Ashford and St. Peter's Hospitals
NHS Foundation Trust

Use of Oxygen in Neonatal Patients

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Guideline History		
Date	**Comments**	**Approved By**
2013	New guideline	NGG
2015	Reviewed, updated	
2019	Reviewed, updated	NGG

Contents

1. Oxygen use in NICU

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

The international NeoProm studies showed that babies with SpO2 set at the higher 91-95% range had a lower mortality rate. It is not known what the optimal individual SpO2 is for a preterm baby and it may vary by gestation or by individual.

Premature babies in air

Saturation limits to be set at 91-100%. As soon as a baby requires oxygen, then the 91-95% 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%

Monitoring

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 91-95%

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

Response to saturation alarms

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 hyperoxemia (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.

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 FiO_2 to a level within 5% of the baseline level a review of ventilatory requirements is warranted.

Response to <u>high</u> 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 (PaO_2) is when the SpO_2 is reading 100% due to the oxygen dissociation curve. Therefore the SpO_2 in infants receiving supplementary oxygen should be monitored carefully to avoid sustained hyperoxaemia, and this is why <u>100% saturations are only acceptable if a baby is in air.</u>

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 34 weeks will be used to establish baseline. Other causes for an O2 requirement such as gastro-oesophageal reflux should be considered. Further studies will be needed to establish whether oxygen will be needed at home and how much oxygen is required.

How should the saturations study be used?

- To inform the discharge process and to show parents whether oxygen is or is not required
- To determine that a baby who is still in oxygen will be discharged in adequate fixed oxygen
- To determine that a baby in air can have saturation monitoring discontinued

Interpretation of saturation studies

We should aim not to use more oxygen than is necessary to maintain saturations (range 91-95%) 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 (SpO_2) 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 91-95%).

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 SpO_2 in the range 91-94%, or "high saturation" oxygen therapy with SpO_2 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 trials (NeoProm) 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.

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.

2. Supporting References

Askie L. M., Henderson-Smart D. J., Irwig L. and Simpson J. (2003) Oxygen Saturation Targets and Outcomes in Extremely Preterm Infants. The New England Journal of Medicine, 2003 Sep 4;349(10):959-67

Shriver, E. K. (2011). Surfactant Positive Airway Pressure and Pulse Oximetry Trial (SUPPORT). N Engl J Med 2010;362:1959-69 http://clinicaltrials.gov/ct2/show/NCT00233324

Oxygen targeting in preterm infants using the Masimo SET Radical pulse oximeter Ewen D Johnston, Breidge Boyle, Ed Juszczak, Andy King, Peter Brocklehurst, Ben J Stenson Arch. Dis. Child. Fetal Neonatal Ed. 6 March 2011 10.1136/adc.2010.206011 Open Access http://fn.bmj.com/cgi/content/abstract/adc.2010.206011v1?papetoc

Stenson, B., Brocklehurst, P. and Tarnow-Mordi, W. (2012) Increased 36-Week Survival with High Oxygen Saturation Target in Extremely Preterm Infants (Letter to the Editor) The New England Journal of Medicine http://www.nejm.org/doi/full/10.1056/NEJMc1101319

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)

Target Ranges of Oxygen Saturation in Extremely Preterm Infants. SUPPORT Trial. N Engl J Med 2010;362:1959-69.

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
The BOOST II United Kingdom, Australia, and New Zealand Collaborative Groups. N Engl J Med 2013; 368:2094-2104. May 30, 2013

Effects of Targeting Higher vs Lower Arterial Oxygen Saturations on Death or Disability in Extremely Preterm Infants: A Randomized Clinical Trial
Barbara Schmidt et al for the Canadian Oxygen Trial (COT) Group . JAMA. 2013;309(20):2111-2120.

Achieved Oxygenation Saturations and Outcome in Extremely Preterm Infants. Stenson, Benjamin J. Clinics in Perinatology 2019, Volume 46, Issue 3, 601 - 610

3. Supporting relevant trust guidelines

4. Guideline Governance

a. Scope

This guideline in relevant to all staff caring for babies across neonatal intensive care.

b. Purpose

i. This guidelines aims to facilitate a common approach to the management of babies admitted under neonatal care. At times deviation from the guideline may be necessary, this should be documented and is the responsibility of the attending consultant.

ii. This guideline is subject to regular review to ensure ongoing evidence based practice.

c. Duties and Responsibilities

All health care professionals carrying for infants in NICU are responsible for being aware of the correct use of oxygen; and how to respond to alarms for both desaturation and oversaturation.

d. Approval and Ratification

This guideline will be approved and ratified by the Neonatal Guidelines Group.

e. Dissemination and Implementation

i. This guideline will be uploaded to the trust intranet 'Neonatal Guidelines' page and thus available for common use.
ii. This guideline will be shared as part of ongoing education within the Neonatal Unit for both medical and nursing staff.
iii. All members of staff are invited to attend and give comments on the guideline as part of the ratification process.

f. Review and Revision Arrangements

a. This policy will be reviewed on a 5 yearly basis.
b. If new information comes to light prior to the review date, an earlier review will be prompted.
c. Amendments to the document shall be clearly marked on the document control sheet and the updated version uploaded to the intranet. Minor amendments will be ratified through the Neonatal Guidelines Group. A minor amendment would consist of no major change in process, and includes but is not limited to, amendments to documents within the appendices.

g. Equality Impact Assessment

Background • Who was involved in the Equality Impact Assessment
Methodology • A brief account of how the likely effects of the policy was assessed (to include race and ethnic origin, disability, gender, culture, religion or belief, sexual orientation, age) • The data sources and any other information used • The consultation that was carried out (who, why and how?)
Key Findings • Describe the results of the assessment • Identify if there is adverse or a potentially adverse impacts for any equalities groups
Conclusion • Provide a summary of the overall conclusions
Recommendations • State recommended changes to the proposed policy as a result of the impact assessment • Where it has not been possible to amend the policy, provide the detail of any actions that have been identified • Describe the plans for reviewing the assessment

h. Document Checklist

To be completed (electronically) and attached to any document which guides practice when submitted to the appropriate committee for approval or ratification.

Title of the document:

Policy (document) Author:

Executive Director:

		Yes/No/ Unsure/NA	Comments
1.	**Title**		
	Is the title clear and unambiguous?		
	Is it clear whether the document is a guideline, policy, protocol or standard?		
2.	**Scope/Purpose**		
	Is the target population clear and unambiguous?		
	Is the purpose of the document clear?		
	Are the intended outcomes described?		
	Are the statements clear and unambiguous?		
3.	**Development Process**		
	Is there evidence of engagement with stakeholders and users?		
	Who was engaged in a review of the document (list committees/ individuals)?		
	Has the policy template been followed (i.e. is the format correct)?		
4.	**Evidence Base**		
	Is the type of evidence to support the document identified explicitly?		

		Yes/No/ Unsure/NA	Comments
	Are local/organisational supporting documents referenced?		
5.	**Approval**		
	Does the document identify which committee/group will approve/ratify it?		
	If appropriate, have the joint human resources/staff side committee (or equivalent) approved the document?		
6.	**Dissemination and Implementation**		
	Is there an outline/plan to identify how this will be done?		
	Does the plan include the necessary training/support to ensure compliance?		
7.	**Process for Monitoring Compliance**		
	Are there measurable standards or KPIs to support monitoring compliance of the document?		
8.	**Review Date**		
	Is the review date identified and is this acceptable?		
9.	**Overall Responsibility for the Document**		
	Is it clear who will be responsible for coordinating the dissemination, implementation and review of the documentation?		
10.	**Equality Impact Assessment (EIA)**		
	Has a suitable EIA been completed?		

Committee Approval (Neonatal Guidelines Committee)			
If the committee is happy to approve this document, please complete the section below, date it and return it to the Policy (document) Owner			
Name of Chair		**Date**	
Ratification by Management Executive (if appropriate)			
If the Management Executive is happy to ratify this document, please complete the date of ratification below and advise the Policy (document) Owner			
Date: n/a			