then flattens out (sigmoid shape). The most important aspect of the oxygen dissociation curve is that as the oximeter reading falls below 90%, the partial pressure of oxygen in the blood drops very rapidly and oxygen delivery to the tissues is reduced and may lead to cardiac arrest. You must intervene swiftly if the oxygen saturation drops below 90%.

Clinical use of the oximeter

Oxygen saturation is a very useful measurement clinically, but unless it is interpreted correctly and appropriate action taken, the use of an oximeter will not benefit the patient.

Oxygen gets to the tissues from the atmosphere by inhalation into the lungs, transfer to arterial blood, loading on to haemoglobin, transport by blood pumped to the tissues and finally released via the capillaries to the cells. Interruptions to the oxygenation process may occur at any point, and during anaesthesia low oxygen saturations must be treated immediately and appropriately. For example if the patient has an obstructed airway and is unable to breathe effectively to get oxygen into the lungs, clearing the airway is the correct immediate action rather than administering extra oxygen.

Whenever faced by low saturations the problem is normally caused by one or more of the following factors which need specific management (remember: **ABLE**)

A Airway	<ul style="list-style-type: none"> • Airway obstructed? 	Look, listen and feel. <ul style="list-style-type: none"> • Chin lift, jaw thrust • Consider oropharyngeal airway • Treat laryngospasm • Check tracheal tube/LMA • Suction airway
B Is the patient breathing adequately?	<ul style="list-style-type: none"> • Drugs? • High spinal? • Bronchospasm? 	Look, listen and feel. <ul style="list-style-type: none"> • Assist ventilation • Check depth of anaesthesia • Listen for wheeze
L Are the lungs working normally?	<ul style="list-style-type: none"> • Infection? • Pulmonary oedema? • Trauma/pneumothorax? • Lung collapse? 	Look, listen and feel <ul style="list-style-type: none"> • Suction airway • Assist ventilation • Listen to both lungs – tube down too far? • Consider chest X-ray
E Equipment	<ul style="list-style-type: none"> • Oxygen cylinder empty? • Oxygen concentrator malfunction? • Obstruction in breathing circuit? 	Check equipment <ul style="list-style-type: none"> • Oxygen supply • Breathing circuit

When faced with low oxygen saturations the anaesthetist must assess the situation using clinical skills thinking through the different possibilities – airway, breathing, lungs, equipment, solving any problems as they are diagnosed. Remember, the oximeter gives you an early warning of falling oxygen saturation – it is important that you **intervene early** to prevent cardiac arrest.

What is a normal oxygen saturation?

A healthy individual has an arterial saturation of 95 -100%. A saturation of 93- 94% is abnormal but may occur during anaesthesia due to less efficient oxygenation. It should always be investigated and treated. A saturation of less than 93% is highly abnormal and should be taken seriously by diagnosing the problem, increasing the oxygen and rechecking. Levels below 90% represent serious hypoxia.

Clinical scenario workshop

Discuss the problems in each case, deciding why the SpO₂ is low (ABLE) and what the most appropriate action should be.

1. A 12 year old child is scheduled for elective anaesthesia for foot surgery. The patient is ASA 1 and is induced with thiopentone then given halothane in air and oxygen via a face mask. During the induction the patient starts to cough and gets laryngospasm. The SpO₂ which started at 98% falls to 88% during coughing and then to 74% when laryngospasm occurs. Discuss with your class colleague – why has the saturation fallen, what would be the most appropriate actions?

- Learning points: – airway obstruction, early warning with SpO₂ starting to fall, actions to take

2. A 56 year old obese patient is undergoing a laparotomy for bowel obstruction. Preoperatively he is reasonably fit and his SpO₂ is 95%. After rapid sequence induction and intubation, the patient is ventilated and anaesthesia maintained using halothane in air with 30% oxygen. Over the next 10 minutes the patients SpO₂ falls to 85%. What are the most likely causes and what action would you take?

- Learning points: – check ET, mode and effectiveness of IPPV, lung collapse in the obese, increasing FiO₂, rechecking;? aspiration

3. During a Caesarean section under spinal anaesthesia, a fit 23 year old primigravida complains of tingling in the fingers and difficulty breathing. The SpO₂ falls from 97% to 83%. What are the most likely causes and what action would you take?

- Learning points: – breathing, high spinals, oxygenation, implications for the baby)

4. In recovery, following a soft tissue knee operation under face-mask anaesthesia, a 43 year old patient is reported to have a SpO₂ of 77%. What are the most likely causes and what action would you take?

- Learning points: - ABC, effects of anaesthesia drugs in recovery period, position, drugs, aspiration.

5. In recovery, following a laparotomy under relaxant anaesthesia, a 43 year old patient is reported to have a SpO₂ of 77% and making twitching, jerky movements. What are the most likely causes and what action would you take?

- Learning points: – in addition to above – role of muscle relaxants.

6. Following a road traffic accident 3 days previously, a patient with 5 fractured ribs is found to have an SpO₂ of 83%. He is not on oxygen, but is in a great deal of pain. What are the most likely causes and what action would you take?

- Learning points: – pain, ineffective respiratory pump, lung contusion and collapse.

7. In a patient undergoing splenectomy following an RTA, the pulse oximeter which was showing a pulse rate of 120 beats / min and an SpO₂ of 94%, stops reading and alarms. What are the most likely causes and what action would you take?

- Learning points: – poor signal, cool peripheries, need for resuscitation etc.

PRACTICAL DEMONSTRATION OF THE TRUSAT OXIMETER

In the previous two tutorials the theory and practical clinical application of pulse oximetry was reviewed. During this tutorial you will learn to use the TruSat oximeter and will be assessed on the different functions.

1. How should the oximeter be left when not in use and how do you clean the probe?

The oximeter should be left switched off and plugged into the mains to charge the oximeter's internal battery. The green light on the front of the oximeter is illuminated to show mains supply. SpO₂ cables should be gently cleaned with soapy water, an alcohol swab or dilute bleach. DO NOT submerge in water or wet the electrical connection. When not in use the cable should be gently coiled and stored neatly.

2. How do you select the most appropriate sensor and how do you connect it to the monitor?

Oximeter sensors are chosen by the size of the patient and the site where you will use them. Adult sensors are generally applied to either the finger or the ear lobe. Paediatric and neonatal sensors can also be applied to toes and feet. Adhesive sensors can be used if the patient is moving excessively as movement may interfere with the measurement. The sensor is connected to the back of the monitor, taking care to align the probe in the correct orientation. DO NOT force the probe into the monitor – check the alignment first.

3. How do you connect the selected sensor to the patient?

The sensor should be applied to a clean, well perfused site. Adult finger probes are marked to indicate which way up they should be used. Adhesive sensors should be wrapped gently around the finger (or side of the hand in a neonate) so that the LED light shines through the tissues to reach the sensor.

4. What conditions could cause inaccurate readings?

These may include: excessive ambient light, electrical interference, excessive motion, low perfusion, low signal strength, incorrect sensor placement, poor sensor fit.

5. When should you change the position of the sensor?

Watch for signs of skin reddening, blistering or discolouration. The probe must be moved otherwise there is the risk of ischemic skin necrosis or skin erosion.

6. How can you tell when the battery is running low?

The battery indicator comprises of 4 shaded segments. The number of segments decreases as the charge decreases. If no segments are displayed and the indicator is flashing the oximeter can only be powered for 10 to 60 minutes longer and should be re-connected to AC power.

7. How do you maximise the life of the battery?

Where possible, always keep the battery on charge using the dedicated charger. To extend battery life, fully charge the battery at least once a month and fully discharge the battery every six months.

To discharge the battery use battery power to monitor a patient until only one segment of the battery indicator is shaded. Then reconnect the oximeter to the AC supply.

The battery capacity of the Oximeter is sufficient to power it for 32 hours when fully charged (24hours for the TD version). Continuous use of the backlight reduces the time by approximately 50%.

The charging time to full capacity is typically 3 hours.

8. What is the start up routine for using the oximeter?

Press the power button to power ON and verify the following during start up:

- The power-on tones sound.
- All display elements, including on-screen symbols, illuminate briefly
- The alarm LED is lit red, then yellow
- The backlight is ON until dashes are displayed for the SpO₂ and pulse rate. The backlight remains 'on' if it is set to ON.
- (TD option only) A patient number (P01,P02, etc) is displayed.

9. What are the values in the main oximeter display?

The left hand side displays the Oxygen Saturation value (SpO₂) and the associated high and low alarm limits.

The right hand side displays the pulse rate value and the associated high and low alarm limits.

10. What does the plethysmographic pulse bar (pleth bar) show?

The plethysmographic pulse bar (pleth bar) indicates the pulse strength. The pulse strength is considered low when only four pleth bar segments pulsate. When the sensor is first attached to the patient the pleth bar will slowly rise and descend indicating that the oximeter is searching.



11. How do you use the 'ComWheel' to adjust the alarm limits?

The ComWheel is on the right hand side of the oximeter. Press the ComWheel once to display the pointer (◀ or ▼). The backlight temporarily switches ON (if OFF). The on-screen symbols are displayed for several seconds.

Turn the ComWheel to move the pointer.

As you turn the ComWheel the pointer appears beside each alarm limit value or above each on-screen control symbol. Press the ComWheel when it is adjacent to the alarm limit that requires adjustment. Turn the ComWheel to adjust the alarm limit to the value required. Press the ComWheel to confirm the value. The display will return to the normal screen after a few seconds

12. How do you use the ComWheel to adjust the Pulse Beep and Alarm Volumes?

Press the ComWheel once to display the pointer (◀ or ▼). Rotate the ComWheel to select the Pulse Beep Volume or Alarm Volume.

Press the ComWheel and, when the pointer flashes, turn the ComWheel to adjust the volume. Press the ComWheel to confirm the new value.

13. How do you turn the backlight ON or OFF?

Press the ComWheel once to display the pointer (◀ or ▼). Rotate the ComWheel to select the Backlight Symbol.

Press the ComWheel to toggle the status of the backlight. When the oximeter is switched ON the backlight setting is the same as when the oximeter was last switched OFF.

14. What do the various alarms mean?

The alarm LED besides the Alarm Silence Button indicates the presence of an alarm and the alarm priority.

LED Status	Priority	Meaning
RED ON or RED flashing	HIGH	Serious situation requiring an immediate response: <ul style="list-style-type: none">• SpO₂ LOW• Sensor Off – dashes are displayed• System Error or Sensor Error• Battery completely depleted
YELLOW flashing	Medium	Situation requiring a prompt response: <ul style="list-style-type: none">• Pulse Rate too HIGH or LOW• Low Battery
YELLOW ON	Low	Alarms are silenced OR Situation requiring your attention: <ul style="list-style-type: none">• Continuous Severe Motion –displayed SpO₂ value alternates with dashes.

15. How do you silence the alarms?

WARNING: When alarms are silenced, you must observe the patient carefully.

A tone sounds each time you press the alarm silence button.

Press the Alarm Silence button once to silence the alarm for two minutes. To silence the alarms indefinitely, press the Alarm Silence button 3 times in quick succession. The alarm silence indicator is displayed at the upper right of the screen. When the alarms are silenced indefinitely it will flash. To cancel the alarm silence, press the Alarm Silence Button once again.

16. How do you lock and unlock the oximeter settings?

Press the ComWheel 5 times in quick succession, holding it down for five seconds on the fifth press. A tone sounds and the lock indicator appears/disappears on the display.

WARNING: When you silence alarms indefinitely and then lock the oximeter, only visual alarm signals are activated when alarms occur. Audible alarm signals are all silenced.

17. What is the 'Pir' pulsatile value?

Pir is a relative value that varies from patient to patient. It is the perfusion index measurement and is a clinical tool that provides a numeric indication of the perfusion at the measurement site. It indicates the strength of the pulse signal – the higher the Pir value, the stronger the pulse signal. A strong pulse signal increases the validity of SpO₂ and pulse rate data. Always select the site with the highest Pir value.

18. How do you monitor the Pir value?

Press the ComWheel once to display the pointer (◀ or ▼). Rotate the ComWheel until the pointer is over the Pir symbol. Press the ComWheel to display the Pir value. Press the ComWheel again to return to the normal display.

Competency Test TruSat Pulse Oximeter

Following the demonstration and time for practice students will sit a practical assessment on the above principles.

1. Describe how to charge the oximeter's battery and store the accessories ready for clinical use.
2. Select the most appropriate sensor for the patient.
3. Correctly apply the sensor to the patient.
4. Demonstrate an understanding of conditions that could cause inaccurate readings.
5. When to frequently change the sensor site.
6. Understand the battery condition indicator.
7. Demonstrate how to manage the battery performance.
8. Be able to switch the monitor on and understand the self check routine.
9. Understand the main display.
10. Understand the Plethysmographic Pulse Bar (Pleth Bar).
11. Use the ComWheel to adjust the alarm limits.
12. Use the ComWheel to adjust the Pulse Beep and Alarm Volumes.
13. Turn the backlight on or off.
14. Understand and interpret the various alarm conditions.
15. Silence the Alarm, temporarily and permanently.
16. Lock and Unlock the oximeter
17. Demonstrate an understanding of the Pir numeric value
18. How to monitor the Pir value.

GO Uganda – Final Assessment answers

This short assessment will be taken at the end of the day of instruction on the TruSat and again at 3, 6 and 12 months. The test will reveal whether the anaesthesia provider has reached the level of knowledge to allow safe and effective use of the oximeter, and also the correct care of the device. There are three sections – multiple choice questions, data interpretation and a practical assessment on the TruSat.

Multiple Choice Questions

Correct answers highlighted:

1. The pulse oximeter measures:
 - a. Haemoglobin level in blood
 - b. How much oxygen is contained in the blood
 - c. Percentage of haemoglobin saturated with oxygen
 - d. Heart rate
 - e. Cardiac output
2. About oximeter probes:
 - a. Ear probes tend to read higher than finger probes
 - b. Probes cost around \$20
 - c. Avoid using soap to clean the probe
 - d. If a signal is not picked up, the probe is always faulty
 - e. Nail varnish does not affect probe function
3. The following may cause false readings on a pulse oximeter:
 - a. Black skinned patients
 - b. Fast heart rates with normal blood pressures
 - c. Overhead lights shining on probes
 - d. Carbon monoxide poisoning
 - e. Oxygen treatment
4. Oxygen saturation:
 - a. Should always be 100% during anaesthesia
 - b. In a 2 year old is normally above 95%
 - c. In a 70 year old is normally less than 95%
 - d. Only becomes seriously low when under 75%
 - e. Is not worth measuring during spinal anaesthesia for Caesarean Section
5. The following may reduce the chance of a successful oximeter reading:
 - a. Pyrexia
 - b. Hypertension
 - c. Sickle cell disease
 - d. Arrhythmia
 - e. Hypovolaemia
6. When caring for your oximeter:
 - a. The lead should be detached after each use
 - b. The probe should be cleaned after every patient
 - c. The battery should always be kept fully charged
 - d. After an HIV patient, the oximeter and probe should be autoclaved
 - e. The oximeter should be left on all the time when not in use

Answer the following questions:

1. What should be the pulse rate alarm settings for:
 - a. A fit adult male aged 35 years? Lower 50/ min Upper 100/min
 - b. A one year old infant? Lower 80/min Upper 160/min
2. What is the correct way to store the probe? Gently coiled
3. How much does a TruSat cost? \$2000
4. What does a probe cost to replace? \$80
5. How long does the battery last after a full charge? 32 hours (continuous use of backlight reduces this by 50%)

Clinical scenarios

1. In an adult undergoing anaesthesia with ketamine for an ankle operation the saturation becomes 77%. What should you do?
 - ABC, give oxygen
2. During a Caesarean section under spinal anaesthesia, the SpO₂ falls to 85% - what should you do?
 - ABC, give oxygen
3. A man is scheduled for a hernia repair under GA. His haemoglobin saturation before induction is 88%. What should you do?
 - Examine patient and find cause – consider local anaesthesia if operation required. GA is not acceptable in an elective case who is hypoxic.
4. During surgery on a fractured femur, the pulse oximeter stops picking up a signal – what are the possible diagnoses?
 - Check ABC. Hypovolaemia? Probe correctly attached?

TruSat demonstration.

The candidate must:

1. Connect the probe and mains lead to the TruSat
2. Demonstrate how to switch on the TruSat and start to measure haemoglobin saturation using a finger probe.
3. Demonstrate how to clean the probe
4. Adjust the lower heart rate alarm to 50 beats / min
5. Adjust the lower oximetry alarm to 93%
6. Demonstrate how electronic menu works

Uganda Global Pulse Oximetry Project

This is to certify that

has been trained to operate
the TruSat pulse oximeter
Kampala 2007



Signed by

GO UGANDA LOGBOOK AND AUDIT

As one of the GO Uganda partners you are required to use your TruSat on every patient you anaesthetise. You must keep an audit of all the patients you care for and record the details of the surgery, anaesthesia and oximeter readings. The project is designed to find out if there are any problems using the oximeters effectively in Uganda, and whether the equipment works reliably.

The project officer Dr, will visit you after 3, 6 and 12 months to collect your logbooks and data collected. He will examine your records and ask you to describe some of the cases you have looked after. He will examine the oximeter and probe and will also repeat the assessment you passed earlier today. This is to test how effective the teaching on this course has been.

If you have had any problems with your oximeter or probe, he will consider the best way to solve the problem with you.

If you manage to complete a full 12 months in the project, the oximeter will become your personal property to use for the rest of your anaesthesia career!

In order to understand how to complete the logbook, try filling in the logbook for the following cases:

1. A 6 year old child under ketamine anesthesia for reduction of a dislocated elbow. Saturations above 95% at all times.
2. A 23 year old adult induced with thiopentone and then maintained on halothane anaesthesia for incision and drainage. At incision he developed laryngospasm and his saturations fell to 77%. They improved with airway management and additional oxygen.
3. In recovery a patient developed a saturation of 82% lying on his back following a laparotomy. Anaesthesia was with endotracheal intubation following thiopentone and suxamethonium. Maintenance was with ether. He improved when turned on his side and his airway opened.
4. A Caesarean Section under spinal anaesthesia developed a saturation of 92% with mild difficulty in breathing. Her airway and breathing were satisfactory. BP was 75 mmHg systolic. She responded to left lateral tilt, oxygen and fluid.

Let's GO!

