

OXYGEN

Use

Supplemental oxygen is used to correct hypoxia in babies with pulmonary problems, especially where this is causing a mismatch between the ventilation and the perfusion of the lung.

Pathophysiology

Oxygen deserves its place in any pharmacopoeia because - like almost any other drug - oxygen can do a lot of harm as well as a lot of good. It needs to be used with care; all use should be documented, and the 'dose' used recorded. While lack of oxygen can be damaging, the body can manage with blood that is only about 50–60% saturated as long as the *quantity* of oxygen delivered to the tissues is adequate. Were this not true, the fetus would be in substantial trouble before birth, as would the brain of the baby with cyanotic heart disease. Cardiac output and tissue perfusion matter more than blood pressure, and anaemia can undermine oxygen delivery as much as overt cyanosis. While tissue hypoxia can be damaging, it is the combined effect of CO₂ accumulation and oxygen lack (asphyxia) that is most damaging, causing a respiratory (carbonic acid) as well as a metabolic (lactic acid) acidosis.

Too much oxygen can also be damaging however. Prolonged exposure to more than ~60% oxygen can be toxic to the pulmonary epithelium, and hyperbaric oxygen can cause convulsions. There is also evidence that a relatively high partial pressure of oxygen in the blood is one of a range of factors that can interfere with the normal growth of blood vessels into the retina at the back of the eye in the last ten weeks of what should have been intrauterine life. In most cases the retinal changes resolve spontaneously leaving no damage, but severe change can lead to permanent (cicatricial) scarring if it involves more than the outer rim of the retina, and this scarring can sometimes progress to retinal detachment and complete blindness. Good controlled trial evidence that excessive oxygen could cause blindness first appeared in 1952, but we still do not know precisely what constitutes 'excessive' oxygen. Even the 'routine' use of 100% oxygen during resuscitation at birth is now being questioned.

The more immature the baby the greater the risk to the eye, but changes take at least six weeks to develop, and most severe disease develops at a postconceptional age of 33 to 40 weeks. Damage can be reduced by surgery to limit the capillary proliferation that precedes permanent scarring, but the disease can progress quite rapidly. It is essential, therefore, for every baby born before 28 weeks gestation to be seen by an experienced ophthalmologist when they reach a postmenstrual age of 31 weeks, and then serially every 7–14 days until any acute proliferative change has started to regress. Babies of 28–32 weeks gestation first merit review when 4 weeks old. Review can be discontinued after 36 weeks if there is still no retinal abnormality because disease appearing for the first time after this is extremely unlikely to progress to permanent scarring.

Diode-laser treatment should be offered *immediately* if stage 3 change develops in zone I (the central area of the retina), or if any change develops in this zone accompanied by 'plus' disease (vessel dilatation and tortuosity involving two quadrants [usually 6 or more clock hours]). It is also indicated if stage 2 or 3 change with plus disease develops in zone II. The recent ET-ROP trial showed that there was a 15% risk of the child becoming near blind in that eye if nothing is done once the disease process had become that extensive, and that prompt intervention can probably reduce that risk by a third.

Administration

Oxygen is usually given into an incubator, especially in small babies, but cot nursing using a nasal cannula is a valuable (and economic) alternative that simplifies parental involvement. Some form of humidification is, however, called for if the baby is getting much oxygen this way. Devices delivering a high flow of warm humidified gas for cannula use are becoming increasingly popular, but there is concern that, at flows of more than 2 l/min, the main benefit derived from their use is caused by the fact that they deliver an unmeasured, uncontrolled, and potentially dangerously high, form of constant positive airway pressure (or CPAP). A humidified head box (see below) is the only satisfactory way of providing more than 50% oxygen to a Baby requiring incubator care – oxygen tents are seldom very satisfactory at any age. It is not generally recognised that substantial (but not very precisely controlled) amounts of oxygen can also be given directly into any high-sided carry cot or basinette since oxygen, because of its temperature and density, 'layers' immediately above the surface of the mattress; it is not necessary to put a plastic sheet over the top of the basinette.

Measurement in air

The amount of oxygen each baby is breathing (as a percentage) should be recorded regularly, and those given oxygen via a nasal catheter should have the ambient concentration needed to provide an equivalent arterial saturation documented periodically, because the relation between catheter flow and the inspired concentration varies. Equipment needs daily calibration against room air (20.9% oxygen).

Measuring blood levels

What constitutes a safe range for arterial oxygen pressure is not known. It is said that there must be 50 g/l of desaturated haemoglobin for cyanosis to be visible. Cyanosis is certainly difficult to detect by eye until 25% of the blood is desaturated, and in the neonate this often only occurs when the arterial partial pressure (P_{aO_2}) is down to 35 mmHg or 4.7 kPa (the left hand vertical line in fig 1). There is no good controlled trial evidence that the use of arterial catheters improve outcome, although their use can reduce trauma to the heels from repeated capillary sampling. Transcutaneous pressure and saturation monitors are valuable but not free from error.

OXYGEN continued

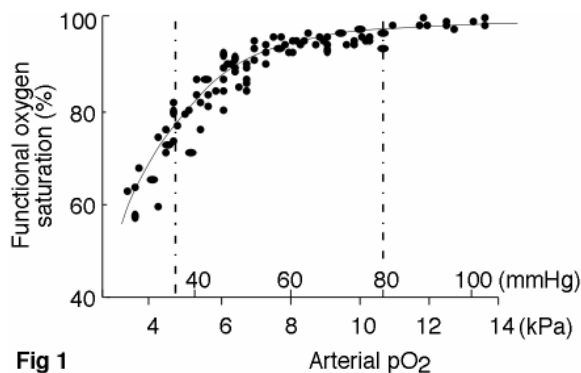


Fig 1

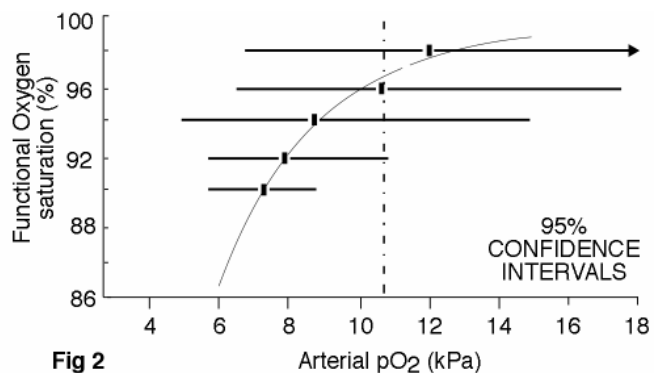


Fig 2

Measuring blood levels continued

The largest cohort study ever mounted showed an association between the prevalence of acute retinopathy and the duration of exposure to a transcutaneous oxygen ($TcpO_2$) of more than 80 mmHg (~10.7 kPa). As a result it has long been considered good practise to monitor all babies with a postmenstrual age of less than 37 weeks requiring supplemental oxygen to prevent unnecessary hyperoxia, aiming for $TcpO_2$ levels of 6–10 kPa. Pulse oximeters are now widely used to supplement, or replace, the monitoring of $TcpO_2$ even though the relation between PaO_2 and arterial saturation is quite variable (fig 1). In particular, blood that is cool, that contains relatively few hydrogen ions, little carbon dioxide, and a minimum of adult haemoglobin, remains well saturated at relatively low pressures. To be 98% certain of keeping PaO_2 below 80 mmHg, the *functional* saturation in babies has to be kept from exceeding 92% (fig 2) – equivalent to a *fractional* saturation of 90%. Given the variable performance of some monitors even this may leave preterm babies at some small risk of 'hyperoxia'. Four trials are currently trying to identify what range of saturation optimises long term outcome

No such restriction needs to limit management in babies in whom retinal vascular development is complete. Here monitoring is only necessary to identify hypoxia, and significant central cyanosis is not difficult to detect (although badly chosen fluorescent lighting can affect assessment). Babies with chronic lung disease are often given oxygen in the belief that this will improve weight gain and reduce emergency hospital readmission, but there was no evidence of this in the recent Australian BOOST trial, and babies given enough supplemental oxygen to maintain a *fractional* saturation of 96–99% in the American STOP-ROP trial actually had *more* pulmonary problems than those only given enough to achieve a saturation of 89–94%. Views differ as to how often home use is necessary, and a UK register of such use (CHORD) has recently been set up.

Supply

Piped hospital supplies result in our taking the provision of oxygen for granted: the same is not true in many developing countries. Arrangements for providing oxygen for home use in the UK have recently undergone a major, and initially unsettling, change. The supply of an oxygen concentrator and of lightweight cylinders by one of four commercial companies must now be authorised by a designated official in each Trust hospital.

Humidification

Piped supplies and cylinders are devoid of water vapour, and humidification is essential to avoid excessive drying of the respiratory tract when giving >40% oxygen. A range of commercial equipment (such as the VapoTherm[®]) has now become available for delivering a flow of warm well-humidified gas with a variable oxygen content. Just bubbling gas through water at room temperature however adds 20 grams of water to each cubic metre of gas (equivalent to 50% saturation at body temperature), and this is generally adequate unless flow is high or the nose's humidification system has been at least partially by-passed. For babies breathing high concentrations of head-box oxygen in an incubator reasonable humidification can be achieved without a heated humidifier by bubbling oxygen through a small bottle situated actually inside the incubator.

References

See also the relevant Cochrane reviews ©

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