Administration & monitoring of oxygen delivery in the newborn

Introduction:

Oxygen therapy is one of the most commonly used treatments in neonatal care\(^1\). Whilst recent studies have highlighted the adverse effects of excess oxygen there are no standardised guidelines for the management of oxygen therapy for the high risk newborn.

A recent RCT concluded that the targeting of oxygen saturations in preterm infants who were dependant on supplemental oxygen conferred no significant benefits to their growth or development and resulted in an increased use of health services\(^2\). This trial challenged the emerging practice of using high oxygen saturations to improve growth and development in premature babies. The target population was babies born under 30 weeks who required supplemental oxygen at 32 weeks post conceptual age. The study demonstrated no benefit to the preterm infant in targeting an oxygen saturation range of 95-98% compared with the lower 91-94%.

The STOP-ROP trial did not demonstrate a statistical difference in the rates of ROP or the need for ablative surgery for babies in the conventional (median SaO2 89 - 94%) versus the supplemental group (median SaO2 96 -99%)\(^3\). Babies receiving supplemental oxygen however had an increased risk of adverse pulmonary events including pneumonia and/or exacerbations of chronic lung disease and the need for long term oxygen therapy, diuretics, and hospitalisation at 3 months of corrected age.

All RNs must be familiar with the following guidelines to ensure the safe and effective use of oxygen in the high risk newborn.
**Administration of Supplemental Oxygen. (Table 1)**

***All babies in the acute phase of ventilation/ oxygenation support must be continuously monitored***

<table>
<thead>
<tr>
<th>Method of O₂ Administration</th>
<th>Guideline for Use</th>
<th>Requirement of O₂ Analyster (2)</th>
<th>Requirement of O₂ Blender (7)</th>
<th>Requirement of Humidity (11)</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incubator/Crib Oxygen</strong></td>
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<tr>
<td><em>Air-Shield C200</em> (1)</td>
<td>Appropriate for the stable chronic infants and infants in transition to air, e.g. requiring less than 25% O₂. (Efficiency of upper limits of oxygen supplied depends on type of incubator used.)</td>
<td><em>Essential</em> if not built into the incubator. Alarm must be set appropriately and analyzer always placed next to face.</td>
<td>Not necessary</td>
<td>Not a requirement to O₂ therapy (but refer to the Small Baby Protocol if appropriate)</td>
<td>Increased accessibility for care givers and parents</td>
<td>Increased lability of O₂ delivery and time to re-establish target dose when portholes are opened.</td>
</tr>
<tr>
<td><em>Air-Shield C2000</em> (3)</td>
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<tr>
<td><em>Drager 8000IC</em> (4)</td>
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<tr>
<td>*<em>Headbox Oxygen</em> (6)</td>
<td>Babies admitted to the nursery requiring O₂ for acute respiratory distress</td>
<td><em>Essential</em> and must be placed inside the headbox next to baby’s face.</td>
<td>Recommended but gases (O₂ and air) may be mixed using a ‘Y’ connector. (8) (see table 2)</td>
<td>Essential. temperature must be aimed at a low NTE to prevent overheating. F&amp;P 850 model delivers at 34° in non invasive mode F&amp;P 750 set at NTE.</td>
<td>Consistent levels of inspired gas with access to baby for handling.</td>
<td>Impaired access to baby. Can cause overheating and irritability as baby’s condition improves.</td>
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<tr>
<td>gas flow of 10L / min</td>
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<tr>
<td>*<em>Nasal Prong Oxygen</em> (10)</td>
<td>O₂ administered via a low flow meter and short nasal prongs often used in babies where use of prolonged supplemental O₂ is required. May be an alternative to headbox O₂ for infants recovering from RDS.</td>
<td>Not necessary</td>
<td>Not essential with low flow O₂ gauges. Type of low flow outlet depends on baby requirements. Extra/ultra low flow outlet delivers up to 100mls; low flow delivers from 100ml to 250ml. (9)</td>
<td>Not essential with low flow O₂ rates of &lt; 500mls. Recommended with higher flows to minimize drying out of the airways.</td>
<td>Ease of care and increased comfort for baby facilitating optimal positioning and accessibility for carers and parents</td>
<td>Poor accuracy in administration O₂ desaturation may occur if baby crying or irritable. Flow of O₂ titrated with SaO₂ % measurements.</td>
</tr>
</tbody>
</table>

Intermittent monitoring may be applied in babies in chronic phase with mild O₂ requirements (Chronic lung disease protocol)

# NUMBERS CORRELATE TO SUBSEQUENT PICTURES
Oxygen is introduced via the wall O2 outlet to the back of the incubator and must be regulated by the use of an oxygen analyzer.

The oxygen concentration guide on the back can only be used as an estimate and factors as the doors being opened etc. An oxygen analyser must be used. It is estimated that it can take about 20 minutes to achieve desired O2 concentration each time the doors are opened.

**The Air-Shield C200 (#1)**

**Oxygen Analysers (#2)**

Analysers should be calibrated and alarm limits checked each shift.

- **Measurements of oxygen**
  
  If < 40% O2 being administered calibrate to air. Remove the analyser from any oxygen source and the display panel should read 21%. Alter the reading by adjusting the buttons until calibrated. If >40% then the analyser should be placed in a glove filled with O2 and calibrated to 100%.

- **Buttons to set alarm limits**
  
  Alarm limits should be set at 5% above and below the required dose.
The gas outlets on this incubator are connected directly to the wall outlets. After calibrating the O₂ sensor, the accuracy of the amount of oxygen given into the incubator is displayed here. The required amount of O₂ is adjusted by unlocking the keypad (1), selecting oxygen (2) and adjusting the percentage with the up and down buttons (3). Return to home when adjustment is complete.

This display shows what is ordered and what is being delivered.

The gas outlets on this incubator are also connected directly to the wall outlets. After calibrating the O₂ sensor, the accuracy of the amount of oxygen given into the incubator is displayed here. This display shows what is ordered (1) and what is being delivered (2). The amount ordered can be adjusted by the arrows.
Guidelines for administration of Headbox oxygen via Y-connector from wall O₂ and Air outlets. (Table 2.)

<table>
<thead>
<tr>
<th>O₂ Percentage</th>
<th>O₂ Flow L/min</th>
<th>Air Flow L/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>50</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>60</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>70</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>80</td>
<td>7.5</td>
<td>2.5</td>
</tr>
<tr>
<td>90</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>
Oxygen Blender (#7)

This is attached to the outlets labeled BLENDED AIR and is used for the anaesthetic bag & mask and bubble CPAP circuits. Oxygen required can then be dialed here from 21% (air) to 100%.

Infants in air (21% O₂ via bubble CPAP are to be connected to an air flow meter at 8-10 L/min.

Oxygen and Air outlets (#8)

Flows of up to 15 L / min – read top of ball

Extra/ultra low flow meter

This allows for oxygen flows up to 100 ml (0.1 L/min).

Low flow oxygen meter

This allows for oxygen flows up to 250 ml (0.25 L/min).
Nasal prongs (10)
These should only be attached to Low flow or Ultra/ extra low flow meters.

Equipment For Nasal Prongs:
Low flow/ Ultra low flow meter
Green O₂ tubing
Salter nasal cannula
Duoderm & ½ ” Leucoplast or Opsite cut to size.

Documentation must include:
*Oxygen flow range during rest and necessary changes during feeds/handling.
*Suction requirements (frequency & return).
*Observations, hourly or as per Chronic Lung Policy

The flow of oxygen being delivered is observed by looking at the centre of the ball bearing in the flow meter.

The prongs should be checked for any occlusion from secretions.
Suction should be performed PRN.

Prongs are held insitu by tape with Duoderm underneath to protect the skin.
Tubing/tape should be changed PRN and change documented.
Mothercraft and parenting skills should be enhanced by nasal prongs as their use facilitates easier handling of the babies.
**Administration of Oxygen with Assisted Ventilation. (Table 3.)**

<table>
<thead>
<tr>
<th>Method of O₂ Administration</th>
<th>Guideline for Use</th>
<th>Requirement of O₂ Analyser</th>
<th>Requirement of O₂ Blender</th>
<th>Requirement of Humidity</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPAP (Continuous Positive Airway Pressure)</td>
<td>Treatment of acute respiratory distress and/or apnoea. Used to facilitate weaning from ventilation.</td>
<td>Essential.</td>
<td>Recommended but gases (O₂ and air) may be mixed using a ‘Y’ connector with ‘bubbly’ CPAP. (see appendix) Internal blender in the Infant Flow Driver</td>
<td>Essential. Target humidity temperature to core temperature of baby. The F&amp;P 850 model delivers at 37° when set at the invasive mode. The F&amp;P 750 should be set at 39°/-2</td>
<td>Non invasive and maintains functional residual capacity. Facilitates recruitment of the alveoli thus decreasing the work of breathing. Maintains a PEEP which facilitates maximum gaseous exchange.</td>
<td>Can cause irritability and excessive handing if baby is resistant. Restricts parental access to baby. Pressures are maintained with adequate seal so mouth must be closed with prongs &amp; hat correctly positioned. Incorrectly sized prongs will increase leak and / or damage nares</td>
</tr>
<tr>
<td>IPPV (Intermittent Positive Pressure Ventilation)</td>
<td>Treatment of respiratory failure</td>
<td>Integral to ventilator function.</td>
<td>Integral to ventilator function.</td>
<td>Essential – observe for misting at patient wye. Target humidity &amp; temperature to core temperature. The F&amp;P 850 model delivers at 37° when set at the invasive mode. The F&amp;P 750 should be set at 39°/-2 Stephanie set at 39° (-2.0) for conventional ventilation &amp; HFOV</td>
<td>Allow control of ventilation. Enables route of administration of medications (surfactant/ adrenaline)</td>
<td>Invasive procedure that can increase risk of barotrauma, pneumonia, secretion production &amp; airway trauma. Potential to increase time of maternal separation.</td>
</tr>
</tbody>
</table>

*RPA Newborn Care Clinical Guidelines
Administration & Monitoring of Oxygen Therapy
Main Author: Cynthia Martin (April 2006) Revised Oct 2009; Revised July 2011
Total Revision due Oct 2012*
Flow Driver CPAP Delivery System (11)

Oxygen desired is dialed up here

Oxygen concentration is displayed here

Flow desired is measured here

Guidelines for deciding the type of CPAP delivery – see **CPAP protocol**

- Infants with suspected RDS < 1250g use the Infant Flow Driver (EME, UK) or Bubble CPAP (Fisher & Paykel) starting at 6-8cm water
- Infants with suspected RDS >1250g: use ventilator CPAP 8-10cm water via short binasal prongs (Argyle prong® Tyco Healthcare) or Bubble CPAP (Fisher & Paykel)

After extubation use the CPAP device appropriate for weight & maturity at a minimum setting of 6 cms H₂O: the pre-extubation MAP should be used as a guide.

F&P Bubble CPAP Delivery System (12)

Oxygen is attached directly to the wall to a **Blended Air** outlet & an oxygen analyser MUST be attached here.

Humidifier Bases (11)

- F &P 850 model
- F &P 750 model
Drager Babylog Ventilator (#13)

Delivers Oxygen via ventilation and CPAP modes

Stephanie Ventilator (#14)
Monitoring of oxygenation.

There are two non-invasive and continuous methods used to monitor the effects of supplemental O2. These allow for the targeting of an appropriate ambient O2 concentration to maintain oxygenation (PaO₂ / SpO₂%) within the accepted range for gestation, postnatal age and lung pathology. These methods are the transcutaneous O₂ / CO₂ (TCM) monitor which measures PaO₂ / PaCO₂ and the pulse oximeter that measures O₂ saturation.

*A TCM is to be used with all term or near term babies with perinatal asphyxia.*

**Non invasive Monitoring** (Table 4)

<table>
<thead>
<tr>
<th>Type (Transcutaneous Monitoring)</th>
<th>Method</th>
<th>Target Range</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCM</td>
<td>The measurement of the partial pressure of O₂ and CO₂ found in the capillary beds via a permeable membrane of the transducer electrode. The heated electrode changes the lipid structure of the stratum corneum allowing the gases to diffuse through the skin</td>
<td>Target oxygen to avoid hypoxia – PaO₂ 60-80mmHg (term) 50-60mmHg (preterm) Target oxygen to avoid hypoxia – if PPHN is suspected – discuss PaO₂ target range with consultant / fellow</td>
<td>Monitors PaCO₂ as well as PaO₂. Is a continuous and non-invasive method of monitoring. Can decrease frequency of blood sampling. Useful when ventilation/oxygenation parameters are being altered.</td>
<td>Electrode can cause damage to skin. Is not suitable for gestations &lt; 27 weeks (Small baby protocol) Accuracy can be impaired if The TCM requires correct calibration &amp; application for accuracy. Tends to under-read PaO₂ if infant is shocked, cold, oedematous or receiving high doses of dopamine.</td>
</tr>
</tbody>
</table>

| SpO₂% Functional Oxygen Saturation monitoring | Measurement of the percentage of haemoglobin saturated with O₂ by a light emitting/light receiving sensors | Target SpO₂ to avoid hypoxia – 90-95% (preterm) 92-98% (term) Target oxygen to avoid hypoxia – if PPHN is suspected – discuss PaO₂ target range with consultant / fellow | Is a continuous & non-invasive method of monitoring oxygenation. Easily mobile. No skin preparation & minimal potential for damage when sites are rotated. Can be used for all gestations. No calibration is required. | Accuracy can be impaired if infant is shocked, cold and/or oedematous. Sensor is sensitive to motion artifact if infant is active and ambient light (e.g. phototherapy lights) No CO₂ reading. |
**Recommended Alarm Limits** (Table 5)

<table>
<thead>
<tr>
<th>Preterm infant &lt; 37 weeks</th>
<th>Target Oxygen</th>
<th>Alarm limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant in air SpO₂%</td>
<td>Target greater than 90%</td>
<td>88-100%</td>
</tr>
<tr>
<td>Infant in oxygen SpO₂%</td>
<td>90-95%</td>
<td>88-96%</td>
</tr>
<tr>
<td>Transcutaneous TcO₂ mmHg</td>
<td>50-60 mmHg</td>
<td>45-70 mmHg</td>
</tr>
<tr>
<td>Transcutaneous TcCO₂ mmHg</td>
<td>45-55 mmHg</td>
<td>40-60 mmHg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term infant</th>
<th>Target Oxygen</th>
<th>Alarm limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant in air SpO₂%</td>
<td>Target greater than 95%</td>
<td>88-100%</td>
</tr>
<tr>
<td>Infant in oxygen SpO₂%</td>
<td>92-98%</td>
<td>91-99%</td>
</tr>
<tr>
<td>Transcutaneous TcO₂ mmHg</td>
<td>60 – 80 mmHg</td>
<td>50-90 mmHg</td>
</tr>
<tr>
<td>Transcutaneous TcCO₂ mmHg</td>
<td>45-55 mmHg</td>
<td>40-60 mmHg</td>
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</table>

For the **term** infant with Persistent Pulmonary Hypertension of the Newborn (PPHN) then discuss target oxygen and alarm limits with staff specialist & document on NICU chart. Modify target oxygen only after discussion with staff specialist / Fellow.

TCM electrode should be 43-44 °C. Preferable sites for electrode placement are over well perfused areas: Anterior chest, abdomen, lower back and thighs. If calibration takes longer than fifteen minutes the sensor must be checked and possibly a new membrane.

It is important that the probes are **NOT** placed over a boney prominence, a site with poor blood flow or with excess fat. The probe requires an air tight seal to prevent room air entering and giving a false reading.

Documentation of ABG gas results correlating with TCM values allow for greater accuracy over the four hours of monitoring. When placing the TCM probe, an attempt should be made to co-ordinate it’s placement with a blood gas if one is to be required. This ensures a correlation to the accuracy of the reading if TCM values are noted at the exact time of taking ABG.
The invasive measurements may be more accurate but offer only a snapshot of actual oxygenation and can be altered by the baby’s response, for example crying which may decrease CO₂.

### Invasive Monitoring (Table 6)

<table>
<thead>
<tr>
<th>Type</th>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capillary Gas</td>
<td>Sample attained by a small prick on the outer aspects of the heel.</td>
<td>Although invasive, it is minimal and can be done frequently by nursing staff CO₂ and pH are accurate readings.</td>
<td>Limited accuracy. Painful procedure every time. Limited accuracy with O₂.</td>
</tr>
<tr>
<td>ABG</td>
<td>Sample attained by accessing a central or peripheral arterial line</td>
<td>Accurate and although initially invasive with insertion does not cause discomfort when sampling.</td>
<td>Invasive monitoring increases risk of infection.</td>
</tr>
</tbody>
</table>

*see Blood sampling/ Arterial line protocols*

- Documentation of O₂ concentration and / or flow, SpO₂ % and / or TC PO₂ / PCO₂ should be documented **at the time of sampling** to determine a correlation / trend at the time of sampling.

### Nursing considerations

**It is the responsibility of the RN to ensure that:**

- Oxygen is administered to maintain the SpO₂ / TC PO₂ / PCO₂ as per guidelines.
- The SpO₂ % probe position should be changed every 8 hours with cares – observe for possible pressure areas.
- The TCM electrode is changed every three-four hours.
- Registrar is notified of an increase in oxygen concentration greater than 10% if outside the usual presentation for that infant.
- The oxygen concentration is documented (including the flow where appropriate and the SpO₂ % and / or TCM values)
  - hourly if the baby is on CPAP, ventilated, or in acute phase of treatment
  - 2-4 hourly if baby is receiving low flow – *see Chronic Lung Disease protocol*
- Appropriate humidification is given, temperature and water is checked with routine observations.
- The oxygen analysers are calibrated every shift and alarm limits are set 5% either side of ambient O₂
  - calibrate to air if baby receiving <40 % O₂
  - calibrate to 100% if baby receiving >40 % O₂
Documentation
Any baby receiving supplemental oxygen during the acute phase of their illness requires documentation of the above every hour. The type and frequency of documentation will depend on the method of administration and stage/type of pathology present.

Documentation must include:
- Method of O₂ administration
- Flow and concentration (%) of O₂ administered
- Sp O₂%, readings and/or TC PO₂/TC PCO₂ readings & calibration times
- Humidification temperature and water level
- Changes to administration method, concentration, flow rates or oxygenation target.
- Tolerance to handling, feeding etc

Feeds and Oxygen Therapy

Babies on assisted ventilated including CPAP
For infants less than 28 weeks a 5Fg intra gastric tube is placed in situ, secured and placed on free drainage to ensure air does not accumulate in the stomach. Babies larger and more mature, or infants with abdominal anomalies, have an 8Fg tube placed. If the baby is receiving feeds the tube may be occluded for 10-15 minutes to prevent the feed flowing back up the tube, but must be put back on free drainage.

Babies in receiving oxygen via head box or low flow nasal oxygen
Babies do not require their IGTs on free drainage when in nursed in a head box or on low flow oxygen via nasal cannula.
Babies requiring head box O₂ are usually in an acute phase of their respiratory illness and are at risk of aspiration, the majority are left nil by mouth.
An intra gastric tube is normally passed for a gastric aspirate (C&S) for all babies presenting with respiratory distress after birth. If the infant is nil by mouth the intra gastric tube may be removed unless there are concerns regarding gut pathology etc.

For babies on low flow nasal oxygen the usual enteral feeding protocols can be followed – see management enteral feeds.

Nursing Considerations
Nursing considerations with regards to parental support, minimal handling, suctioning and thermal management are to be considered on an individual basis in accordance to current clinical guidelines. The importance of clustered care should be emphasised so as to minimise stress, therefore energy/oxygen expenditure and heat loss.

See the- NICPIC Individualised Developmental Care Protocols, Thermal Management, Suction and Small Baby protocols
References


