Getting the Basics Right

Pulse oximetry: not an infallible test – use clinical judgement!

Whilst pulse oximetry is a simple non-invasive monitoring system and has been described as the greatest advance in monitoring since the invention of the electrocardiogram,[1] it is not to be used in isolation. Rather, it should be used to support a comprehensive patient assessment and physical examination and aid the decision making process.

Pulse oximetry can rapidly detect changes in oxygen (O_2) saturation, enabling clinicians to identify problems before the patient is compromised.

The measurement of O_2 saturation is endorsed in numerous guidelines to aid the assessment process and, therefore, pulse oximeters should be widely available in primary care. Indeed, increasingly, people with chronic lung disease are purchasing their own pulse oximeters.[2]

Purchasing a pulse oximeter

Pulse oximeters are available, highly portable and increasingly less costly to purchase. In purchasing equipment, it is worth considering what factors are important. Within primary care – especially when carried in diagnostic bags – the equipment needs to be:

- Reliable
- Reproducible
- Safe
- Accurate
- Robust
- Portable
- Cost effective
- Simple to use

How does pulse oximetry work?

The pulse oximeter calculates the amount of light of two separate wavelengths absorbed from a source in the probe when put onto a finger or toe. This reflects the red colour of arterial blood, thus producing an estimate of O_2 saturation/desaturation in the body. This is referred to as % SpO_2.

The pulse oximeter is designed to pick up arterial pulsed flow rather than venous flow in its estimations, and needs an arterial pulse to do this. An SpO_2 greater than 95% is considered normal. Indeed, O_2 saturations in the normal healthy individual are often more than 98%. In an acute situation when O_2 saturations are decreased below 92%, O_2 is given to maintain the level at 94–98%, and one should consider hospital admission. If a healthy individual during an acute episode has saturations of 93–94%, this may – depending on the total clinical picture – warrant hospital admission or earlier clinical review.[3]

A reduction of normal O_2 saturations on exertion (1 minute sit to stand test or 40 step test) of 3% is also considered highly significant in those with acute respiratory. infections including COVID-19.[4]

Use and training

Like any equipment, it is important that clinicians using a pulse oximeter are able to use the equipment correctly, know when to use the equipment and know its limitations and how to interpret test results. It is also important to check that you know when the results are reliable.

Most available pulse oximeters are accurate between O_2 saturations of 70% and 100% with a range of ±2%. Pulse oximeters are calibrated during manufacture and most have an internal check system to ensure that calibration remains valid, hence they do not need recalibration.

Limitations

There are many factors that can affect the readings displayed. It is essential clinicians are aware of the potential limitations to ensure effective management of the patient. Most errors are the result of factors that affect light transmission, perfusion or pulse detection.

There are several situations where the pulse oximeter readings may not be accurate:

1. **Low perfusion state** which reduces peripheral pulsatile blood flow (e.g. cold digits). This usually results in the machine not providing a reading at all and can arise due to:
   a. Hypotension
   b. Hypovolaemic shock
   c. Cold weather/house
   d. Cardiac failure
2. **Carbon monoxide poisoning**. Carboxyhaemoglobin (haemoglobin combined with carbon monoxide) is bright red in colour therefore the pulse oximeter will overestimate the saturation in this situation and may be falsely reassuring.
3. **Shivering**. The background movement causes problems for pulse oximeters which may be unable to differentiate an adequate signal from arterial pulsation.
4. **Nail varnish or dirt** may cause falsely low readings. If a patient has nail varnish on, this should be removed (or use of alternative digits – e.g. toes) where the varnish is absent.
5. The evidence for change of O_2 saturation in a patient who is **jaundiced**[5] or **anaemic**[6] remains debatable. There is evidence to suggest that dark skin colour may reduce the accuracy of pulse oximetry at low O_2 saturation levels.[7–9]
6. Pulse oximetry in patients with **arrhythmias** needs to be interpreted with some caution. Pulse oximetry relies on a steady pulse signal, therefore conditions such as slow atrial fibrillation will affect the result.[10,11]
7. If patients are being assessed in an area with a **high level of artificial light** this can falsely reduce the readings (e.g. operating theatre fluorescent lighting).[12]
8. This article is written for UK-based practice; however, it should be remembered that **at altitude** O_2 saturations can drop causing altitude sickness (the use of pulse oximetry at high altitude is not within the scope of this article).

Pulse oximetry in the young and the elderly

Pulse oximetry is equally useful in the management of children as it is in adults, and the same ranges are applicable. Many of the "adult" pulse oximeters can be used in children over the age of 2 years. Below the age of 2 years, more specialised oximeters are generally preferred. There are two particular challenges with measuring O_2 saturation in young children. First, they may be difficult to examine and not want to stay still while the oximeter reading is taken. Second, small digits (fingers) are more likely to have poor perfusion (see above) and a reading may not be obtainable.

In older people and those with COPD, the normal O_2 saturation levels may be lower than in younger people.

Uses of pulse oximetry in respiratory disease

This section will look at the use of pulse oximetry in three areas; it is appropriate to refer to recognised national or international guidance for more comprehensive details on the individual conditions.

1. Acute respiratory infection (including community acquired pneumonia and influenza)
2. Asthma
3. Chronic obstructive pulmonary disease (COPD)

Whatever the clinical circumstances, it is essential to record whether the patient was breathing room air or receiving O_2 at the time the O_2 saturation was measured.

Acute respiratory infections (including influenza and community acquired pneumonia [CAP])

The British Thoracic Society guidance on emergency O_2 suggests that pulse oximetry is the "fifth vital sign" along with temperature, pulse, blood pressure and respiratory rate and should be considered for all those presenting with acute breathlessness in primary care.[13,14]

One of the key considerations for hospital admission is an O_2 saturation below 92% in a previously healthy individual, especially if other clinical features that indicate severity are evident. There has been a trend in the UK to use a hospital-based review system to evaluate severity in primary care (NEWS2; Box 1).[15] However, recent data indicate that patients can be seriously ill in primary care even with relatively preserved NEWS2 scores.[15]

There are also some acute respiratory infections during which saturation levels are normal at rest but after relatively small exertion can decline (so-called "silent hypoxia"). Clinicians should be aware that a 3% drop in saturation from resting when exerting (1 minute sit to stand or 40 steps on the flat test) should be considered as a potential indicator of more severe disease and would

suggest likely hospital admission. If emergency O_2 is given, it should aim to achieve 94–98% saturation until further assessment is available within a more specialist setting where arterial blood gases can be measured.[3]

Box 1: Clinical features indicating severity of condition and requirement for consideration of admission to hospital[15]

Pulse oximetry (less than 92% or an exertional drop of 3%)

New onset confusion

Respiratory rate >25/minute

Systolic blood pressure <90 mmHg

Pulse rate (>130/min)

Note: At times clinical history alone may override these findings – for example, myocardial infarction or stroke

Asthma

In addition to the usual assessments considered appropriate in asthma (history, examination, pulse, respiratory rate, peak expiratory flow rate compared with patient's best), it is important to measure O_2 saturation in an acute asthma attack or if an acute episode is suspected. If the O_2 saturation before treatment with bronchodilators is below 92%, the patient should be considered for acute admission to hospital.[16] If emergency O_2 is given, aim to keep SpO_2 levels between 94% and 98% until further assessment is available within a secondary care setting.

COPD

In a routine review, a patient with moderate to severe COPD should be considered for screening pulse oximetry. A figure of 92% or less, especially if repeated on more than one occasion, should trigger referral for more comprehensive O_2 assessment.[17]

It is recognised that some people with hypercapnic respiratory failure will deteriorate if given high-dose O_2. In the acute situation, pulse oximetry should be used to ensure that oxygen saturations are maintained between 88% and 92% if at risk. These patients usually have a history of significant respiratory problems and some will have an alert warning card.[3]

Acute COVID-19 illness

Pulse oximetry has been used in the home setting to detect hypoxia associated with acute COVID-19 illness as part of a virtual ward remote monitoring model.[2,4] UK guidelines recommend that pulse oximetry should form part of the assessment and monitoring of acutely unwell or high-risk patients with suspected COVID-19.[18,19] Reduced O_2 saturation alongside a worsening clinical picture should prompt further clinical assessment and consideration of transfer to hospital.[4]

Conclusions

Pulse oximetry is a useful non-invasive investigation that is easily performed and is reproducible in primary care. Research findings in other settings may be applicable in primary care. The evidence for benefit is clear, and it is difficult to justify failure to use pulse oximetry with the current evidence-based guidelines in influenza, community acquired pneumonia, asthma and COPD.

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