The pulse oximeter is a common measurement device used in acute wards, operating theatres and general practice settings, and it is also routinely used by healthcare professionals such as paramedics and physiotherapists. The British Thoracic Society refers to oxygen saturation as “the fifth vital sign” (Kane et al., 2013) and it is a key component of the National Early Warning Score 2 (NEWS2) for assessing patients with acute illness (RCP, 2017). It is important that pulse oximetry is used to check oxygen saturation in all breathless and acutely ill patients, and it must be available wherever emergency oxygen is used (O’Driscoll et al., 2017).

Pulse oximetry measures the saturation of haemoglobin by oxygen in the arterial blood of the peripheries (SpO2) and gives this figure as a percentage. It therefore provides a guide to oxygen delivery to the tissues. Almost all oxygen transported in the blood is carried by the iron-containing protein haemoglobin in red blood cells, and only a small amount (1–2 per cent) is found dissolved in the blood plasma. It is desirable for the haemoglobin to carry a high percentage of oxygen: the target oxygen saturation for most acutely ill patients is 94–98 per cent, or 88–92 per cent (or a patient-specific target range) for those at risk of hypercapnic respiratory failure (O’Driscoll et al., 2017). If you hear the colloquial term “checking their sats”, this refers to pulse oximetry measurements.

The probe, which is painless to use, is usually placed on a finger in an adult patient, to assess oxygen delivery to the extremities. There are a variety of probes for adult, paediatric and neonatal patients. Probes can be for single or multiple patient use and are designed to attach to specific parts of the body, such as a finger or ear, but are not interchangeable between sites, in order to ensure a reliable reading (NHS Improvement, 2018). More recently, probes that use reflectance technology have become available for use on the forehead (Jubran, 2015).

Some pulse oximeters are small and portable, but the probe can also be attached to a larger monitor, such as in an intensive care unit. The pulse oximeter is sensitive enough to show a drop in the oxygen saturation of haemoglobin before cyanosis is evident; it also helps to confirm suspected cyanosis. The use of pulse oximetry guides oxygen therapy by verifying the presence of hypoxaemia. This is important because oxygen should not be given to patients unless they are hypoxaemic.

As with all assessment devices, the pulse oximeter must be used as part of a wider and holistic assessment of the patient (Preston & Flynn, 2010). Record the pulse oximetry recording, the respiratory rate, the percentage of oxygen being inhaled, and if the patient is breathing air or oxygen. Remember that the device will only tell you the percentage of haemoglobin saturated with oxygen. It will not tell you how hard the patient’s respiratory and cardiovascular system is working to achieve this level. The patient may be working hard to maintain good “saturations” or be relatively comfortable. Pulse oximetry relies on good blood flow to the extremities, so measurements need to be carefully assessed, especially in deteriorating patients. More accurate methods such as arterial blood gas analysis may be required, which will not only give accurate information about the patient’s oxygenation status but also the lungs’ ability to ventilate (see clinicalskills.net procedures on arterial blood gas analysis). This procedure outlines how the pulse oximeter device works and how to use it.
How a pulse oximeter works

The pulse oximeter emits red and near-infrared light from one side of the probe, and detects it on the other side, after the light has passed through the tissues of the body. The amount of each type of light absorbed by both oxygenated and deoxygenated haemoglobin is measured, and is used to calculate the oxygen saturation of the arterial blood (Gonce Morton & Rempher, 2013).

Assess the patient: (a)

Before using the device, take time to assess the cardiorespiratory status of the patient. Observe the respiratory rate, pattern and depth, as well as the chest movement, pulse and blood pressure. Observe the patient for signs of respiratory distress such as accessory muscle use, and note the colour and warmth of their skin. Document the amount of supplemental oxygen, if in use.

Explain the procedure to the patient

Explain the purpose of the measurement to the patient and gain their consent.

Hand hygiene

Before patient content, wash and dry your hands, or decontaminate visibly clean hands with alcohol-based hand sanitiser.

Remember that a rising respiratory rate can be a valuable early warning of the increased risk of cardiopulmonary arrest. A high (greater than 25 breaths/minute) or increasing respiratory rate is a marker of illness and a warning that the patient may deteriorate suddenly (Resuscitation Council [UK], 2015). Abnormal findings should be escalated to a senior member of staff.

Clean the site if necessary

Ensure that the the site where you are going to place the probe is free from blood or dirt, which could affect the reading (also see page 5, “Factors affecting light absorption”).

Do not undertake or attempt any procedure unless you are, or have supervision from, a properly trained, experienced and competent person. Always first explain the procedure to the patient and obtain their consent, in line with the policies of your employer or educational institution.
Before attaching the probe, it is advisable to remove any nail polish from the patient’s nails. Although its effect on oximetry readings is debatable (see page 5) it will in any case be necessary to remove nail polish to assess the colour of the extremities for signs of cyanosis.

The finger is the site most commonly selected for placing the probe. Remember that the probe relies on good blood flow to the peripheries so it is important to select the warmest, pinkest finger on which to place the probe. Wait for the signal to stabilise.

Ear probes can be useful if readings are difficult to obtain in cold or poorly perfused peripheries, which are often present in deteriorating patients. A recent patient safety alert highlights the need for ear probes to be available in all areas where pulse oximetry is being used (NHS Improvement, 2018). Finger probes should not be used on ears as they can give false readings.

If the probe is re-usable, ensure that it is cleaned between patients. Refer to the manufacturer’s instructions or local policy for directions on cleaning. You will usually need to wipe exposed surfaces with a soft cloth or a pad moistened with a mild detergent or medical alcohol solution. Never immerse the probe in solution.

Avoid taking a pulse oximetry reading from a limb on which a blood pressure cuff is being used as measuring blood pressure simultaneously will affect the reading.

Smaller probes, suitable for the little finger, are available for children. Probes for babies and children need to be selected according to weight (NHS Improvement, 2018). A Velcro fastener may help to attach the probe in children.
**Avoid taping the probe**

If possible, avoid taping the probe in place. If the tape is too tight, poor blood flow or pressure sores can develop. Ideally, you should rotate the probe between different fingers. Check the site every few hours and rotate the site used to avoid damage (Dougherty & Lister, 2015).

**Check the probe is attached to the pulse oximeter**

Make sure that the probe is correctly attached to the monitor, as this is a common source of technical error. Follow the manufacturer’s guidance.

**Turn on the pulse oximeter**

Once the monitor is switched on, you will be able to check the oxygen saturation of haemoglobin, along with the pulse rate. In patients who are acutely ill, at risk of deteriorating or have an irregular heart beat, pulses should be taken manually and not read from the machine. If continuous monitoring is needed, set the alarm limits, so that you know if the measurements recorded drop below or rise above acceptable levels for the patient.

**Waveform display**

The monitor will show a pulsatile waveform corresponding to bloodflow. This display allows you to assess the quality of the pulse at the extremity where the probe is measuring the oxygen saturation. Although a well-defined trace is an indication of a good-quality signal, a good trace may not always equal good perfusion. The pulse oximeter should not be used as an assessment tool for perfusion (Sinex, 1999).

**When using a handheld oximeter**

Many pulse oximeters, including portable devices, do not display a pulsatile waveform. Instead they have a signal strength indicator. Follow the manufacturer’s guidance and local policy. Comparing a manually counted pulse to the pulse oximeter reading is an additional method for checking accuracy of the device.

**Integrate the assessment**

Although pulse oximetry is a key part of the National Early Warning Score 2 (NEWS2), it is only one part of the clinical assessment (RCP, 2017). Combine the results with other observations and clinical findings to make an accurate assessment of the patient. Be aware that pulse oximetry has certain limitations, which are explored in the following pages.
Troubleshooting: (a) Cold peripheries

Consider the feel of the patient's skin to help you assess tissue perfusion. The skin should be warm and dry. Cold and clammy skin suggests circulatory compromise, which requires further investigation. Try warming the skin with blankets or rubbing the skin (WHO, 2011). If the readings continue to be unreliable, try a more central site, such as the ear lobe, using the correct probe.

(b) Poor peripheral perfusion

Peripheral vasoconstriction, e.g., in shock, hypotension or hypothermia, can cause an inadequate pulsatile flow, producing a poor signal for the monitor to interpret. Cardiac arrhythmias or severe heart failure may also result in inadequate perfusion. Try using an ear probe, and consider whether more advanced assessment, e.g., arterial blood gas analysis, may be required.

(c) False high readings

In carbon monoxide (CO) poisoning, CO binds to haemoglobin in place of oxygen, forming carboxyhaemoglobin (O’Driscoll et al., 2017). Standard pulse oximeters cannot distinguish between oxyhaemoglobin and carboxyhaemoglobin, and oxygen saturations will appear normal or falsely high despite significant hypoxaemia.

Carbon monoxide poisoning

If CO poisoning is suspected, give the patient 100% oxygen, send blood to measure carboxyhaemoglobin levels, and obtain expert help. Bedside measurement of carboxyhaemoglobin levels, using a CO-oximeter, can be helpful (Hampson et al., 2012).

Factors affecting light absorption

Researchers have studied factors that affect the absorption of light from the device. It is advisable to remove any barrier to the light such as dried blood on the skin. High ambient light levels, e.g., in the operating theatre, may cause interference in older machines, although newer devices are able to compensate for this (Page, 2017). The effect of factors such as nail polish and false nails on the accuracy of oximetry readings is probably small, but it remains good practice to remove them as described earlier (Ford, 2018).

Reduced accuracy in severe hypoxaemia

At around 70 per cent, oxygen saturation measurements become unreliable, so the true level might be lower still. Oxygen saturations of 70 per cent are dangerously low, and should trigger emergency interventions to restore blood oxygen levels.
### Weak signal

Patient movement can interfere with measurement, and result in falsely low readings. This may occur if the patient is shivering or agitated. A single-patient-use taped probe may be useful in this instance.

### Observation of the site

Check the probe site frequently, so that you detect any problems promptly. Ensure that the device is calibrated and serviced according to the manufacturer’s guidance. When the probe is no longer required, ensure it is cleaned before use on another patient.

### Complications: pressure damage

Be aware that the probe can cause damage to tissue. Do not keep the probe on one finger all the time; instead, rotate sites. Blisters at the probe site can occur, perhaps due to a faulty probe. Those with delicate skin, such as children and those with poor tissue perfusion, are especially at risk. Joint stiffness in fingers may result, because the probe restricts joint movement.

### Record your results

#### Patient Notes

- **NAME:** Tony Pace
- **D.O.B.:** 11.04.43

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>SpO2</th>
<th>R. Rate</th>
<th>H. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/06/2019</td>
<td></td>
<td>93%</td>
<td>25/min</td>
<td>75 bpm regular</td>
</tr>
<tr>
<td>12/06/2019</td>
<td></td>
<td>90%</td>
<td>29/min</td>
<td>82 bpm regular</td>
</tr>
</tbody>
</table>

#### Allergy Notes

Record the pulse oximeter measurement, along with other observations as guided by the NEWS2 escalation protocol and/or local policy. Continuous monitoring will be required in critically ill patients who require respiratory support.

### Interpreting oxygen saturation

<table>
<thead>
<tr>
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<td></td>
<td>90%</td>
<td>29/min</td>
<td>82 bpm regular</td>
</tr>
</tbody>
</table>

#### Blood gas analysis

- **SpO2:** 93% on O2
- **SpO2:** 95% on O2
- **SpO2:** 93% on air
- **SpO2:** 88-92%
- **SpO2:** 86-87%
- **SpO2:** 84-85%
- **SpO2:** ≤83%
- **SpO2:** ≥96%
- **SpO2:** 94-95%
- **SpO2:** 92-93%
- **SpO2:** ≤91%

Pulse oximetry is a non-invasive method to assess the oxygenation status of a patient. In acutely ill or deteriorating patients, arterial blood gas analysis is routinely performed because it gives an accurate picture of the respiratory status, including carbon dioxide levels and metabolic status, such as pH and lactate levels (O’Driscol et al., 2017).

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**Observations**

**Adults**

**Pulse oximetry**

**Page 6**

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**Do not undertake or attempt any procedure unless you are, or have supervision from, a properly trained, experienced and competent person.**

**Always first explain the procedure to the patient and obtain their consent, in line with the policies of your employer or educational institution.**