Guideline Title  SpO\textsubscript{2} monitoring in the ICU

Summary: Pulse oximetry is a simple non-invasive method of monitoring the percentage of haemoglobin (Hb), which is saturated with oxygen. The pulse oximeter consists of a probe attached to the patient’s finger, toe, ear lobe or forehead, which is linked to a computerised unit. The unit displays the percentage of Hb saturated with oxygen together with an audible signal for each pulse beat, and calculated heart rate. A pulse wave related to flow is displayed graphically.

Approved by:  ICU Medical Director

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Replaces Existing Guideline:  SpO\textsubscript{2} monitoring in the ICU


Contents:

Background Information:

Oxygen is transported in the blood in two ways. A small amount of oxygen is dissolved in the plasma, but the chief means of oxygen is chemical bonding to haemoglobin. Haemoglobin is the red-pigmented protein found in red blood cells. Iron within the haem portion of haemoglobin combines with oxygen entering the red blood cell (erythrocyte). The result is oxygen bound haemoglobin (oxyhaemoglobin). Each haemoglobin molecule has a limited capacity for holding up to four molecules of oxygen which is then 100% saturated with oxygen. Oxygen saturation is a measure of how much oxygen the blood is carrying as a percentage of the maximum it could carry. The oxygen carrying capacity is determined by the amount of haemoglobin present in the blood.

The colour of blood varies depending on how much oxygen it contains. A pulse oximeter shines 2 beams of light through a finger one beam is a red light (which is seen) one is infrared light (invisible) These 2 beams of light can let the pulse oximeter detect what colour the arterial blood is and it can then work out the oxygen saturation. However there are lots of other parts of a finger which will absorb light (such as venous blood, bone, skin, muscle etc) so to work out the arterial blood a pulse oximeter looks for the slight change in the overall colour caused by a beat of the heart pushing arterial blood into the finger. The change in colour is very small so pulse oximeters work best when there is a good strong pulse in the finger or area the probe is on. If the signal is to low the measured oxygen saturation may not be reliable.

The pulse oximeter measures the percentage of the patient's haemoglobin, which is saturated with oxygen. This provides important clinical data about the patient's oxygenation status, since 97% of oxygen is transported bound to haemoglobin, and only 3% dissolved in plasma.

In normal circumstances the SaO\textsubscript{2} correlates with the partial pressure of dissolved oxygen (PaO\textsubscript{2}), which can be represented by the oxyhaemoglobin dissociation curve. However, this relationship is not linear, such that SaO\textsubscript{2} does not equal PaO\textsubscript{2}.
Philips pulse oximetry, used at the Liverpool ICU, uses a motion-tolerant signal-processing algorithm, based on Fourier artifact suppression technology (FAST).

1. Introduction contains:
The risk addressed by this policy:

- Appropriate standard of care of patients that require oxygen saturation monitoring.
- Safe and competent management of patients that require pulse oximetry monitoring in the ICU.
- Accurate monitoring of oxygen saturation via a pulse oximetry device.

The Aims / Expected Outcome of this policy:

- To ensure that patients receive optimal management when they require or have a pulse oximeter device.
- To ensure staff are aware of factors that affect the safety and accuracy of pulse oximetry monitoring and management of the patient with a pulse oximeter in situ.
- To provide a clear guideline and to facilitate uniform practices regarding pulse oximetry monitoring of patients in the ICU.

Related Standards or Legislation

- NSQHS Standard 1 Governance
- National Standard 4 Medication Safety

Related Policies

LH_PD2014_ICU_Management_Guidelines_Documentation

2. Policy Statement:

- All care provided within Liverpool Hospital will be in accordance with infection prevention/control, manual handling and minimisation and management of aggression guidelines.
- All patients in the ICU are to have pulse oximetry monitored unless stipulated other ways.
- All bed areas in ICU are to be equipped with pulse oximetry.
- Oxygen saturation and pulse alarms, as appropriate, are to be turned on at all times and within appropriate parameters.
- If there is doubt of the measured SpO2, use the pleth wave, perfusion numeric, or signal quality Indicator to assess the signal quality.
- Do not use disposable sensors when there is a known allergic reaction to the adhesive.
3. Principles / Guidelines

- \(\text{SpO}_2\) is used to continuously monitor the oxygenation status of critically ill patients in the ICU.
- The \(\text{SpO}_2\) measurement provides:
  - Pleth waveform - visual indication of patient’s pulse.
  - Oxygen saturation of arterial blood (\(\text{SpO}_2\)) in percent.
  - Pulse rate (derived from Pleth wave).
  - Perfusion indicator (Perf)- numerical value for the pulsatile portion of the measured signal caused by arterial pulsation.

**Pleth waveform:** The size of the Pleth wave indicates the quality of the \(\text{SpO}_2\) signal. The two inner gridlines represent the minimum size of the Pleth wave needed to derive a reliable \(\text{SpO}_2\) value. The Pleth wave is auto scaled to maximum display size. It decreases only when the signal quality becomes marginal. It is NOT directly proportional to the pulse volume. If you need an indication of change in pulse volume, use the perfusion indicator.

To Set \(\text{SpO}_2\)/Pleth as Pulse Source:

- In the Setup \(\text{SpO}_2\) menu, select pulse (\(\text{SpO}_2\)) to enter the setup pulse menu.
- In the setup pulse menu, select syst.pulse and select \(\text{SpO}_2\) from the pop-up list.

**Perfusion numeric:** The perfusion numeric (Perf) gives a value for the pulsatile portion of the measured signal caused by the pulsating arterial blood flow. The Perf gives an absolute indication of the quality of the signal being used to calculate \(\text{SpO}_2\). The larger the Perf numeric, the better the measurability of \(\text{SpO}_2\).
  - Above 1 is optimal.
  - Between 0.3-1 is acceptable.
  - Below 0.3 is marginal; reposition the sensor or find a better site.

**Signal quality indicator:** The \(\text{SpO}_2\) numeric is displayed together with a signal quality indicator (if configured). The level to which the triangle is filled shows the quality of the signal; the signal quality is at a maximum when the triangle is completely filled.

**Tone modulation:** If tone modulation is on, the QRS tone pitch lowers when the \(\text{SpO}_2\) level drops. Remember that the QRS tone is derived from either heart rate or pulse depending on which is currently selected as the active alarm source.

- In the Setup \(\text{SpO}_2\) menu, select Tone Mod. to toggle between Yes (for on) and No (for off).
The perfusion change indicator: Is a graphic symbol, which shows the change in the perfusion value, relative to a reference value, which can be set. To set the current perfusion value as the reference value:

- In the Setup SpO₂ menu, select Set Perf Ref.

When a reference value has been set, the perfusion change indicator is displayed next to the perfusion numeric.

### Equipment:

- Pulse oximetry module
- Pulse oximetry cable
- Pulse oximetry device as required

![Phillips S₉O₂ Module](image)

At the Liverpool ICU the monitoring equipment utilised for bed site monitoring and transport is from Phillips.

### Procedure:

- Select the optimal measurement site
- Avoid catheters and infusions proximal to the site.
- Check that site has good skin integrity and no discolorations
- If necessary, remove colored nail polish from the application site.
- Apply SpO₂ sensor as per instructions. There are different reusable and disposable sensors available for different SpO₂ measurement sites and patient categories. Examples are finger, toe, ear, and forehead sensors.
- Select the appropriate sensor for the site.
- Make sure the sensor size matches the application site so that the sensor can neither fall off, nor apply excessive pressure.
- Check that the light emitter and the photo detector are directly opposite each other. All light from the emitter must pass through the patient’s tissue.
Connect the sensor cable to the color-coded socket on the monitor. You can connect some Philips sensors directly to the monitor. For other sensors, use the corresponding adapter cable.

Select the correct patient category setting (adult/pediatric and neonatal), as this is used to optimise the calculation of the SpO₂ and pulse numerics.

Set the SpO₂ measurement on the monitor.

Setup SpO₂ menu.

Adjust the tone modulation and QRS tone. When tone modulation is turned on, the pitch of the QRS tone changes in accordance with the patient’s saturation.

Adjust the volume of the QRS tone.

Adjust the SpO₂ alarms.

Set the high limit and low limit alarm plus the desaturation limit alarm. The desaturation alarm is a high priority (red) alarm notifying you of potentially life threatening drops in oxygen saturation.

The SpO₂ low limit cannot be set below the desaturation alarm limit.

During measurement, ensure that the application site:
- Has a pulsatile flow, ideally with a perfusion indicator value above 1.0.
- Has not changed in its thickness (for example, due to oedema), causing an improper fit of the sensor.

Checking the application site
- Inspect the application site every two to three hours to check skin quality and correct optical alignment. Skin irritations may occur as a result of the sensor being attached to one location for too long.
- If the skin quality changes, move the sensor to another site.
- Change the application site at least every four hours.

Measurement limitations/ complications
The following limitations may influence the measured value of the oxygen saturation and may result in misinterpretation of the patient’s oxygen status.
- **Interference** caused by possible excessive patient movement, high levels of ambient light.
- **Electrical Interference**: Position the sensor cable and connector away from power cables, to avoid electrical interference.
- **Injected dyes** can affect the light way through the blood.
- **Dysfunctional haemoglobin** can mimic oxygenated hemoglobin although the true oxygenation is poor, e.g. caused by carbon monoxide poisoning.
- **Pressure area on the site of probe application.**
- **False reading**, commonly due to:
  - patient being cold
  - perfusion of the extremity inadequate
  - patient shivering or moving hand/foot
  - anaemia.
- The pulse oximeter will not differentiate oxyhaemoglobin from carboxyhaemoglobin, which makes the device misleading in cases of carbon monoxide poisoning.
- **Loose sensor**: If a sensor is too loose, it might compromise the optical alignment or fall off. If it is too tight, for example because the application site is too large or becomes too large due to edema, excessive pressure may be applied. This can result in venous congestion distal from the application site, leading to interstitial edema, hypoxemia and tissue malnutrition. Skin irritations or lacerations may occur as a result of the sensor being attached to one location for too long. To avoid skin irritations and lacerations, periodically inspect the sensor application site and change the application site at least every four hours.
- **Venous pulsation**: Do not apply sensor too tightly as this results in venous pulsation, which may severely obstruct circulation and lead to inaccurate measurements.
- **Ambient temperature**: At elevated ambient temperatures be careful with measurement sites that are not well perfused, because this can cause severe burns after prolonged
application. All listed (Phillips) sensors operate without risk of exceeding 41°C on the skin if the initial skin temperature does not exceed 35°C.

4. Performance Measures
All incidents are documented using the hospital electronic reporting system: IIMS and managed appropriately by the NUM and staff as directed.

5. References / Links

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