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Using Pulse Oximeters

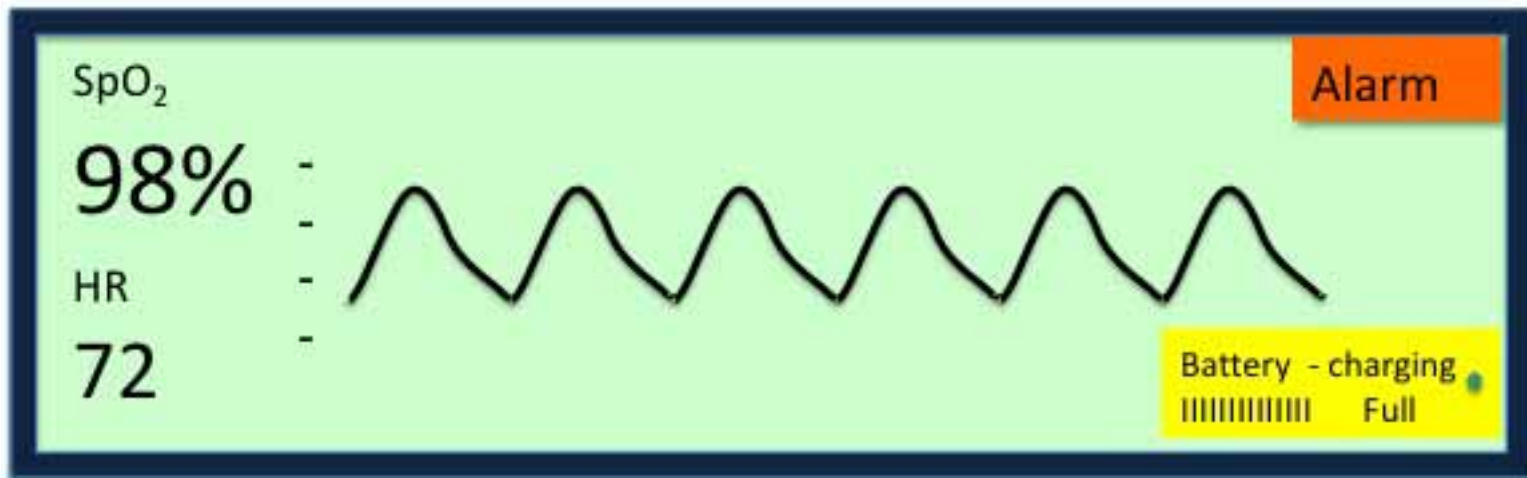
Tutorial 1 – the basics

The Pulse Oximeter

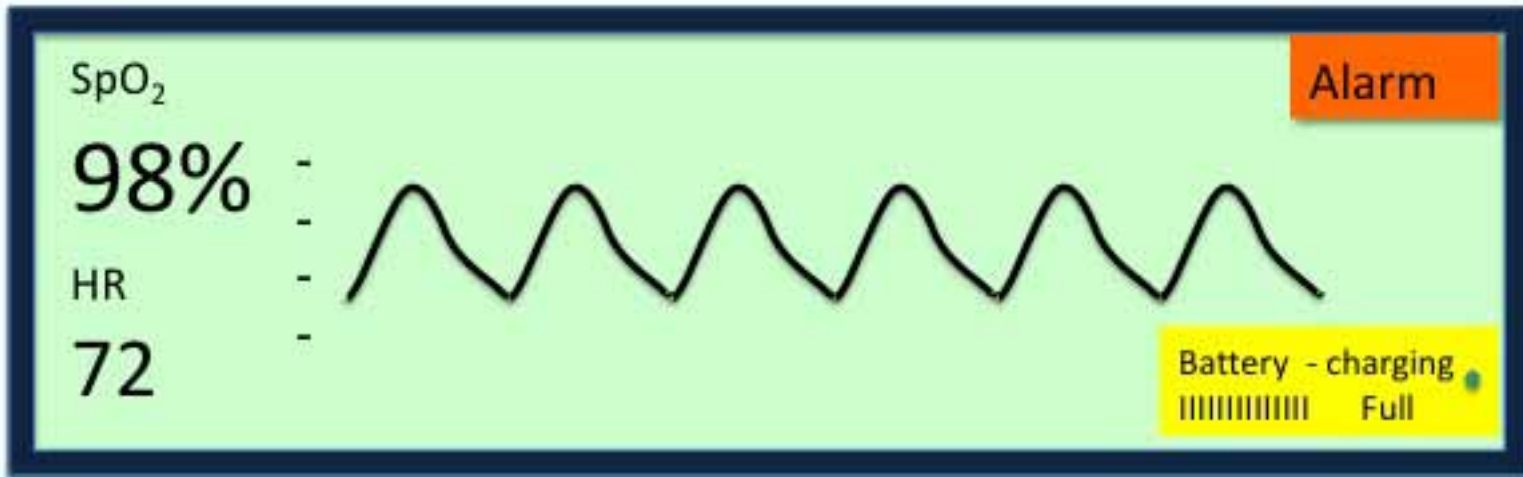
In this tutorial you will learn about:

- The function of a pulse oximeter
- How oxygen is transported to the tissues
- How a pulse oximeter can help you in anaesthesia

This is a diagram of a pulse oximeter – examine it carefully:

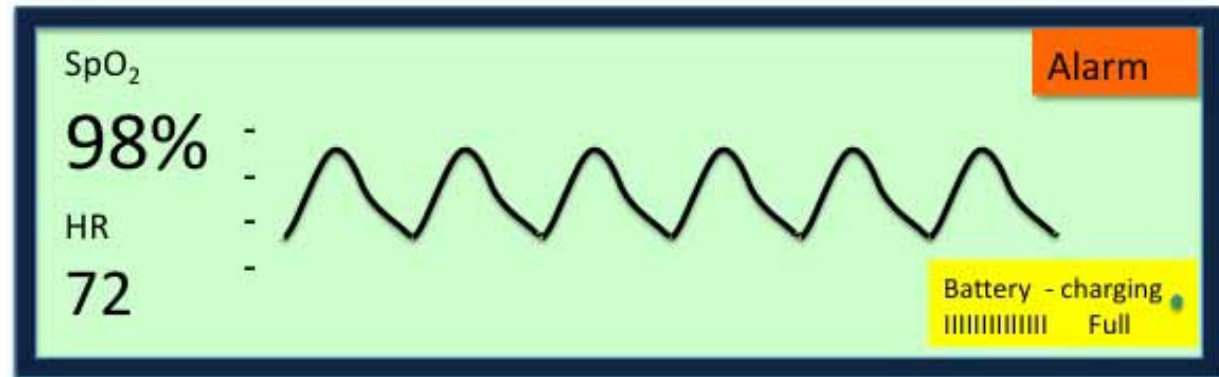


**What do the two numbers indicate?
The answer is on the next slide**



The pulse rate is 72 beats per minute

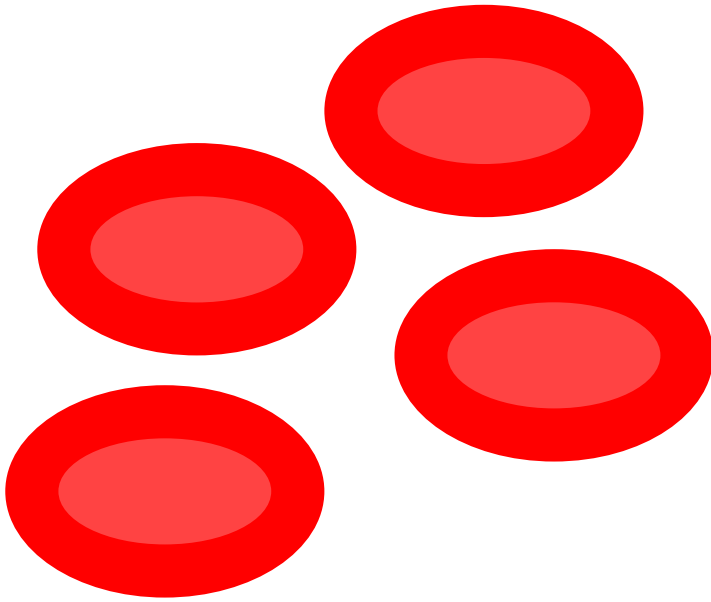
The oxygen saturation is 98%



What is oxygen saturation?

Red blood cells contain haemoglobin which carries oxygen.

When haemoglobin is carrying oxygen it is described as “saturated with oxygen”



Red blood cells



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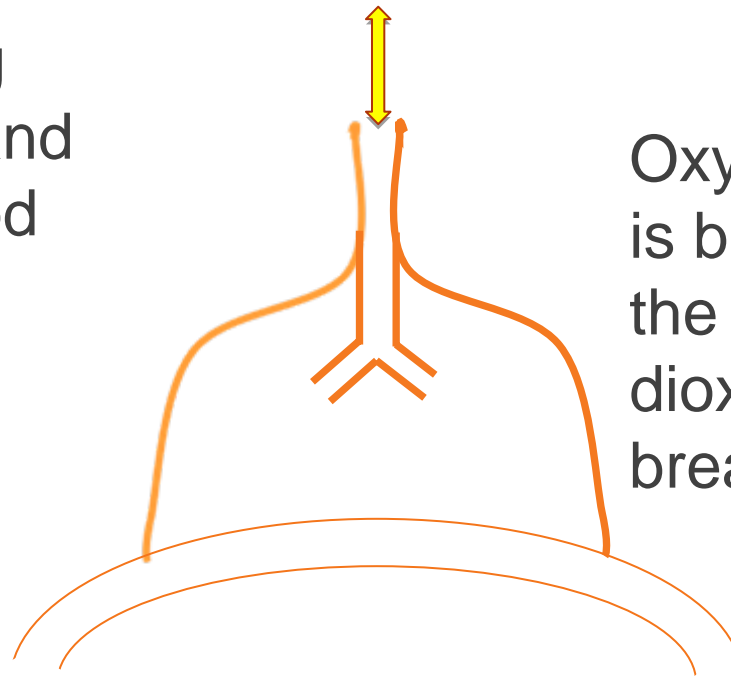
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Arterial and venous blood contain different amounts of oxygen – can you describe why?

Lung-Circulation Unit

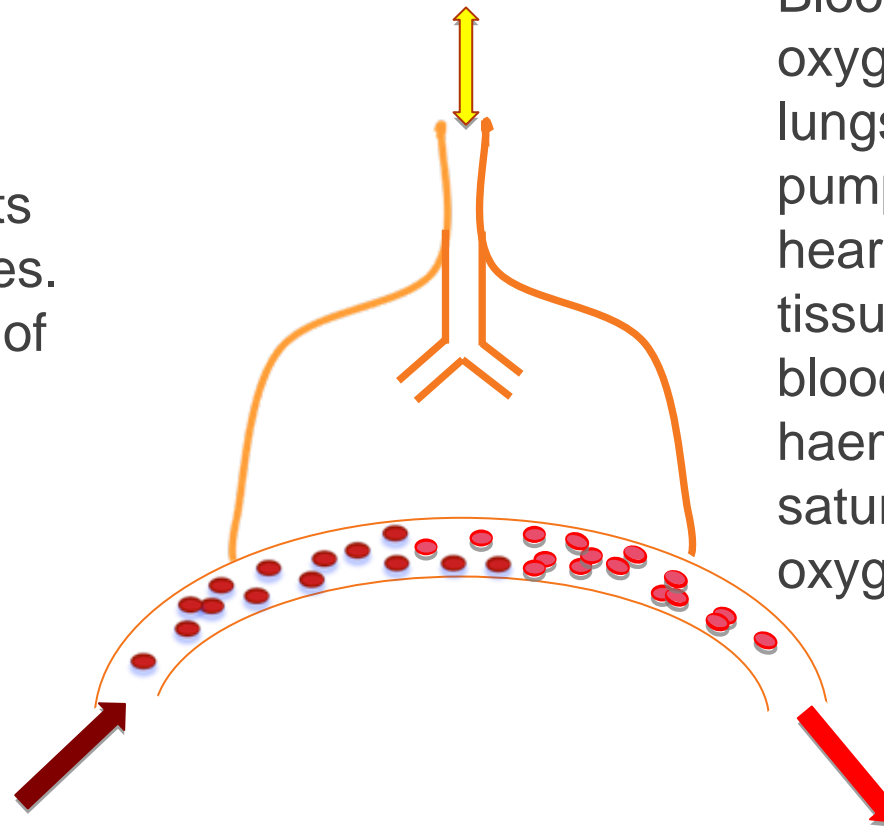
This diagram represents the lung and upper airway and the pulmonary blood flowing through the lungs



Oxygen in the air is breathed into the lung; carbon dioxide is breathed out

Lung-Circulation Unit

Venous blood from the tissues has delivered some of its oxygen to the tissues. Normally only 75% of the haemoglobin of venous blood is saturated with oxygen.



Blood is oxygenated in the lungs and is then pumped by the heart to the tissues. In arterial blood 98% of haemoglobin is saturated with oxygen.



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Why is arterial blood bright red and venous blood dark red?

Why is arterial blood bright red and venous blood dark red?

The colour of blood depends how much haemoglobin is saturated with oxygen. Arterial blood is fully saturated and is **bright red**; venous blood has less oxygen and is **dark red**.

Why is oxygen vital for life?

- All tissues in the body depend on oxygen for survival
- A shortage of oxygen in the tissues is called **hypoxia**.
- When a patient is hypoxic their tissues lose the **bright red** appearance of being well oxygenated and become **dark red** or look **blue**.
- The brain is damaged very quickly if the supply of oxygen to the tissues is interrupted.

In the body how is oxygen supplied to the tissues?

- If you are in a class – describe this to your colleagues
- If you are working alone – summarise your thoughts on a piece of paper

In the body how is oxygen supplied to the tissues?

Answer part 1:

- Oxygen makes up approximately 21% of the gases in the air we breathe
- Air is breathed into the lungs via the upper airway by the action of the diaphragm and other respiratory muscles
- In the alveoli (air sacs of the lung) oxygen passes into the blood combining with haemoglobin

In the body how is oxygen supplied to the tissues?

Answer part 2:

- Arterial blood is pumped to the tissues by the heart
- The tissues receive oxygen from haemoglobin in the capillary networks in each organ
- The cells burn the oxygen creating carbon dioxide which is returned to the lungs in venous blood and excreted in the exhaled gas



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What can happen during anaesthesia that might cause problems with oxygenation of the tissues?

What can happen during anaesthesia that might cause problems with oxygenation of the tissues?

- During anaesthesia the patient becomes unconscious and loses the ability to keep a clear airway
- Anaesthesia drugs depress breathing
- Anaesthesia drugs may reduce the cardiac output and therefore the oxygen supply to the tissues
- Patients may have clinical problems (eg pneumonia interfering with oxygenation or hypovolaemia reducing cardiac output) that may also be significant



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During anaesthesia how can we detect hypoxia?

During anaesthesia how can we detect hypoxia?

The presence of **cyanosis** indicates that the blood is not being oxygenated effectively

- Where should you check for cyanosis?
- In which patients may it be difficult to see cyanosis?

- Cyanosis is best seen in the tongue
- It is harder to detect cyanosis in darker skinned people
- It is harder to detect cyanosis in anaemic patients as they have low levels of haemoglobin and their blood is not a strong colour in the tissues.

How does an oximeter work?

- Discuss in the class how an oximeter works before proceeding.

How does an oximeter work?

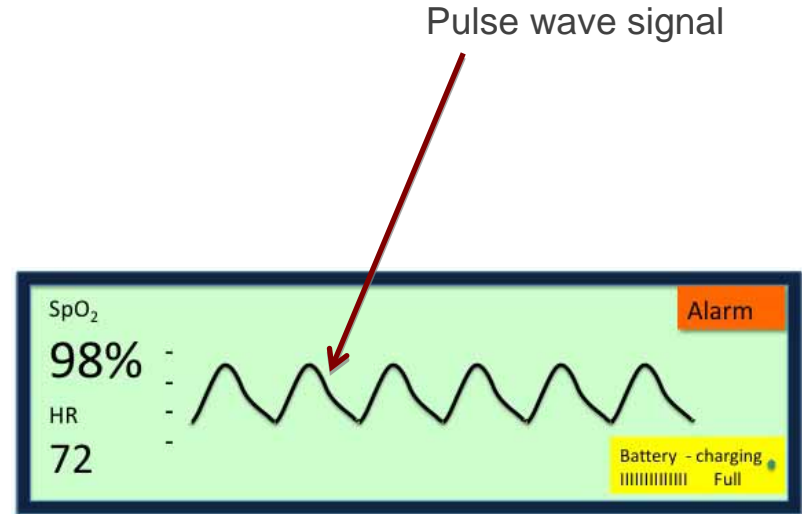
A pulse oximeter is composed of the sensor (or probe) and the monitor with the display.

The probe is on the finger and is detecting the flow of blood through the finger. This is displayed as a pulse wave on the monitor.

A pulse wave must be present to demonstrate that a pulse is being detected.

In this figure, the patient has a pulse rate of 72 beats / minute and an SpO₂ of 98%.

This monitor describes the pulse rate as the heart rate.

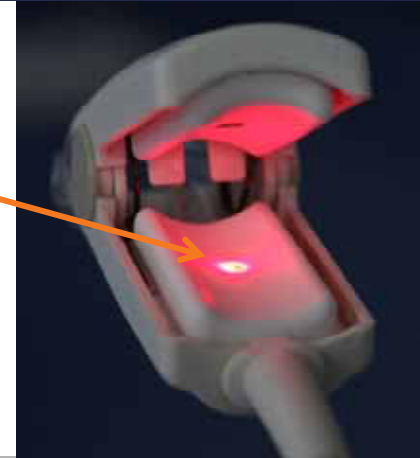


How does an oximeter work?

This is a photo of a probe.

Note the bright red light coming from one side of the probe.

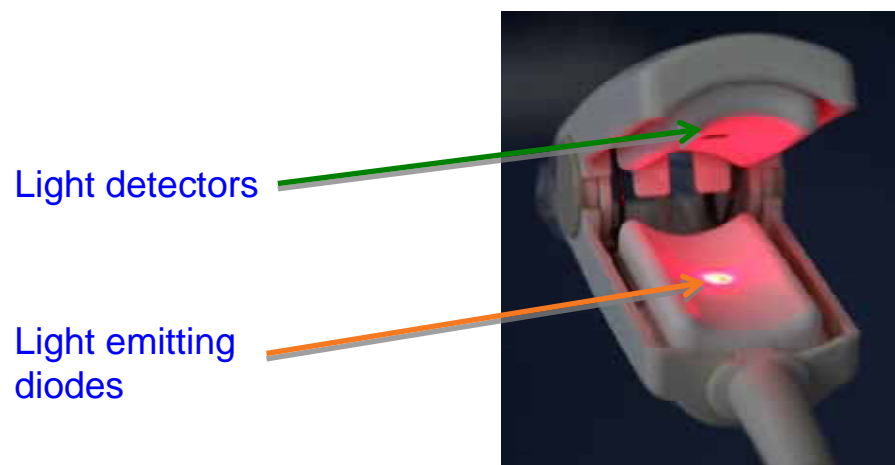
What is this red light for?



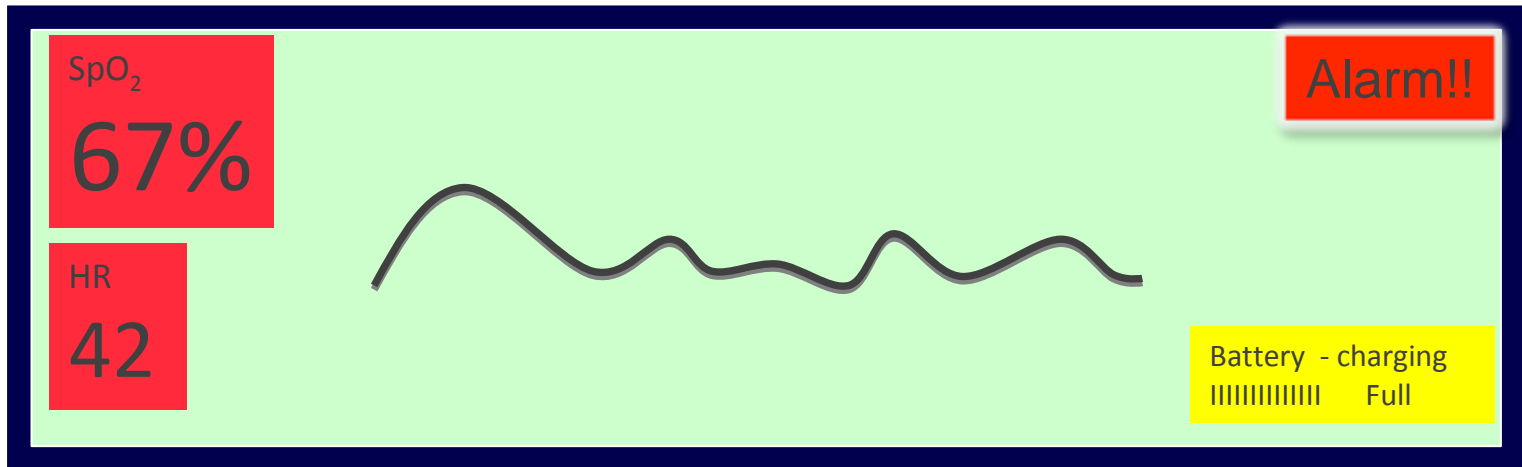
How does an oximeter work?

All pulse oximeter probes (finger or ear) have light emitting diodes (LEDs) which shine two types of red light through the tissue. The sensor on the other side of the tissue picks up the light that is transferred through the tissues.

The oximeter can determine which of the haemoglobin is in pulsatile blood (arterial) and can then determine the SpO₂ of arterial blood in the peripheral circulation.



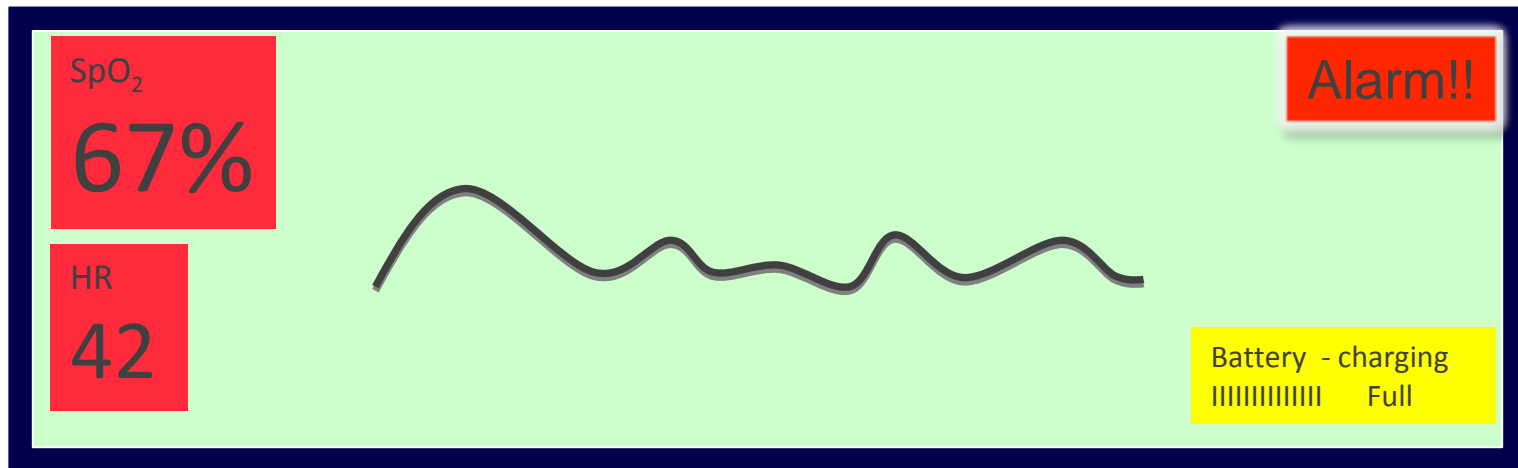
What do you notice about this oximeter?



What do you notice about this oximeter?

The pulse rate is 42 beats/min but the SpO₂ is only 67% representing dangerous hypoxia.

What do you think of this pulse waveform?

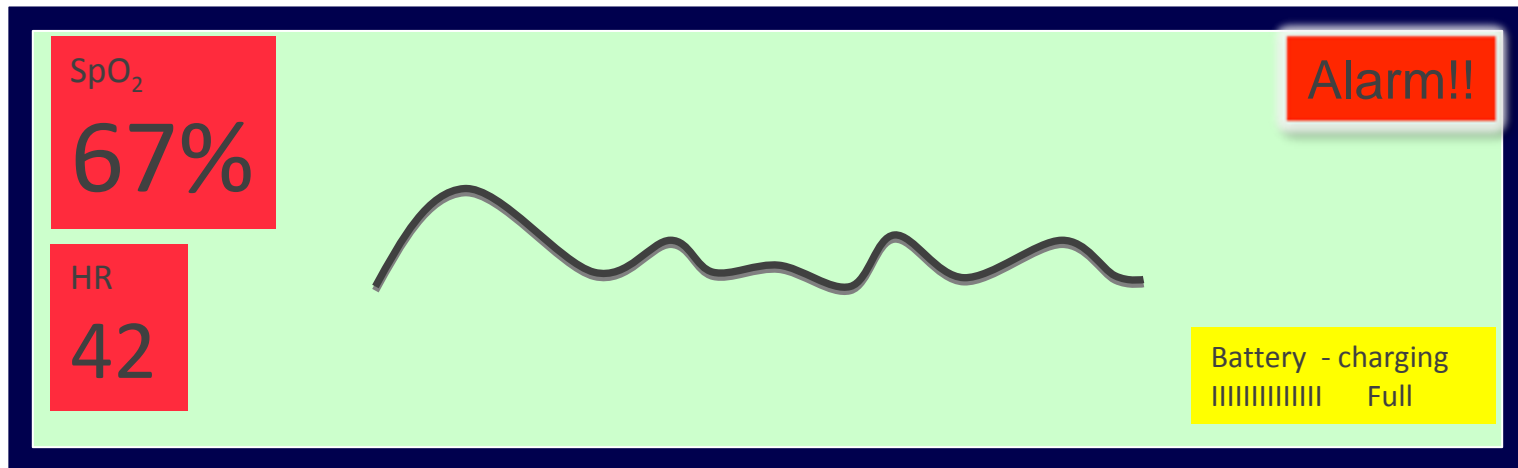


What do you notice about this oximeter?

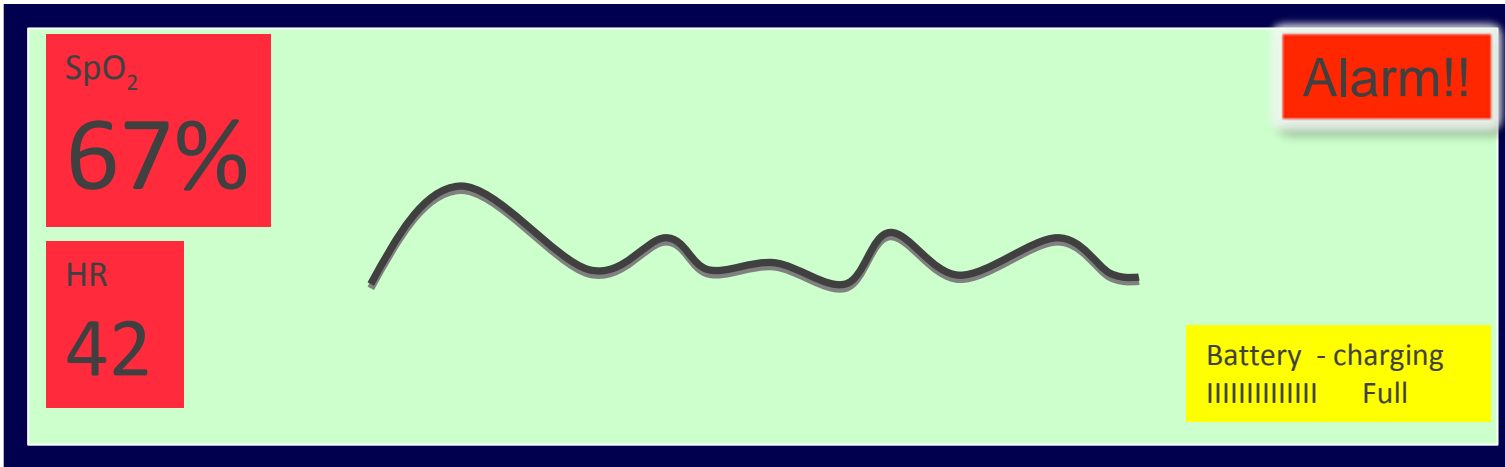
The pulse rate is 42 beats/min but the SpO₂ is only 67% representing dangerous hypoxia.

What do you think of this pulse waveform?

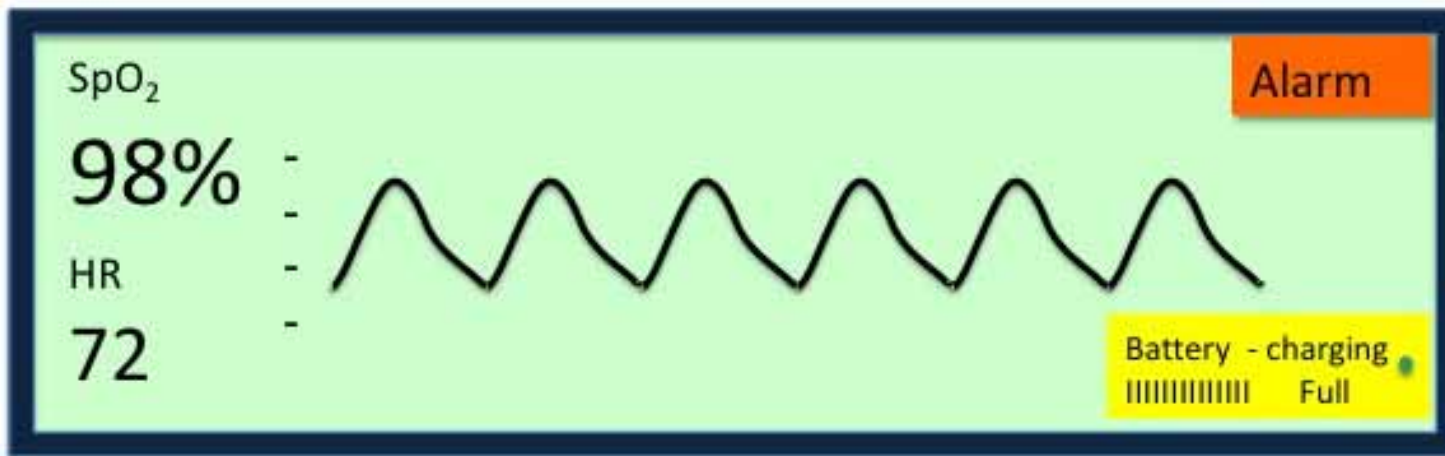
The trace is erratic and suggests that either the pulse is weak or the patient is moving. Both of these may cause false readings – this will be discussed later.



Compare the last oximeter trace with the normal trace



Previous erratic trace



Normal trace for comparison

Which is better at detecting hypoxia?

- A skilled anaesthetist?

OR

- A pulse oximeter?

Which is better at detecting hypoxia?

Unless there is no detectable pulse, the pulse oximeter is much more accurate at detecting hypoxia. It provides an early warning whenever the patient starts to desaturate. Most oximeters have an audible tone which gets lower in pitch as the SpO₂ falls.

This audible note allows the anaesthetist to concentrate on looking after the patient but still hear the pulse rate and SpO₂.

Pulse oximeters have made anaesthesia much **safer** since their introduction.



In theatre the sound of the pulse oximeter is a vital safety signal.

Never turn off the pulse sound!

What level of SpO₂ is important during anaesthesia?

- SpO₂ should always be 95% or greater during anaesthesia with all ages of patients
- When the SpO₂ falls below 90%, the patient is becoming seriously hypoxic. This needs immediate attention.
- Start to check the patient if the SpO₂ is 94% or below

Revision

1. What is the normal haemoglobin saturation in arterial blood?
2. What does SpO₂ stand for?
3. What happens to the SpO₂ if the patient is given 100% nitrous oxide to breathe?
4. What happens to the SpO₂ if the patient stops breathing?

Revision

1. What is the normal haemoglobin saturation in arterial blood?

- In arterial blood, haemoglobin is normally 95 – 99% saturated with oxygen.

2. What does SpO₂ stand for?

- Peripheral haemoglobin oxygen saturation.

Revision

3. What happens to SpO₂ if the patient is given 100% nitrous oxide to breathe?

- The nitrous oxide dilutes and replaces the oxygen in the lung causing a shortage of oxygen in the lung and severe hypoxia

4. What happens to SpO₂ if the patient stops breathing?

- The SpO₂ will fall as the blood no longer receives oxygen in the lungs

Summary - in this tutorial you have:

- Learned how a pulse oximeter works
- Reviewed how oxygen is transferred from the atmosphere to the tissues
- Recognised that anaesthesia may interfere with tissue oxygenation
- Understood how to detect hypoxia in a patient under anaesthesia
- Considered why an oximeter gives better information about oxygenation than clinical signs