PULSE OXIMETRY

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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 or ear lobe 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, a calculated heart rate and in some models, a graphical display of the blood flow past the probe. Audible alarms which can be programmed by the user are provided. An oximeter detects hypoxia before the patient becomes clinically cyanosed.

How does an oximeter work? A source of light originates from the probe at two wavelengths (650nm and 805nm). The light is partly absorbed by haemoglobin, by amounts which differ depending on whether it is saturated or desaturated with oxygen. By calculating the absorption at the two wavelengths the processor can compute the proportion of haemoglobin which is oxygenated. The oximeter is

dependant on a pulsatile flow and produces a graph of the quality of flow. Where flow is sluggish (eg hypovolaemia or vasoconstriction) the pulse oximeter may be unable to function. The computer within the oximeter is capable of distinguishing pulsatile flow from other more static signals (such as tissue or venous signals) to display only the arterial flow.

Calibration and Performance. Oximeters are calibrated during manufacture and automatically check their internal circuits when they are turned on. They are accurate in the range of oxygen saturations of 70 -100% (+/-2%), but less accurate under 70%. The pitch of the audible pulse signal falls with reducing values of saturation.

The size of the pulse wave (related to flow) is displayed graphically. Some models automatically increase the gain of the display when the flow decreases and in these the display may prove misleading. The alarms usually respond to a slow or fast pulse rate or an oxygen saturation below 90%. At this level there is a marked fall in PaO_2 representing serious hypoxia.

In the following situations the pulse oximeter readings may not be accurate.

1. A reduction in peripheral pulsatile blood flow produced by peripheral vasoconstriction (hypovolaemia, severe hypotension, cold, cardiac failure, some cardiac arrhythmias) or peripheral vascular disease. These result in an inadequate signal for analysis.

2. Venous congestion, particularly when caused by tricuspid regurgitation, may produce venous pulsations which may produce low readings with ear probes. Venous congestion of the limb may affect readings as can a badly positioned probe. When readings are lower than expected it is worth repositioning the probe. In general, however, if the waveform on the flow trace is good, then the reading will be accurate.

3. Bright overhead lights in theatre may cause the oximeter to be inaccurate, and the signal may be interrupted by surgical diathermy. Shivering may cause difficulties in picking up an adequate signal.

4. Pulse oximetry cannot distinguish between different forms of haemoglobin. Carboxyhaemoglobin (haemoglobin combined with carbon monoxide) is registered as 90% oxygenated haemoglobin and 10% desaturated haemoglobin - therefore the oximeter will overestimate the saturation. The presence of methaemoglobin will prevent the oximeter working accurately and the readings will tend towards 85%, regardless of the true saturation.

5. When methylene blue is used in surgery to the parathyroids or to treat methaemoglobinaemia a shortlived reduction in saturation estimations is registered.

6. Nail varnish may cause falsely low readings. However the units are not affected by jaundice, dark skin or anaemia.

Pulse oximeters may be used in a variety of situations but are of particular value for monitoring oxygenation and pulse rates throughout anaesthesia. They are also widely used during the recovery phase. The oxygen saturation should always be above 95%. In patients with long standing respiratory disease or those with cyanotic congenital heart disease readings may be lower and reflect the severity of the underlying disease.

In intensive care oximeters are used extensively during mechanical ventilation and frequently detect problems with oxygenation before they are noticed clinically. They are used as a guide for weaning from ventilation and also to help assess whether a patient's oxygen therapy is adequate. In some hospitals oximeters are used on the wards and in casualty departments. When patients are sedated for procedures such as endoscopy, oximetry has been shown to increase safety by alerting the staff to unexpected hypoxia.

Oximeters give no information about the level of CO_2 and therefore have limitations in the assessment of patients developing respiratory failure due to CO_2 retention. On rare occasions oximeters may develop faults and like all monitoring the reading should always be interpreted in association with the patient's clinical condition. Never ignore a reading which suggests the patient is becoming hypoxic. There is no

doubt that pulse oximetry is the greatest advance in patient monitoring for many years and it is hoped that their use will eventually become routine during anaesthesia and surgery world wide. Since pulse oximeters cost at least £1200 their purchase will depend mainly on economic considerations.