Oxygen

Over the past few years there have been significant changes, based on high quality research, in our understanding of how to give the right amount of oxygen to babies, although most research has been in the preterm population. What has emerged is that too little oxygen and too much oxygen can both be harmful, and that ex-preterm babies who are more mature should not be considered to be the same as term babies born at term.

More detailed background information and references can be found at the end of this guideline

Oxygen Targeting
The set target range (saturation limits) represents the values aimed for when the infant is stable and at rest.

Premature babies (<37 weeks) in oxygen
A recent audit on our unit showed that the most frequent saturation was 95%, and as a result we have implemented a small change to reduce the saturation limits to 88-93%.

![Oxygen saturations - Premature](image)

Premature babies in air
Saturation limits to be set at 88-100%. As soon as a baby requires oxygen, then the 88-93% limits must be applied.

Term babies (≥37 weeks) in oxygen
Keep the saturations over 95%, with saturation limits 95-99%

Term babies in air
Set the saturation limits at 95-100%
Where to place the oxygen saturation probe?
The best place is on the right hand/wrist, which will give a pre-ductal reading of oxygen saturation – this is the blood that goes to the brain and eyes. If there are concerns about right-to-left ductal shunting, then post-ductal monitoring (on the lower limbs) may also be used and differences of >4% may be significant.

Targets and limits apply to these infants until discharge, even when they have become more mature e.g. an infant born at 27 weeks who has a corrected gestational age of 39\(^{+4}\) weeks and is still requiring oxygen will continue to have the monitor alarm limits set at 88-93%

Monitor alarm limits should be checked and documented when monitoring is commenced and at the start of each shift.

Continuous monitoring of saturation is mandatory for all:
- Infants <32\(^{+6}\) weeks gestation.
- Infants >32\(^{+6}\) weeks receiving oxygen
- Infants who have respiratory or cardiac problems

Excessive oxygen, wide swings of oxygen, and too little oxygen can all be potentially harmful

Exposure to high oxygen levels, rapid and wide changes in oxygenation, sustained hypoxemia (increased oxygen content of blood), and episodes of hypoxemia (insufficient oxygen content of blood) are all thought to be deleterious to the developing brain, eyes, and lungs. It can be difficult, and require intensive nursing input, to get the balance right in a baby with shunting, respiratory disease etc. Looking at trends on the monitoring, and the use of saturation studies can be useful.

Do not alter oxygenation too swiftly, infants should be allowed to “pick up” after crying, coughing etc. The oxygen should only be changed if the desaturation is persistent and dipping below 85%.

The following approaches to help avoid excessive oxygen use and limit overreaction to desaturation events should be considered first

1. **No Treatment.** Assess whether the desaturation represents monitoring artefact. Look at the monitor to ensure there is a good pulse wave and that the heart rate correlates with the ECG. Remember to look at the infant. Many infants will recover from desaturation events spontaneously with no intervention.

2. **Gentle stimulation.** If an infant is apnoeic there is no benefit to increasing the FiO\(_2\).

3. **Gentle Manual breaths/ mask ventilation.** For the infant who is apnoeic and does not respond to stimulation. Use a similar FiO\(_2\) to that which the baby is currently receiving.

If an increase in FiO\(_2\) is necessary

- When it is necessary to increase the FiO\(_2\) (if SpO\(_2\) remains low after adequate respirations have been established) this should be done in small increments of around 5% oxygen e.g. if in 30% increase to 35%
- If the FiO\(_2\) is increased by more than 5% from baseline levels the carer (doctor or midwife/nurse) should remain with the baby until the SpO\(_2\) recovers and the FiO\(_2\) has been returned to its original level.
- Alarms should not be muted unless the carer remains with the baby and alarms must not be set outside of the standards above.

- If it is not possible to return the FiO₂ to a level within 5% of the baseline level a review of ventilatory requirements is warranted.

**Response to high saturation alarms**

It is important to respond to high saturation alarms with the same degree of urgency as the response given to desaturation alarms. If we look at the oxygen saturation audit, the second most frequent oxygen saturation was 96%.

When we give infants oxygen we are giving a drug. It is impossible to know how high the oxygen tension in arterial blood (PaO₂) is when the SpO₂ is reading 100% due to the oxygen dissociation curve. Therefore the SpO₂ in infants receiving supplementary oxygen should be monitored carefully to avoid sustained hyperoxaemia, and this is why 100% saturations are only acceptable if a baby is in air.

**Discharge planning in infants requiring home oxygen**

We are keen that our most immature infants should be clearly demonstrated to have adequate oxygenation at the time of discharge home and that this should have been documented by a saturation study.

At the same time we wish to avoid unnecessarily lengthy periods in hospital of fixed oxygen.

**Who should get a saturation study?**

Any infant who was born before 30 weeks gestation and required oxygen for at least 4 weeks. Infants who have ongoing oxygen requirements for any reason may also benefit from a saturation study.

**How is a saturation study done?**

The probe should be placed on the right hand/wrist, secured and covered with a glove/mitten. This is to ensure that a preductal study is conducted. Normally one of the neonatal community nurses will arrange the study, print out the results and make written suggestions based on the latest study, which should be filed in the notes. The attending consultant should be shown all the inpatient studies to ensure that consistent advice is given to parents, nursing and medical staff.

**When should the saturation study be done?**

- If the baby has been weaned to air using the above criteria, the saturation study should be done a week after the baby is in air to check that oxygen is definitely not required prior to stopping routine saturation monitoring.
- If the baby is still in oxygen then a saturation study at about 34-35 weeks will be used to establish baseline. Further studies will be needed to establish that oxygen will be needed at home and how much oxygen is required.

**How should the saturations study be used?**
**Interpretation of saturation studies**

We should aim not to use more oxygen than is necessary to maintain saturations around 93% (range 90-95%) in babies born at risk of chronic lung disease who are still in hospital. However they need a little more reserve to be safe at home. By the time of discharge, any infant who was born before 30 weeks gestation and needed oxygen for at least 4 weeks should have an average saturation during sleep of 93% or above during their sleep study.

The % of time spent with saturations <90% should be no more than 5%. The presence of bradycardic episodes may indicate that more oxygen is required, although of course there may be other causes which should be investigated for if a small increase in oxygen does not resolve the episodes.

Some babies need more oxygen during feeds and/or at night, and we will use the studies to guide a management plan.

- If the baby is in oxygen when the study is done, the study will be used to fix the oxygen for discharge
- If the baby is in air when the study is done and it is acceptable, no further studies will be required before discharge

There will be an occasional baby who is in air and during the sleep study can maintain saturations above 90% but cannot average 93% or more.

- These babies can stay in air in hospital if they are not ready for discharge
- If they are to go home in the near future they will need to go home in oxygen
- In these “borderline” babies, it may be worth delaying discharge for 5-7 days to do another study in air as a further weeks maturation may be enough to save them the complexities of discharge home in oxygen
- This is something that we will need to deal with on an individual basis, supported by consultant communication
Background Information

Oxygen is the most commonly used drug given to premature infants. However, they are highly sensitive to its harmful biochemical and physiological effects.

There have been several large trials to ascertain the optimum range of oxygen saturation (SpO₂) for infants nursed on the Neonatal Unit.

The first BOOST trial demonstrated that babies from 32 weeks corrected gestation with oxygen saturation targeted at 91-94% (alarm limits 90-95%) had lower rates of chronic lung disease and respiratory morbidity compared to babies targeted at a higher oxygen saturation range. Therefore all babies on the NNU apart from the exceptions below are to have their oxygen saturation targeted in the same range of 91-94% (alarm limit 90-95%).

The Benefits of Oxygen Saturation Targeting “BOOST” study

The Benefits of Oxygen Saturation Targeting “BOOST” study was performed in Australia. The hypothesis behind the study was that chronic hypoxaemia in preterm neonates would result in poor growth and development.

Infants born at less than 30 weeks gestation, who remained oxygen dependent at 32 weeks postmenstrual age, were randomised to “standard saturation” oxygen therapy to maintain SpO₂ in the range 91-94%, or “high saturation” oxygen therapy with SpO₂ in the range 95-98%.

The study found no significant differences in the primary outcomes of growth or major developmental abnormality at corrected age 12 months. There was no significant difference in the rates of ROP, of any stage, between the two groups. However there were more pulmonary complications in the higher oxygen group.

The BOOST II trial compared oxygen saturation ranges of 85 to 89% versus 91 to 95% it discovered that babies nursed in the lower saturation range had a statistically significantly higher rate of NEC, although rate of ROP was also significantly lower. However the rate of death in the babies targeted at <90% was significantly greater. We plan to follow these saturation limits from birth to discharge, but recognise that there has been no study of changing saturation limits (upwards) for more mature babies which might one day be found to be better. In the absence of any evidence, we will be guided by existing evidence and expert views. We also recognise that staying within targets is extremely challenging sometimes and that frequent fluctuations seem to be part and parcel of prematurity. The COT trial showed less variation in outcomes, perhaps indicating that rigorous control of saturations is the most important aspect we should be aiming for.

The Canadian Oxygen “COT” Trial

Also published in 2013, the COT group studied 2 saturation limits 85% to 89% (n = 602) or 91% to 95% (n = 599). They found no differences in deaths or outcomes between the groups. There was a software update in the middle of the trial, which had made such a difference to the BOOST study, but no difference was seen in COT. The combined results of all oxygen trials may yet influence recommendations.

The STOP-ROP Trial

The concept that relative hypoxia in the peripheral avascular retina is responsible for the pathological angiogenic response in the second phase of ROP, and that this response might be mitigated by increased supplemental oxygen was tested in the “Supplemental Therapeutic Oxygen for Pre-threshold Retinopathy of Prematurity” (STOP-ROP) trial, published in 2000. It should be emphasised that this trial differed from other oxygen trials in that it was designed to test a possible treatment for acute, severe ROP, rather than prevent the development of severe ROP.
Infants with “Pre-threshold” ROP in at least one eye, who had an oxygen saturation < 94% in room air, were randomised at a mean post-menstrual age of around 35 weeks to oxygen therapy that resulted in 89-95% saturation – “conventional oxygen”, or 96-99% saturation – “supplemental oxygen”. 48% of conventional oxygen infants and 41% of supplemental oxygen infants progressed to Threshold ROP.

After adjustment for baseline factors there was no significant difference between the groups. At 3 months post term, there was no difference in the structural outcome of the retina (4.8% abnormal in the conventional group and 4.1% in the supplemental group). The supplemental oxygen group had worse systemic outcomes, with pneumonia or worsening chronic lung disease in 13.2% vs. 8.5% in the conventional oxygen group.

Babies >37 weeks

There is not much good evidence for the best use of oxygen in more mature babies. Whilst high saturations are less of a concern than they should be in more premature babies <35 weeks, hyperoxia may still be harmful e.g. in babies with neonatal encephalopathy. We should aim not to give supplemental oxygen for prolonged periods if babies are consistently saturating at 99 or 100%, so the upper alarm limit is set at 99%

If saturations are still <95% at discharge or the difference in pre- and post-ductal saturations is 4% or greater, then consideration to echocardiography may be given if not previously performed and there is no other clear explanation.

References, Sources and Acknowledgements


Dr. C Doherty, Neonatal Consultant, Cardiff and Vale University Health Board (personal communication)

Prof. Ben Stenson, Edinburgh Royal Hospital for Sick Children (NHS Lothian) (personal communication)


Chow LC et al. Can Changes in Clinical Practice Decrease the Incidence of Severe Retinopathy of Prematurity in Very Low Birth Weight Infants? Pediatrics 2003;111;339-345

Oxygen Saturation and Outcomes in Preterm Infants
Effects of Targeting Higher vs Lower Arterial Oxygen Saturations on Death or Disability in Extremely Preterm Infants: A Randomized Clinical Trial

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