Respiratory distress and CPAP
Cultural acknowledgement
We acknowledge the Traditional Custodians of the land on which we work and pay our respect to the Aboriginal and Torres Strait Islander Elders past, present and emerging.

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The guideline is not a substitute for clinical judgement, knowledge and expertise, or medical advice. Variation from the guideline, taking into account individual circumstances, may be appropriate.

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- Providing care within the context of locally available resources, expertise, and scope of practice
- Supporting consumer rights and informed decision making, including the right to decline intervention or ongoing management
- Advising consumers of their choices in an environment that is culturally appropriate and which enables comfortable and confidential discussion. This includes the use of interpreter services where necessary
- Ensuring informed consent is obtained prior to delivering care
- Meeting all legislative requirements and professional standards
- Applying standard precautions, and additional precautions as necessary, when delivering care
- Documenting all care in accordance with mandatory and local requirements

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Flow Chart: Neonatal respiratory distress and CPAP in babies ≥ 32 weeks gestation

**Signs**
- Tachypnoea > 60 breaths/minute
- Increased respiratory effort
  - Audible expiratory grunt
  - Recession–sternal, intercostal, subcostal
  - Nasal flaring
- Cyanosis/oxygen need

**Indications for CPAP**
- Signs of respiratory distress or
- Oxygen requirement ≥ 30% to maintain SpO₂ within target

**Principles of care**

**Oxygenation**
- Maintain SpO₂ within target range
  - Term baby 92–98%
  - Preterm baby 90–95%

**Monitor and record**
- Monitor continuously SpO₂ (sensor on right hand), respiratory rate, heart rate
- Observe for signs of increasing respiratory distress/work of breathing

**Blood gas**
- pCO₂ may assist assessment (capillary)

**Fluids**
- 10% glucose IV at 60 mL/kg/day
- Small gavage feeds if stable

**Sepsis management**
- Full blood count and blood cultures
- Antibiotics as per local protocol or
- Penicillin or
- Ampicillin and gentamicin
- Refer to QCG NeoMedQ

**Chest x-ray to identify:**
- Respiratory disease
- Air leak (e.g. pneumothorax)
- Congenital diaphragmatic hernia
- Chest masses
- Cardiomegaly
- Other anomalies

**Blood glucose level**
- Refer to QCG Hypoglycaemia-newborn

**Supportive care**
- Family centred approach
- Observe baby unclothed in incubator
- Thermoneutral environment
- Position prone/quarter prone
- Development care–minimal handling
- Skin-to-skin if stable

**Consult/Refer/Transfer** as indicated

**Ongoing care as indicated**
- Clinical assessment
- Supportive care
- Consult with higher level service for advice or to organise transfer/retrieval
- Transfer/retrieval
  - Contact NeoRESQ or ANTS-NQ via RSQ phone 1300 799 127
  - Intubation and mechanical ventilation

**Flowchart:**
- CPAP indicated?
  - Yes
    - Assess & monitor clinical condition
      - Signs of deterioration/CPAP failure?
        - Yes
          - Wean/cease CPAP
        - No
          - Signs of improvement?
            - Yes
              - Wean/cease CPAP
            - No
              - CPAP

**Capability**
- Level 4 neonatal service or above
- Appropriate equipment and human resources available

**Commence**
- CPAP at 7–8 cm H₂O; 6–8 L/minute
- O₂ to maintain SpO₂ within target
- O₂ requirement
- O₂ until 25% then O₂ requirement

**Neonatal care**
- Monitor continuously:
  - SpO₂ (sensor preferably right hand)
  - Vital signs (heart rate, respiratory rate, temperature, blood pressure)
  - FiO₂
  - Record hourly:
    - Vital signs, SpO₂, work of breathing
    - Sternal and intercostal recession, grunting, nasal flaring, tachypnoea
- CPAP—pressure, flow, FiO₂
- Humidifier and circuit temperature
- Water level in humidifier
  - Vigilant surveillance and record hourly
  - CPAP interface positioned correctly
  - Septal columnar integrity
  - Eyes are clearly visible
  - Secure devices not causing indentation, pitting or periorbital oedema

**Signs of deterioration/CPAP failure**
- O₂ > 40% to maintain SpO₂ within target range
- A rapid rise in O₂ requirement—10% over 2 hours (e.g. an increase from 30% to 40%)
- Respiratory acidosis (e.g. pH < 7.25 with normal base excess or PaCO₂ > 60 mmHg)
- Recurrent apnoea requiring stimulation
- Increased work of breathing
- Agitation that cannot be relieved—refer to QCG HIE guideline

**Signs of improvement**
- Decreased
  - Respiratory rate
  - Work of breathing
  - O₂ requirement
- Improved
  - Blood gas
  - Chest x-ray
  - Baby comfort

**Weaning**
- Commence when:
  - O₂ < 25% and SpO₂ within target
  - Respiratory distress not present
  - < 3 self-reverting apnoea, bradycardia, desaturation in previous 6 hours
- Wean
  - O₂ until 25% then O₂ requirement
  - Pressure incrementally—1 cm as tolerated until 5 cm H₂O

**Cease if stable in**
- 21% O₂ and CPAP 5 cm H₂O

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ANTS-NQ: Advanced Neonatal Transport Service-North Queensland, CPAP: continuous positive airway pressure, FG French gauge, FiO₂: fractional inspired oxygen, HIE: Hypoxic-ischaemic encephalopathy, IV: intravenous, NeoRESQ Neonatal Retrieval Emergency Service Southern Queensland, pCO₂: partial pressure of carbon dioxide, QCG: Queensland Clinical Guidelines, RSQ: Retrieval Services Queensland, SpO₂: peripheral capillary oxygen saturation, ≥: greater than, ≤: greater than or equal to, <: less than; ≤: less than or equal to

Flowchart: F20.3.1-V8-R25
Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP</td>
<td>Antero-posterior</td>
</tr>
<tr>
<td>BPD</td>
<td>Broncho-pulmonary dysplasia</td>
</tr>
<tr>
<td>CPAP</td>
<td>Continuous positive airway pressure</td>
</tr>
<tr>
<td>CSCF</td>
<td>Clinical Services Capability Framework</td>
</tr>
<tr>
<td>DIP</td>
<td>Diabetes in pregnancy</td>
</tr>
<tr>
<td>FiO2</td>
<td>Fractional inspired oxygen</td>
</tr>
<tr>
<td>FRC</td>
<td>Functional residual capacity</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
</tr>
<tr>
<td>OGT</td>
<td>Orogastric tube</td>
</tr>
<tr>
<td>PaCO2</td>
<td>Partial pressure of arterial carbon dioxide</td>
</tr>
<tr>
<td>PaO2</td>
<td>Partial pressure of arterial oxygen</td>
</tr>
<tr>
<td>pCO2</td>
<td>Partial pressure of carbon dioxide</td>
</tr>
<tr>
<td>pO2</td>
<td>Partial pressure of oxygen (unreliable on venous or capillary samples)</td>
</tr>
<tr>
<td>PIE</td>
<td>Pulmonary interstitial emphysema</td>
</tr>
<tr>
<td>PPHN</td>
<td>Persistent pulmonary hypertension of the newborn</td>
</tr>
<tr>
<td>RDS</td>
<td>Respiratory distress syndrome</td>
</tr>
<tr>
<td>RSQ</td>
<td>Retrieval Services Queensland</td>
</tr>
<tr>
<td>SpO2</td>
<td>Peripheral capillary oxygen saturation</td>
</tr>
<tr>
<td>SSRI</td>
<td>Selective serotonin reuptake inhibitors</td>
</tr>
<tr>
<td>SNRI</td>
<td>Serotonin norepinephrine reuptake inhibitor</td>
</tr>
<tr>
<td>TTN</td>
<td>Transient tachypnoea of the newborn</td>
</tr>
</tbody>
</table>

Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrocyanosis</td>
<td>Peripheral cyanosis around the mouth and extremities (palms of hands and soles of feet and is benign in the absence of central cyanosis).</td>
</tr>
<tr>
<td>Functional residual capacity</td>
<td>Volume of air in the lungs at the end of passive expiration.</td>
</tr>
<tr>
<td>Hypoxaemia</td>
<td>PaO2 less than 60 mmHg.</td>
</tr>
<tr>
<td>Hypercarbia</td>
<td>PaCO2 greater than 45 mmHg.</td>
</tr>
<tr>
<td>Tachypnoea</td>
<td>Respiratory rate greater than 60 breaths per minute.</td>
</tr>
<tr>
<td>Pulse pressure</td>
<td>Difference between the systolic and diastolic blood pressure.</td>
</tr>
<tr>
<td>Ventilation-perfusion mismatch</td>
<td>Poor perfusion to well oxygenated area and poor perfusion to poorly oxygenating areas.</td>
</tr>
<tr>
<td>Vital signs</td>
<td>Temperature, heart rate, respiratory rate, blood pressure.</td>
</tr>
<tr>
<td>Work of breathing</td>
<td>Tachypnoea, chest recession (sternal, intercostal, subcostal); nasal flaring; expiratory grunt.</td>
</tr>
</tbody>
</table>
1 Introduction

1.1 Lung development and respiratory physiology

The transition to potentially viable lungs occurs at the canalicular stage of fetal development (at 16–25 weeks gestation). At this stage, respiratory bronchioles and alveolar ducts develop in the gas exchange region of the lung. From 24 weeks gestation, large and primitive forms of alveoli have developed and provide potential for viability.

Surfactant production is related to the developmental stage of the fetus. After 20 weeks gestation, lamellar bodies develop, indicating that surfactant is being produced from glycogen, and being stored. The protein content of surfactant in the preterm baby’s lung is low relative to the surfactant lipid. Surfactant is not usually produced in sufficient amounts until 32–34 weeks gestation. The most common cause of respiratory distress syndrome (RDS) from surfactant deficiency is preterm birth.

Maturation of the preterm fetal lung is enhanced when antenatal corticosteroids are administered to the woman. These improve lung function by enhancing maturational changes in lung development and inducing enzymes that stimulate phospholipid synthesis and surfactant production.1-3

Newborn babies have a compliant chest wall which leads to an increased susceptibility to more severe manifestations of respiratory disease. The degree of chest wall compliance combined with decreased lung compliance increases the severity of respiratory distress with decreased gestation.2,4

1.2 Clinical course of respiratory distress

Table 1. Respiratory disease clinical course

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulmonary surfactant deficiency²</strong></td>
<td>• Pulmonary surfactant:</td>
</tr>
<tr>
<td></td>
<td>• Reduces alveolar surface tension</td>
</tr>
<tr>
<td></td>
<td>• Facilitates alveolar expansion</td>
</tr>
<tr>
<td></td>
<td>• Reduces the likelihood of atelectasis from alveolar collapse</td>
</tr>
<tr>
<td></td>
<td>• If deficient causes RDS</td>
</tr>
<tr>
<td></td>
<td>• Deficiency may be in the quantity and/or quality of surfactant causing RDS when surfactant is consumed or inactivated resulting in:</td>
</tr>
<tr>
<td></td>
<td>• Generation of increased negative intrathoracic pressure to expand poorly compliant lungs resulting in severe sternal and intercostal recession⁴</td>
</tr>
<tr>
<td></td>
<td>• High surface tension leading to instability of the lung at end-expiration, low lung volume and decreased compliance</td>
</tr>
<tr>
<td></td>
<td>• Pulmonary oedema and increased airway resistance resulting from lung inflammation and respiratory epithelial injury</td>
</tr>
<tr>
<td></td>
<td>• Risk factors and causes include:</td>
</tr>
<tr>
<td></td>
<td>• Preterm birth</td>
</tr>
<tr>
<td></td>
<td>• Elective caesarean section⁵</td>
</tr>
<tr>
<td></td>
<td>• Maternal diabetes in pregnancy (DIP)—poorly controlled</td>
</tr>
<tr>
<td></td>
<td>• Meconium aspiration syndrome (MAS)⁶</td>
</tr>
<tr>
<td></td>
<td>• Infection</td>
</tr>
<tr>
<td></td>
<td>• Genetic surfactant dysfunction disorder²</td>
</tr>
<tr>
<td><strong>Lung function²</strong></td>
<td>• Changes in lung function cause ventilation-perfusion mismatch due to:</td>
</tr>
<tr>
<td></td>
<td>• Collapse of portions of the lungs (atelectasis)</td>
</tr>
<tr>
<td></td>
<td>• Abnormal fluid absorption (due to inefficient clearing of liquid in damaged lung) resulting in pulmonary oedema that impedes gas exchange due to reduced functional residual capacity</td>
</tr>
<tr>
<td><strong>Hypoxaemia²</strong></td>
<td>• Caused by:</td>
</tr>
<tr>
<td></td>
<td>• Ventilation perfusion mismatch from intrapulmonary shunting— influenced by relative size of under ventilated lung</td>
</tr>
<tr>
<td></td>
<td>• Extrapulmonary shunting across foramen ovale and patent ductus arteriosus</td>
</tr>
<tr>
<td><strong>Acidosis²</strong></td>
<td>• Poor ventilation identified from:</td>
</tr>
<tr>
<td></td>
<td>• Elevated pCO₂ and resultant respiratory acidosis</td>
</tr>
<tr>
<td></td>
<td>• Metabolic acidosis caused by lactic acid production from anaerobic metabolism due to hypoxaemia and poor tissue perfusion</td>
</tr>
</tbody>
</table>
### 1.3 Clinical standards

#### Table 2. Clinical standards

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Prevention** | • Antenatal corticosteroids reduce the risk of RDS in the preterm baby less than 35+0 weeks gestation by enhancing the maturation of the lungs and improving lung function\(^1\),\(^2\),\(^7\),\(^8\)  
• Late preterm (34+0–36+6 weeks gestation) corticosteroid administration is associated with decreased risk of serious neonatal morbidity risk including reduced:  
  o Risk of moderate to severe RDS\(^8\)  
  o Incidence of transient tachypnoea of the newborn (TTN)  
  o Need for surfactant\(^1\),\(^2\),\(^7\),\(^8\)  
• Refer to Queensland Clinical Guidelines *Preterm labour and birth* guideline \(^1\),\(^2\),\(^7\),\(^8\) |
| **Principles of care** | • Commence continuous positive airways pressure (CPAP) if:  
  o Signs of respiratory distress or  
  o Oxygen requirement to maintain oxygen saturation (SpO\(_2\)) is greater than or equal to 30%  
• Refer to Queensland Clinical Guidelines *Standard care* \(^2\) guideline for routine aspects of clinical care  
• Humidified high-flow support is not recommended as first-line management of babies with RDS outside of a neonatal intensive care unit |
| **Clinical Services Capability Framework (CSCF)** | • Consider the clinical service capability of the facility  
  o Refer to Clinical Services Capability Framework for neonatal services\(^1\),\(^2\),\(^3\)  
• Care of a baby requiring ongoing CPAP requires level 4 or higher neonatal service\(^1\),\(^2\),\(^3\)  
• Consult with neonatologist via Retrieval Services Queensland (RSQ) for advice or retrieval of baby to a higher level of service as required  
  o If level 2–3 neonatal service and baby has respiratory distress  
    ▪ Oxygen greater than or equal to 30% to maintain SpO\(_2\) within target range [refer to Table 3. Signs]  
    ▪ Oxygen requirement rapidly increases (10% or more over two hours or less)  
    ▪ Baby is less than 35 weeks gestational age  
  o If level 4 neonatal service and baby requires CPAP  
    ▪ Commencing when baby is greater than 24 hours of age  
    ▪ Oxygen requirement is greater than 40% to maintain SpO\(_2\) within target range [refer to Table 3. Signs]  
    ▪ Oxygen requirement rapidly increases  
    ▪ Blood gas partial pressure arterial carbon dioxide (PaCO\(_2\)) is greater than 60 mmHg or pH is less than 7.25  
    ▪ Baby’s birth weight is less than 1500 g  
    ▪ Baby is less than 32 weeks gestational age  
  o If level 5 neonatal service  
    ▪ CPAP commencing when baby is greater than 24 hours of age  
    ▪ Oxygen requirement is greater than 40% to maintain SpO\(_2\) within target range [refer to Table 3. Signs]  
    ▪ Blood gas PaCO\(_2\) is greater than 60 mmHg or pH is less than 7.25  
    ▪ Baby’s birth weight is less than 1000 g  
    ▪ Baby is less than 29 weeks gestational age |
2 Assessment
Assess the baby’s clinical signs, and radiographic and pathology results. Also consider the maternal and neonatal history. Assess changes in the baby’s clinical status over time, including increasing respiratory rate or increasing oxygen requirement to maintain oxygen saturations. Refer to Table 3.

2.1 Signs

Table 3. Signs

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Pale or</td>
</tr>
<tr>
<td>SpO₂</td>
<td>Pre-ductal measure on right hand</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Targets after 10 minutes of age*:</td>
</tr>
<tr>
<td></td>
<td>o Term baby: 92–98%</td>
</tr>
<tr>
<td></td>
<td>o Hypoxaemia usually due to ventilation perfusion mismatch²</td>
</tr>
<tr>
<td></td>
<td>o Left to right shunting of blood occurs in areas of poorly ventilated lungs²</td>
</tr>
<tr>
<td>Urine output</td>
<td>May be low in first 24–48 hours²</td>
</tr>
<tr>
<td>Respiratory</td>
<td>May be tachycardic</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Extra-pulmonary shunting may occur across the foramen ovale and patent ductus arteriosus²</td>
</tr>
<tr>
<td>Respiratory</td>
<td>May be having bradycardic episodes and/or apnoeas²</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Extra-pulmonary shunting may occur across the foramen ovale and patent ductus arteriosus²</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Blood gas not routinely required after initial capillary or venous sample if within normal limits and baby is stable (to minimise pain and handling)</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Measure blood gas depending on individual baby’s clinical presentation or if there are signs of deterioration or CPAP failure [refer to Table 21. CPAP clinical course]</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Supplementary oxygen may assist assessment</td>
</tr>
<tr>
<td>acidosi</td>
<td>Degree of hypoxaemia² (as shown by a low pO₂) is unreliable on a capillary or venous sample</td>
</tr>
</tbody>
</table>
2.2 X-rays

- Standard anteroposterior (AP) chest x-ray is sufficient\(^{17}\)
  - Take chest x-ray at four hours of age unless earlier indication
- Assists with diagnosis\(^{17}\)
- Checks position of tubes and lines—including orogastric tube (OGT)\(^{17}\)
- Assists assessment of pulmonary inflation\(^{17}\)
- Excludes undiagnosed congenital abnormality\(^{17}\)
- Excludes pulmonary air leaks\(^{17,18}\)

Table 4. X-ray interpretation

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normal</strong></td>
<td>Symmetrically aerated lung fields</td>
</tr>
<tr>
<td></td>
<td>• Diaphragm is at level of the 8th ribs posteriorly and 6th ribs anteriorly</td>
</tr>
<tr>
<td></td>
<td>• Heart size—transverse cardiothoracic ratio less than 60% (may be difficult to evaluate due to the thymic shadow(^{17}))</td>
</tr>
<tr>
<td><strong>RDS</strong></td>
<td>Low lung volume</td>
</tr>
<tr>
<td></td>
<td>• Diffuse reticulogranular ground glass appearance</td>
</tr>
<tr>
<td></td>
<td>• Air bronchograms (more severe)</td>
</tr>
<tr>
<td></td>
<td>• Confluent alveolar shadowing(^{17})</td>
</tr>
<tr>
<td></td>
<td>• Radiographic pattern results from:</td>
</tr>
<tr>
<td></td>
<td>- Alveolar atelectasis contrasting with aerated airways</td>
</tr>
<tr>
<td></td>
<td>- Pulmonary oedema may contribute to diffuse appearance</td>
</tr>
<tr>
<td><strong>TTN</strong></td>
<td>Normal or slightly overinflated lung fields</td>
</tr>
<tr>
<td></td>
<td>• Increased streaky shadowing with perihilar densities extending into peripheral lung fields</td>
</tr>
<tr>
<td></td>
<td>• Normal or mildly enlarged heart</td>
</tr>
<tr>
<td></td>
<td>• Fluid in the horizontal fissure and small pleural effusions may be present(^1,17)</td>
</tr>
<tr>
<td><strong>Air leaks</strong></td>
<td>Pneumothorax and other air leaks:</td>
</tr>
<tr>
<td></td>
<td>- Common in initial x-ray</td>
</tr>
<tr>
<td></td>
<td>- More often observed when lung compliance improves</td>
</tr>
<tr>
<td></td>
<td>- Consider air leak if acute deterioration in baby’s condition</td>
</tr>
<tr>
<td></td>
<td>• Pneumothorax:</td>
</tr>
<tr>
<td></td>
<td>- Air in pleural space, atelectasis with flattening of the diaphragm on the affected side, shift of mediastinum away from the pneumothorax(^{18})</td>
</tr>
<tr>
<td></td>
<td>• Pneumomediastinum:</td>
</tr>
<tr>
<td></td>
<td>- Radiolucent halo over the cardiac outline or retrosternal or mediastinal radiolucency (on lateral view)(^{17,18})</td>
</tr>
<tr>
<td></td>
<td>- Thymus gland lifted giving ‘angel wing’ or ‘spinnaker sail’ appearance(^{17,18})</td>
</tr>
<tr>
<td></td>
<td>• Pneumopericardium:</td>
</tr>
<tr>
<td></td>
<td>- Air in the pericardial space</td>
</tr>
<tr>
<td></td>
<td>- May cause cardiac tamponade</td>
</tr>
<tr>
<td></td>
<td>- In antero-posterior (AP) view air surrounds the heart shadow within the pericardium(^{18})</td>
</tr>
<tr>
<td></td>
<td>• Refer to 3.4 Pulmonary air leaks</td>
</tr>
<tr>
<td><strong>Pulmonary interstitial emphysema (PIE)</strong></td>
<td>Interstitial air appearing as cyst-like or linear translucencies(^{18})</td>
</tr>
<tr>
<td><strong>Congenital diaphragmatic hernia</strong></td>
<td>Mediastinal shift</td>
</tr>
<tr>
<td></td>
<td>• Absence of diaphragm—usually left sided</td>
</tr>
<tr>
<td></td>
<td>• Visible bowel gas in chest cavity(^{19})</td>
</tr>
<tr>
<td><strong>MAS</strong></td>
<td>Asymmetric patches of opacification and streaky linear densities</td>
</tr>
<tr>
<td></td>
<td>• Hyperinflation of lungs</td>
</tr>
<tr>
<td></td>
<td>• Flattening of the diaphragm(^{6,20})</td>
</tr>
</tbody>
</table>
3  Diagnosis

3.1  Differential diagnosis

Table 5. Differential diagnosis

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis</td>
<td>• Consider:</td>
</tr>
<tr>
<td></td>
<td>o Baby's history—gestational age and postnatal age</td>
</tr>
<tr>
<td></td>
<td>o Maternal history</td>
</tr>
<tr>
<td></td>
<td>o Clinical features</td>
</tr>
<tr>
<td></td>
<td>o Chest x-ray</td>
</tr>
<tr>
<td></td>
<td>o Capillary/venous blood gas</td>
</tr>
<tr>
<td></td>
<td>• Refer to Appendix A Comparison of respiratory disease</td>
</tr>
<tr>
<td>Non-pulmonary causes§</td>
<td>• Consider:</td>
</tr>
<tr>
<td></td>
<td>o Hyperthermia from overheating baby resulting in tachycardia, tachypnoea and increased oxygen consumption21</td>
</tr>
<tr>
<td></td>
<td>o Sepsis including meningitis</td>
</tr>
<tr>
<td></td>
<td>o Cardiac disease1</td>
</tr>
<tr>
<td></td>
<td>o Metabolic acidosis from inborn error of metabolism</td>
</tr>
<tr>
<td></td>
<td>o Hypoglycaemia—may cause or aggravate tachypnoea</td>
</tr>
<tr>
<td></td>
<td>o Polycythaemia or anaemia</td>
</tr>
<tr>
<td></td>
<td>o Hydrocephalus</td>
</tr>
<tr>
<td></td>
<td>o Intracranial haemorrhage</td>
</tr>
<tr>
<td></td>
<td>o Maternal narcotic use causing respiratory depression</td>
</tr>
</tbody>
</table>

3.2  Respiratory distress syndrome

Table 6. Respiratory distress syndrome

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiology</td>
<td>• Caused by:</td>
</tr>
<tr>
<td></td>
<td>o Under developed lungs</td>
</tr>
<tr>
<td></td>
<td>o Surfactant deficiency and or dysfunction22</td>
</tr>
<tr>
<td>Presentation</td>
<td>• Presents more commonly if:</td>
</tr>
<tr>
<td></td>
<td>o Baby is less than 34 weeks gestation7</td>
</tr>
<tr>
<td></td>
<td>o Maternal DIP7</td>
</tr>
<tr>
<td></td>
<td>• Baby has respiratory distress within first minutes after birth2</td>
</tr>
<tr>
<td></td>
<td>o Worsens over the next 48 hours2</td>
</tr>
<tr>
<td></td>
<td>• Baby generally improves by the third to fourth day of life with onset of diuresis16</td>
</tr>
<tr>
<td>Signs</td>
<td>• Increased work of breathing15 [refer to Definitions</td>
</tr>
<tr>
<td></td>
<td>• Cyanosis and hypoxia</td>
</tr>
<tr>
<td></td>
<td>• Breath sounds diminished; coarse rhonchi in bilateral lung fields15</td>
</tr>
<tr>
<td></td>
<td>• Bell shaped chest</td>
</tr>
<tr>
<td></td>
<td>• Refer to Table 3. Signs</td>
</tr>
<tr>
<td></td>
<td>• Chest x-ray—refer to Table 4. X-ray interpretation</td>
</tr>
<tr>
<td></td>
<td>• Blood gas—hypoxaemia and respiratory acidosis7</td>
</tr>
<tr>
<td></td>
<td>o If baby has metabolic acidosis and history suggestive of hypoxaemic ischaemic encephalopathy (HIE) refer to Queensland Clinical Guideline Hypoxic ischaemic encephalopathy (HIE)23</td>
</tr>
<tr>
<td>Management</td>
<td>• Refer to Section 16 Management</td>
</tr>
<tr>
<td></td>
<td>• Early CPAP is usually indicated24</td>
</tr>
<tr>
<td></td>
<td>• May require exogenous surfactant Curosurf® (poractant alfa) or Survanta® (beractant) with/without intermittent positive pressure ventilation</td>
</tr>
<tr>
<td></td>
<td>o Refer to NeoMedQ25,26 for surfactant indications and administration</td>
</tr>
</tbody>
</table>
### 3.3 Transient tachypnoea of the newborn

Table 7. Transient tachypnoea of the newborn

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Physiology** | • Parenchymal lung disorder more commonly seen in term or late preterm babies<sup>1</sup>  
  • Occurs due to pulmonary oedema resulting from delayed reabsorption and clearance of fetal alveolar fluid<sup>7</sup> |
| **Presentation** | • Common cause of respiratory distress in the newborn baby<sup>1,7</sup>  
  • Occurs two to three times more often in babies of women with diabetes<sup>1</sup>  
  • Onset is usually at the time of birth and within two hours of age<sup>1,7</sup>  
  • Symptoms usually last for 12–24 hours, but may last up to 72 hours  
  • May occur with RDS<sup>1,7</sup>  
  • More common if<sup>1</sup>:  
  o DIP  
  o Born by caesarean section  
  o Precipitous birth<sup>7</sup>  
  o Small for gestational age or large for gestational age/macrosomia  
  o Maternal obesity<sup>1</sup>  
  o Maternal asthma  
  o Born before 39+0 weeks |
| **Signs** | • Increased work of breathing<sup>1</sup> [refer to Definitions  
  • Tachypnoea—higher respiratory rate associated with longer duration of TTN<sup>7</sup>  
  • Cyanosis<sup>1</sup>  
  • Increased AP chest diameter  
  • Breath sounds clear without rales or rhonchi<sup>1,7</sup>  
  • Barrel-shaped chest  
  • Oxygen requirement usually less than 40%<sup>1</sup>  
  • Chest x-ray:  
  o Refer to Table 4. X-ray interpretation  
  • Blood gas—hypoxaemia, hypercapnia or respiratory acidosis<sup>7</sup> |
| **Management** | • Supportive measures<sup>7</sup>  
  • Refer to Table 12. Supportive care  
  • Fluid restriction may be beneficial<sup>7,27</sup> |
### 3.4 Pulmonary air leaks

Pulmonary air leaks occur more often in the neonatal period than at any other time of life.\(^\text{18}\) Refer to Appendix B Pulmonary air leaks.

#### Table 8. Pulmonary air leaks

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Context\(^7\)** | • Air escapes from the lungs into the extra-alveolar space  
• Results from overdistension of alveoli due to uneven distribution of gas or generalised air trapping  
• May be:  
  o Complication of RDS  
  o An isolated presentation  
  o Associated with another underlying disorder  
• Diagnosis is made from chest x-ray\(^2\) and clinical assessment  
  o Refer to Table 4. X-ray interpretation |
| **Pneumothorax\(^18\)** | • Air escapes into the pleural space  
• Suspect in baby with unexpected deterioration in oxygenation, ventilation or cardiovascular status  
• Signs:  
  o Increased work of breathing [refer to Definitions  
  o Positive chest transillumination (if available)  
    ▪ May require chest x-ray to confirm (refer to Table 4. X-ray interpretation)  
    ▪ Not reliable in term or large baby  
    ▪ May be incidental finding |
| **Tension pneumothorax\(^18\)** | • Increases intrathoracic pressure, increases central venous pressure and decreases venous return  
• Signs:  
  o Acute deterioration in baby’s condition  
  o Chest asymmetry with enlargement on the affected side  
  o Decreased breath sounds on affected side  
  o Shift of heart sound away from the affected side  
  o Hypotension (with narrow pulse pressure), bradycardia, oxygen desaturation and poor perfusion  
  o Sudden increase in oxygen requirement to maintain SpO\(_2\) within target range [refer to Table 3. Signs]  
  o Positive chest transillumination (if available)  
    ▪ Not reliable in term or large baby  
• Requires emergency management  
  • Refer to Appendix B Pulmonary air leaks |
| **Pneumomediastinum\(^18\)** | • Air escapes into the mediastinal space  
• Usually caused by high peak pressures during IPPV\(^\text{28}\)  
• Signs:  
  o Usually asymptomatic—may be detected by cardiac auscultation (distant heart sounds) |
| **Pneumopericardium\(^29\)** | • Air escapes from the mediastinum or pleural space into the pericardial sac  
• If untreated, the air causes a tamponade with shock and subsequent cardiac arrest  
• Consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required |
| **PIE\(^18\)** | • Air is trapped in the perivascular space resulting in decreased compliance and increased airway resistance  
• More common in very low birth weight ventilated babies  
• Signs:  
  o Increasing hypoxaemia and hypercapnia usually presenting within 96 hours of birth |
3.5 Congenital anomalies

Congenital anomalies are less common causes of respiratory distress in newborn babies and are usually diagnosed antenatally. Consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required.

| Table 9. Congenital anomalies |

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| Congenital heart disease | • Usually presents with less respiratory distress unless persistent pulmonary hypertension is also present  
  o Refer to Table 11. PPHN  
  • Chest x-ray characterised by absence of diffuse reticulonoduargranular ground glass appearance with air bronchograms  
  • Respiratory support and surfactant do not improve the baby's clinical condition |
| Pulmonary hypoplasia | • May occur in isolation or be associated with other congenital anomalies, (e.g. congenital diaphragmatic hernia)  
  • Unilateral:  
    o Chest x-ray characterised a small lung with reduced vascularity and ipsilateral heart displacement  
  • Bilateral:  
    o Associated with oligohydramnios and prolonged preterm rupture of membranes  
    o Chest x-ray may show bell shaped thorax, reduced inflation increased pulmonary shadowing and pulmonary air leaks |
| Diaphragmatic hernia | • Usually diagnosed antenatally by ultrasound scan  
  • Signs include scaphoid abdomen, diminished breath sounds ipsilateral to the side of the hernia, displacement of heart sounds contralateral to the side of the hernia  
  • Refer to Table 4. X-ray interpretation |
| Airway | • Obstruction:  
  o Pierre Robin sequence  
  o Choanal atresia  
  • Malformation:  
    o Tracheo-oesophageal fistula  
    o Oesophageal atresia  
    o Laryngeal web |
| Other | • Congenital cystic adenomatoid malformation  
  o Chest x-ray characterised by large isolated cystic area above diaphragm |
### 3.6 Other respiratory distress

#### 3.6.1 Infection, aspiration and interstitial lung disease

Table 10. Infection and aspiration

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Infection**           | • Bacterial pneumonia\(^7\)  
                          • X-ray demonstrates patchy opacities and/or lobar consolidation  
                          • Blood cultures assist diagnosis  
                          • Refer to Table 12. Supportive care |
| **MAS**                 | • History:  
                          o Meconium stained liquor or evidence of meconium staining on examination  
                          o Baby frequently small for gestational age or postmature  
                          o Intrauterine pathologic processes\(^20\)–asphyxia, infection  
                          • May lead to:  
                          o Airway obstruction  
                          o Chemical irritation  
                          o Inflammation  
                          o Infection  
                          o Increased inactivation of surfactant\(^20\)  
                          o Persistent pulmonary hypertension of the newborn\(^20\)  
                          o Increased incidence of pneumothorax  
                          o Hypoxaemia due to ventilation-perfusion mismatch  
                          • Signs include\(^1\):  
                          o Marked tachypnoea and cyanosis  
                          o Intercostal and substernal recession due to reduced lung compliance and use of accessory muscles  
                          o Grunting and nasal flaring\(^20\)  
                          o Barrel-shaped chest  
                          o Rales and rhonchi on auscultation  
                          o X-ray–refer to Table 4. X-ray interpretation  
                          o Blood gas–respiratory acidosis\(^30,31\)  
                          • Management:  
                          o Monitor preductal and postductal SpO\(_2\)  
                          o Refer to Table 12. Supportive care  
                          o Intermittent positive pressure ventilation may be indicated  
                          o Consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required |
| **Other aspiration**    | • May be caused by aspiration of:  
                          o Blood, liquor or water (if water birth)  
                          • If baby has commenced feeds and aspirates milk, consider trachea-oesophageal fistula or oesophageal atresia |
| **Interstitial lung disease** | • Interstitial and diffuse lung diseases including\(^2\):  
                          o Genetic disorders of surfactant dysfunction  
                          o Lung growth abnormalities  
                          o Pulmonary interstitial glycogenosis  

3.6.2 Persistent pulmonary hypertension of the newborn (PPHN)

Table 11. PPHN

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physiology</strong></td>
<td>• Physiological adaptation after birth has not occurred resulting in persistent or delayed transition of fetal circulation</td>
</tr>
<tr>
<td></td>
<td>• SpO2 difference of greater than 5% between preductal and postductal measures due to right-to-left shunting though the patent ductus arteriosus</td>
</tr>
<tr>
<td></td>
<td>o Right-to-left shunting can also occur through the foramen ovale and will have an absent oxygen saturation gradient</td>
</tr>
<tr>
<td></td>
<td>o Measure on right hand/wrist (preductal), and left hand/wrist or either foot (postductal)</td>
</tr>
<tr>
<td></td>
<td>• Arterial blood gas—normal PaCO2 (if no lung disease present) and PaO2 below 100 mmHg in 100 percent inspired oxygen</td>
</tr>
<tr>
<td></td>
<td>• Barrel-shaped chest</td>
</tr>
<tr>
<td><strong>Causes</strong>32,33</td>
<td>• Idiopathic</td>
</tr>
<tr>
<td></td>
<td>• Abnormalities of pulmonary vasculature</td>
</tr>
<tr>
<td></td>
<td>o Underdevelopment (e.g. fetal growth restriction, diaphragmatic hernia)</td>
</tr>
<tr>
<td></td>
<td>o Maldevelopment (e.g. congenital heart disease, meconium aspiration syndrome)</td>
</tr>
<tr>
<td></td>
<td>o Maladaptation (e.g. post-term birth, caesarean birth, large for gestational age, perinatal asphyxia, sepsis)</td>
</tr>
<tr>
<td></td>
<td>• Associated with maternal use of selective serotonin reuptake inhibitors (SSRI) or serotonin norepinephrine reuptake inhibitors (SNRI) in late pregnancy (greater than or equal to 33+0 weeks gestation)32,33</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>• If PPHN suspected:</td>
</tr>
<tr>
<td></td>
<td>o Aim to keep oxygen saturation at greater than 97%</td>
</tr>
<tr>
<td></td>
<td>o Consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required</td>
</tr>
<tr>
<td></td>
<td>o Minimise noise, light and handling baby</td>
</tr>
<tr>
<td></td>
<td>o Minimise baby crying</td>
</tr>
<tr>
<td></td>
<td>• Refer to Table 12. Supportive care</td>
</tr>
</tbody>
</table>
4 Management

4.1 Supportive care

Observe the unclothed baby (with nappy only), and only disturb the baby when absolutely necessary (minimal handling). Refer to Table 17. Care of baby on CPAP, Table 18. Developmental care and Table 19. Pressure area care for other aspects of care.

Table 12. Supportive care

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Oxygenation** | • Give oxygen to maintain SpO₂ within target ranges  
   o Refer to Table 3. Signs  
   • Monitor delivered oxygen concentration continuously  
   • If greater than or equal to 30% oxygen is required, consider CPAP  
   o Refer to Table 14. CPAP use  
   • If PPHN suspected--refer to Table 11. PPHN |
| **Fluids**      | • Insert intravenous (IV) cannula and commence glucose 10% IV at 60mL/kg/day  
   • If peripheral IV cannulation is difficult (not achieved after three attempts), consider umbilical venous catheter  
   • If the baby’s respiratory status is stable, consider commencing small gavage feeds  
   o If the baby’s respirations are greater than 80 breaths per minute do not feed |
| **Temperature** | • Nurse baby in incubator or on open care system  
   • Refer to Queensland Clinical Guideline Stabilisation for retrieval–neonatal  
   • Maintain temperature within normal range  
   o Axilla 36.8–37.2 °C  
   • Monitor and record temperature every 4 hours |
| **Blood glucose** | • Refer to Queensland Clinical Guideline Hypoglycaemia–newborn  |
| **Infection screening** | • If clinically indicated, surface swabs from baby  
   • Full blood count  
   • Blood cultures—check result at 24 hours:  
   o If negative and respiratory distress resolved—administer 24 hour antibiotic dose and then cease (36 hour coverage provided)  
   o If delay in processing blood cultures—continue antibiotics until 48 hours of treatment  
   o Recheck result at 48 hours  
   o If positive (at any time), consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required |
| **Antibiotics** | • Empirical antibiotics are given prophylactically until cultures and clinical course known benzylpenicillin OR amoxicillin/ampicillin AND gentamicin  
   • Refer to NeoMedQ neonatal monographs for benzylpenicillin AND ampicillin and gentamicin  
   • Refer to Queensland Clinical Guideline Early onset Group B Streptococcal disease  |
| **Monitoring**  | • Monitor and record every hour (or if change in baby’s condition):  
   o Vital signs—temperature, heart rate, respirations, blood pressure and perfusion  
   ▪ If PPHN suspected, refer to Table 11. PPHN  
   o Oxygen saturations—preferably on right hand/wrist (pre-ductal)  
   ▪ Work of breathing [refer to Definitions  
   • Check blood gases as clinically indicated  
   • Check blood glucose levels [refer to Queensland Clinical Guideline Hypoglycaemia–newborn]  |
| **Blood gas**   | • Determine frequency based on baby’s clinical condition and support required  
   o Not routinely required if previous blood gas within normal limits  
   o If baby is stable, leaving baby undisturbed may be indicated |
| **Pain management** | • Refer to Table 17. Care of baby on CPAP |

*Refer to an Australian pharmacopoeia for complete drug information
5 Continuous positive airway pressure

Preterm babies are prone to lung collapse due to a lack of surfactant. Disparity between chest wall and lung compliance is heightened in babies with surfactant deficiency. CPAP works by maintaining expansion of the alveoli by providing a constant positive pressure to the lungs. This prevents atelectasis and allows gas exchange.

5.1 CPAP physiology

Table 13. CPAP physiology

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| Context               | • Works by delivering continuous distending pressure to the lungs using an air/oxygen mix  
|                       | • Continuous flow (e.g. bubble) is generated using continuous gas flow during the respiratory cycle  
|                       | • Prevents atelectasis  
|                       | • Enhances gas exchange  
|                       | • Rationale for use:  
|                       |   o Stents the airways and maintains functional residual capacity (FRC)  
| CPAP physiology       | • Improves lung compliance and uniformity of ventilation by preventing:  
|                       |   o De-recruitment of alveoli  
|                       |   o Collapse of small airways during exhalation in the surfactant deficient lung  
|                       |   o Increases functional residual capacity and improves oxygenation  
|                       | • Previously constricted blood vessels dilate when atelectasis is reversed, and this leads to increased pulmonary blood flow  
|                       | • Ventilation-perfusion mismatch improves and intra-abdominal pulmonary shunting decreases:  
|                       |   o PaCO₂ lowers  
|                       |   o Progressing arterial hypoxaemia is prevented  
|                       |   o Respiratory muscle fatigue is decreased  
|                       | • Surfactant is conserved by reducing the protein leak associated with atelectasis  
|                       | • Dilates the pharynx, reduces subglottic airway resistance, lessens the incidence of obstructive apnoea  
|                       | • Improves the synchrony of thoracoabdominal movements  

## 5.2 CPAP use

### Table 14. CPAP use

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prophylactic</strong></td>
<td>• Insufficient evidence to compare prophylactic CPAP to oxygen therapy and other supportive care(^{24}) in term babies  \n• Prophylactic CPAP in the very preterm baby provides a small but clinically significant reduction in broncho-pulmonary dysplasia (BPD) and death, and need for mechanical ventilation and use of surfactant(^{24})</td>
</tr>
<tr>
<td><strong>Indications</strong></td>
<td>• Correct existing respiratory failure in babies with RDS(^{4})  \n  o Baby has signs of respiratory distress [refer to Table 3. Signs]  \n  o Treat airway obstruction(^{4})  \n  o Prevent respiratory failure (e.g. apnoea of prematurity)(^{4})</td>
</tr>
</tbody>
</table>
| **Contraindications** | • Nasal CPAP is contraindicated in babies with a range of congenital abnormalities or surgical conditions, including  \n  o Certain cleft palates  \n  o Bi-lateral choanal atresia  
    ▪ Single naso-pharyngeal tube may be used in unilateral choanal atresia  \n  o Tracheo-oesophageal atresia  \n  o Congenital diaphragmatic hernia  \n  o Gastrochisis or omphalocele  \n  o Necrotising enterocolitis (suspected or confirmed)  \n  o Significant loss of skin or septal integrity following use of bi-nasal CPAP  \n  o Congenital lung/airway lesions (e.g. congenital lobar emphysema, congenital pulmonary airway malformation)  \n  o Post-abdominal surgery  \n  • Consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required |
| **Benefits\(^{43,46}\)** | • May improve lung compliance and stabilise the compliant chest wall  \n  • Improves thoracoabdominal synchrony  \n  • Reduces work of breathing [refer to Definitions]  \n  • Upper airway splinting reduces obstructive apnoea  \n    o May decrease central apnoea due to regular breathing pattern  \n  • Reduces oxygen requirements  \n  • Reduces risk of bronchopulmonary dysplasia |
| **Potential harms\(^{43}\)** | • Risk of pulmonary air leaks due to airway distending pressure  \n  • Facial trauma including loss of skin or nasal integrity from the CPAP interface [refer to Table 19. Pressure area care]  \n  • Abdominal distension [refer to Table 17. Care of baby on CPAP] |
5.3 CPAP administration

- Manage the baby on CPAP in a level 4 or higher neonatal service—CSCF
- The nurse:patient ratio is generally 1:2 depending on acuity
- If the baby is unstable the ratio is 1:1
- Completion of a neonatal CPAP training program by clinical staff is recommended
- Consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required

Table 15. CPAP administration

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Context**          | • CPAP system provides stable pressures at required levels with humidity and supplemental oxygen\(^{47}\)  
                      | • Early versus delayed initiation of CPAP reduces the requirement for mechanical ventilation and surfactant\(^{48,49}\) and the incidence of BPD\(^{49,50}\)  
                      | • Goal of CPAP delivery device is to prevent atelectasis and airway closure\(^{47}\)  
                      | • Mean airway pressure delivered to a baby by nasal CPAP is affected by:  
                      | o Seal of the interface  
                      | o Loss of pressure through the mouth  
                      | o Airway resistance\(^{40,51}\)  
| **Nasal CPAP**       | • Improves oxygenation and maintains lung volume  
                      | • Increases FRC, distends the larynx, reduces subglottic airway resistance\(^{52}\)  
                      | • Standard respiratory treatment over invasive intubation\(^{7}\)  
| **Bi-nasal prongs**  | • Standard of care for babies of all gestations who breathe spontaneously and require continued respiratory support\(^{45}\)  
                      | • Better than single prong to deliver CPAP to preterm baby for early treatment of RDS\(^{44}\)  
                      | o Lower oxygen requirements (than single prong)  
                      | o Incidence of BPD, pulmonary air leaks, ventilator associated pneumonia and neurocognitive disorders is lower than with mechanical ventilation\(^{45}\)  
                      | o Longer term outcomes and medium-term outcomes (e.g. chronic lung disease at 36 weeks corrected age) not identified\(^{44}\)  
                      | • Associated with increased resistance to air flow  
                      | • Correct fitting of device minimises perinasal leak and nasal trauma\(^{53}\)  
                      | o Refer to Table 19. Pressure area care  
| **Nasal mask**       | • If staff are competent providing nasal mask CPAP, may be used in non-tertiary facility as an alternative interface to nasal prongs  
                      | • Choose correct size mask—small enough to be flush with side of baby’s face and not slide out of position  
                      | • Ensure mask does not slide up and occlude the nares\(^{45}\)  
                      | • May relieve trauma from prongs\(^{51}\)  
                      | o Evidence from a systematic review and meta-analysis reported a lower incidence of nasal trauma with very low certainty evidence\(^{54}\)  
                      | • May reduce CPAP failure\(^{53}\)  
| **Bubble device**    | • Bubble device versus ventilator to deliver CPAP  
                      | o No difference in physiological parameters in the short-term\(^{47,52}\)  
| **versus ventilator**|                                                                                                                                               |
5.4 CPAP settings
Record CPAP pressure, gas flow, fractional inspired oxygen (FiO₂) and humidifier temperature hourly and when any changes made to settings.

Table 16. CPAP settings

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>• Commence at 7–8 cm H₂O</td>
</tr>
<tr>
<td>Flow</td>
<td>• Generally, 6–8 L per minute⁵⁵ depending on CPAP device being used</td>
</tr>
<tr>
<td></td>
<td>• Use lowest level possible to deliver desired pressure</td>
</tr>
<tr>
<td></td>
<td>○ Refer to manufacturer’s instructions</td>
</tr>
<tr>
<td>Oxygen</td>
<td>• Deliver FiO₂ to maintain the baby’s oxygen saturations within target levels</td>
</tr>
<tr>
<td></td>
<td>• Refer to Table 3. Signs and Table 12. Supportive care</td>
</tr>
<tr>
<td>Humidification</td>
<td>• Humidify and warm gases before delivery to baby</td>
</tr>
<tr>
<td></td>
<td>• Set temperature⁴¹ according to manufacturer’s instructions—generally:</td>
</tr>
<tr>
<td></td>
<td>○ Interface with baby 37 °C</td>
</tr>
<tr>
<td></td>
<td>○ Humidifier 40 °C</td>
</tr>
<tr>
<td>Device management</td>
<td>• Insert circuit through lowest insertion port on incubator to:</td>
</tr>
<tr>
<td></td>
<td>○ Assist drainage of condensation away from the baby⁴⁶,⁵²</td>
</tr>
<tr>
<td></td>
<td>○ Reduce aspiration risk</td>
</tr>
<tr>
<td></td>
<td>• Position inspiratory limb (blue) above expiratory limb (white)</td>
</tr>
</tbody>
</table>
5.5 Care of baby

5.5.1 General care

Table 17. Care of baby on CPAP

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment and monitoring</td>
<td>• To determine observations and assessment required, refer to Table 3. Signs and Table 12. Supportive care</td>
</tr>
<tr>
<td></td>
<td>• Commence/continue IV therapy [refer to Table 12. Supportive care]</td>
</tr>
<tr>
<td></td>
<td>• Insert a size 6–8 FG OGT to minimise gastric distension(^{21,45})</td>
</tr>
<tr>
<td></td>
<td>o If significant abdominal distension the larger (8 FG) OGT may be required</td>
</tr>
<tr>
<td></td>
<td>• OGT:</td>
</tr>
<tr>
<td></td>
<td>o Leave on free drainage to vent stomach(^{45})</td>
</tr>
<tr>
<td></td>
<td>o Cap for 30 minutes after a feed</td>
</tr>
<tr>
<td></td>
<td>o Aspirate air every 4–6 hours and as required</td>
</tr>
<tr>
<td></td>
<td>• Non-nutritive sucking on a pacifier(^{56}) while on CPAP is beneficial:</td>
</tr>
<tr>
<td></td>
<td>o Promotes physiological stability</td>
</tr>
<tr>
<td></td>
<td>o Reduces stress</td>
</tr>
<tr>
<td></td>
<td>o Relaxes the baby during invasive procedures</td>
</tr>
<tr>
<td></td>
<td>o Improves preparation for oral feeding</td>
</tr>
<tr>
<td></td>
<td>o Improves oxygenation</td>
</tr>
<tr>
<td></td>
<td>o Reduces air leak from mouth</td>
</tr>
<tr>
<td>Fluids and feeding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Keep airway clear of secretions</td>
</tr>
<tr>
<td></td>
<td>o Routine suctioning not required</td>
</tr>
<tr>
<td></td>
<td>o Avoid deep suctioning(^{45})</td>
</tr>
<tr>
<td></td>
<td>• Risks from suctioning include:</td>
</tr>
<tr>
<td></td>
<td>o Infection, bradycardia, laryngospasm, blood pressure fluctuations, hypoxaemia, increased intracranial pressure, cardiac arrhythmia, nasal injury(^{57})</td>
</tr>
<tr>
<td></td>
<td>• Provide comfort measures including facilitated tucking, swaddling and oral sucrose to reduce associated pain</td>
</tr>
<tr>
<td></td>
<td>• Consider use of peanut pillow to maintain midline position of head during suctioning</td>
</tr>
<tr>
<td>Suctioning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Minimise unnecessary noxious procedures</td>
</tr>
<tr>
<td></td>
<td>• Assess and record pain every 4 hours using validated pain management tool(^{21})</td>
</tr>
<tr>
<td></td>
<td>• Can be alleviated non-pharmacologically by:</td>
</tr>
<tr>
<td></td>
<td>o Modifying the environmental and sensory stimuli (e.g. noise and light)</td>
</tr>
<tr>
<td></td>
<td>o Sucrose 25% orally(^{58})</td>
</tr>
<tr>
<td></td>
<td>o Positioning of baby [refer to Table 18. Developmental care]</td>
</tr>
<tr>
<td></td>
<td>o Non-nutritive sucking(^{59})</td>
</tr>
</tbody>
</table>
### Developmental care and positioning

#### Table 18. Developmental care

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Supportive care**     | • If baby is fragile or compromised, perform cares by two clinicians, for example if:  
  o Has acute lung disease  
  o Weighs less than 1000 g  
  o Requires greater than 7 cmH₂O CPAP  
  o Requires greater than 25% oxygen  
  • Minimise time off CPAP  
  • Provide oxygen in the incubator at the same concentration as CPAP in case device dislodges  
  • Encourage family collaboration and unrestricted visiting  
    o Encourage parent/s to assist with eye and mouth cares and head massage with assistance from clinician (to maintain CPAP)  
    o Encourage skin to skin contact as soon as clinical condition allows |
| **Positioning**         | • Position baby to avoid:  
  o Inadvertent tension to the interface  
  o Accumulation of condensate to the nares  
  • Use pacifier or chin strap to keep baby’s mouth closed (to maintain CPAP)  
    o If the baby’s mouth habitually remains open use a chin strap  
    o Position the strap under the bony portion of the chin and not over the fleshy portion of the hypopharynx region—may cause airway obstruction and increase risk of aspiration  
  • Avoid lateral positioning of baby with acute lung disease as this may reduce effective bilateral lung expansion and increase the risk of atelectasis  
  • Prone positioning  
    o Positive effect on respiratory mechanics by increasing oxygenation, improving ribcage-abdominal synchrony and better consistency of breathing pattern  
    o Disadvantages include developmental delays, corneal lesions and loss of vascular access in long term use  
  • Prone quarter turn position beneficial for stabilising respiratory rate and increasing oxygen saturation  
    o Place a small neck roll under the baby to prevent neck flexion and airway obstruction  
    o Nest baby by supporting hips, uppermost arm and trunk with roll  
    o Position knees and feet in neutral alignment with hips |
| **Developmental care**  | • Developmental positioning is important to prevent pressure injury and deformational plagiocephaly  
  • Release bonnet for a few minutes with each routine handling and care episode—assess skin including scalp and ears  
  • Perform care as indicated by baby’s clinical condition—usually 4–6 hourly by one or two people  
    o Involve parents in the baby’s cares  
    o Minimal handling—disturb baby only when absolutely necessary  
    o If baby positioned supine during cares, use of a peanut pillow to help maintain head in mid-line position  
    o Refer to Table 12. Supportive care  
  • Comfort and natural development provided by:  
    o Gentle touch and containment  
    o Developmental positioning  
    o Age-appropriate stimulation  
    o Cycled lighting  
    o Decreased environmental stimuli including noise  
    o Family bonding time—encourage parents to be present during painful procedures  
  • Benefits of skin-to-skin positioning when clinically suitable are physiological, psychological, behavioural, neurobehavioral and psychosocial |
5.5.3 Pressure area care

Table 19. Pressure area care

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Context** | • Constant pressure on the nares, nasal septum and forehead can lead to reduced skin integrity and injury\(^{65}\) causing pressure injury (ulcers) and friction shear from respiratory tubing\(^{65}\)  
• Nasal trauma:  
  o Most common complication of nasal CPAP\(^{66}\)–incidence 15–60%  
  o Occurs commonly on medial aspect of nostrils  
  o Pressure caused by poorly fitting nasal prongs or carrying crossbar exerting pressure on septum  
  o Most common nasal injuries–necrosis, scab formation, excoriation of the septum, nasal hyperaemia and disfigurement of the size and shape, nasal erosion, functional airway obstruction\(^{67,68}\)  
  o May progress to facial scarring\(^{42}\) and/or permanent deformity  
• Risk factors for skin breakdown, development of nasal pressure ulcers, compression necrosis, and/or nasal deformities\(^{69}\):  
  o Nasal CPAP device  
  o Length of therapy  
  o Age, gestation and size of baby  
  o Poor perfusion  
  o Environmental humidity and temperature |
| **Assessment** | • Provide vigilant skin assessments and skin resting time\(^{70}\)  
• First sign of skin breakdown is nasal erythema\(^{69}\)  
• Assess baby regularly (with cares) for signs of pressure injury  
  o Nasal: redness, blanching, skin breakdown, necrosis, bruising, indentation, bleeding, altered shape  
  o Ears: creases, folds, pressure areas  
  o Forehead: if using midline device (mask or prongs)  
  o Nasal bridge: mid-facial indentation (mask)  
  o Head: especially on bony prominences–remove hat to assess  
• Documentation of pressure area injury includes location, nature and extent–clinical photos may assist assessment of progression and recovery |
| **Prevention** | • Measure and size the interface device for each baby  
• If prongs fitted correctly pressure is avoided on high risk areas, and excess rubbing and movement are prevented\(^ {45}\)  
  o Position binasal prongs 2 mm from the nares  
  o Avoid contact with the septal columella  
  o Fit firmly without blanching the skin to decrease movement\(^ {45}\)  
  o Avoid pressure on the nasolabial sulcus and philtrum  
  o Avoid propping the cot as baby sliding will cause pressure on the septum  
  o Resizing may be required as the nares increase in size  
• If mask is used ensure it covers entire nose–do not fit mask tightly and avoid indentations and pressure on nasal bridge  
• Consider use of septum skin protector\(^{67,71}\):  
  o Reduces nasal injuries–use soft silicone-based skin protection over vulnerable areas  
    ▪ Assess regularly for moisture\(^{72}\), and change at least every 12 hours  
    ▪ Remove during trial off CPAP as baby is unable to nasal flare [refer to Table 3. Signs]  
  o Helps to provide seal around device  
• Avoid hydrocolloid nasal dressing under binasal prongs within first 15 minutes of insertion as it inhibits visualisation of nares and septal columella, and pressure is injury most likely to occur during this time  
• Avoid tight fitting hat over forehead, ears and bony prominences  
• Position the baby’s hand under their chin to help keep the mouth closed without the use of a chin strap\(^ {45}\) |
| **Management** | • If pressure area(s) present:  
  o Review interface, delivery mechanisms and pressure injury reduction measures\(^ {45}\) and reassess size of prongs or mask  
  o Consider alternating between binasal prongs and mask |
## 5.6 Complications of CPAP

Table 20. CPAP complications

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulmonary air leaks</strong></td>
<td>• Continuous distending pressure (CPAP) may increase the risk of pneumothorax \cite{18,73}</td>
</tr>
</tbody>
</table>
| **Pain**                | • CPAP treatment and associated procedures (e.g. heel pricks \cite{64}, suctioning) are painful or unpleasant \cite{21,74} due to:  
  o Flow of gas through nose and mouth  
  o Restricted head movements  
  o Obstructed vision  
  o Suctioning  
  • Refer to Table 17. Care of baby on CPAP                                                   |
| **Abdominal insufflation** | • Caused by delivered gas entering the stomach and gastrointestinal tract \cite{21,45}  
  • May cause feed intolerance \cite{45,75}  
  • Use lowest possible flow of gas to achieve required CPAP [refer to Table 16. CPAP settings]  
  • Refer to Table 17. Care of baby on CPAP                                                    |
| **Hyperinflation of lungs** | • Caused by excessive pressure that results in:  
  o Increased work of breathing \cite{75} [refer to Definitions]  
  o Reduced cardiac output secondary to impaired venous return \cite{75}  
  • Refer to Table 16. CPAP settings for recommended CPAP in babies                           |
| **Pressure injury**     | • Refer to Table 19. Pressure area care                                                   |
### 5.7 Clinical course

#### Table 21. CPAP clinical course

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Signs of improvement** | • Reduction in the baby’s work of breathing as shown by reduction in:  
  o Respiratory rate (typically by 10–20 breaths per minute)  
  o Expiratory grunting  
  o Chest recession  
  o Nasal flaring  
  • Stabilised or reduced oxygen requirement to maintain SpO₂ within target range  
  • Improvement in blood gas (if taken)  
  • Improvement in appearance and lung volumes on chest x-ray  
  • More settled baby |
| **Weaning/ceasing**   | • Refer to Table 22. Weaning CPAP                                                                                                             |
| **Signs of deterioration** | • If baby's condition deteriorates, consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required  
  • Signs of deterioration include:  
  o Respiratory signs not improving or worsening  
  o Oxygen requirement increasing or greater than 40% to maintain target SpO₂  
  o Apnoeic episodes  
  o Blood gas showing increasing respiratory acidosis |
| **CPAP failure**      | • Defined as the need for endotracheal intubation and mechanical ventilation due to severe respiratory distress and high oxygen requirement within 72 hours of nasal CPAP initiation\(^{53,77}\)  
  • Signs\(^{76}\):  
  o FiO₂ greater than 40% (or according to local protocols) to maintain target SpO₂ with 8 cmH₂O CPAP  
  o Rapid increase of oxygen requirement including a rise of 10% over 2 hours or less  
  o Respiratory acidosis—pH less than 7.25 with normal base excess or PaCO₂ greater than 60 mmHg  
  o Recurrent apnoeic episodes requiring stimulation  
  o Increase in work of breathing [refer to Definitions]  
  o Development of pneumothorax [refer to Table 8. Pulmonary air leaks]  
  o Baby agitated and not settled by comfort measures [refer to Table 18. Developmental care]  
    ▪ Review respiratory status  
    ▪ Assess for other causes and manage [refer to Table 17. Care of baby on CPAP]  
  • If there are signs of failure:  
    o Consult with neonatologist via RSQ for advice or retrieval of baby to a higher level of service as required  
    o Assess baby (by medical officer/nurse practitioner) immediately  
    o Urgent chest x-ray  
    o Transilluminate chest to detect signs of pulmonary air leak  
      ▪ Negative transillumination may not be meaningful in a baby greater than or equal to 32 weeks gestational age [refer to Table 8. Pulmonary air leaks]  
    o Check blood gas for hypercarbia or severe metabolic acidosis  
      ▪ If metabolic acidosis refer to Queensland Clinical Guideline *Hypoxic ischaemic encephalopathy (HIE)*\(^{23}\)  
    o Refer to Queensland Clinical Guideline *Stabilisation for retrieval–neonatal*\(^{23}\) |
### 5.8 Weaning CPAP

Table 22. Weaning CPAP

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Consideration</th>
</tr>
</thead>
</table>
| **Context** | **Lung compliance changes occur between 48 and 96 hours of age due to surfactant secretion**  
  **If CPAP is discontinued prematurely, risk of**:  
  - Atelectasis  
  - Apnoea and bradycardia  
  **If CPAP is continued unnecessarily, risk of complications include**:  
  - Gastric distension; nasal trauma; agitation  
  - Alveolar over distension resulting in longer term consequences (e.g. BPD) |
| **Weaning** | **Reduce FiO\textsubscript{2} before reducing the CPAP pressure**  
  - Maintain SpO\textsubscript{2} levels in target range \[\text{refer to Table 3. Signs}\]  
  **Commence gradual CPAP weaning when**:  
  - Oxygen requirement less than 25%  
  - Respiratory distress improved  
    - Respiratory rate less than 60 breaths per minute  
    - Chest recessions absent  
  - Apnoeas are no longer than 20 seconds duration and are self-reverting  
  - Bradycardic episodes are not lower than 100 beats per minute  
  - Average SpO\textsubscript{2} greater than 95\% for the previous 6 hours  
  **Wean incrementally by 1 cmH\textsubscript{2}O as tolerated until 5 cmH\textsubscript{2}O**  
  **Cease if baby is stable in 21\% oxygen and CPAP 5 cmH\textsubscript{2}O**  
  **Signs of CPAP being ceased too early include**:  
  - Increasing apnoea frequency  
  - Increased oxygen requirement  
  - Increased work of breathing [refer to Definitions]  
  **Weaning too early may result in a need to restart CPAP or intubation and ventilation**  
  **Weaning CPAP to a predefined level and then stopping completely, results in**:  
  - Less total time on CPAP  
  - Shorter durations of oxygen  
  - Reduced length of hospital stay \[\text{43}\] |
| **Duration** | **Clinical criteria to reduce, wean or discontinue CPAP**:  
  - Gestational and chronological age of baby  
  - Current weight  
  - Clinical markers of respiratory stability  
  **Assess clinical signs indicating the baby is not tolerating CPAP reduction or cessation**  
  - Babies born at lower gestations compared to more mature babies (equivalent corrected age) require a longer total duration and are more likely to fail CPAP weaning  
  **Prolonged use of CPAP (as indicated) reduces the overall supplemental oxygen requirement** \[\text{43}\] |
| **Recommencing CPAP** | **Before recommencing CPAP assess baby’s clinical condition to exclude complications requiring additional management (e.g. pneumothorax, apnoea of prematurity)**  
  **Recommence if**:  
  - Work of breathing increases [refer to Definitions]  
  - SpO\textsubscript{2} falls  
  **Recommence at 6–8 cmH\textsubscript{2}O and adjust accordingly** |


## Appendix A Comparison of respiratory disease

<table>
<thead>
<tr>
<th>Type</th>
<th>Gestation</th>
<th>Onset after birth</th>
<th>Cause</th>
<th>Risk factors</th>
<th>Clinical features</th>
<th>X-ray features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TTN</strong></td>
<td>Late preterm/term</td>
<td>Immediate to 2</td>
<td>Caesarean birth</td>
<td>Cyanosis</td>
<td>Normal or slightly overinflated lung fields</td>
<td>Hypoxaemia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hours of birth</td>
<td>Precipitous birth</td>
<td>Increased work of breathing*</td>
<td>Increased streaky shadowing with perihilar densities</td>
<td>Respiratory acidosis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Macrosomia</td>
<td>Increased AP chest diameter</td>
<td>extending into peripheral lung fields</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>Barrel shaped chest</td>
<td>Normal or mildly enlarged heart</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maternal asthma</td>
<td>Breath sounds clear</td>
<td>Small pleural effusions may be present</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maternal diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RDS</strong></td>
<td>Preterm</td>
<td>Immediate</td>
<td>Male</td>
<td>Increased work of breathing*</td>
<td>Ground glass appearance</td>
<td>Hypoxaemia</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Caucasian</td>
<td>Hypoxia</td>
<td>Air bronchograms</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Under-developed lungs</td>
<td>Cyanosis</td>
<td>Decreased lung volumes</td>
<td></td>
</tr>
<tr>
<td><strong>Meconium aspiration</strong></td>
<td>Term/post-term</td>
<td>Immediate</td>
<td>Birth through meconium</td>
<td>Cyanosis</td>
<td>Asymmetric patches of opacification and streaky</td>
<td>Hypoxaemia</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>stained liquor</td>
<td>Increased work of breathing*</td>
<td>linear densities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Barrel-shaped chest</td>
<td>Hyperinflation of lungs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rales and rhonchi on</td>
<td>Flattening of the diaphragm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>auscultation</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Infection</strong></td>
<td>Any</td>
<td>Early: 24–72 hours of</td>
<td>PROM Maternal Group B</td>
<td>Overlap with RDS</td>
<td>Overlap with RDS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delayed: 5–14 days</td>
<td>streptococcal colonisation</td>
<td>Non-specific (e.g. poor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maternal fever</td>
<td>feeding)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Placental transmission</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Infected amniotic fluid aspiration</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Increased work of breathing–tachypnoea, chest recession (sternal, intercostal, lower costal); nasal flaring; audible expiratory grunt
### Comparison of respiratory disease (continued)

<table>
<thead>
<tr>
<th>Type</th>
<th>Gestation</th>
<th>Onset after birth</th>
<th>Risk factors</th>
<th>Clinical features</th>
<th>X-ray features</th>
<th>Blood gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Congenital diaphragmatic hernia</strong></td>
<td>Any</td>
<td>Immediate (usually diagnosed antenatally)–dependent on type and severity</td>
<td></td>
<td>Barrel shaped chest Scaphoid appearing abdomen Absence of breath sounds on ipsilateral side–may have displaced heart beat (left sided)</td>
<td>Absence of diaphragm–usually left sided Visible bowel gas in chest cavity No visible aerated lung on affected side</td>
<td></td>
</tr>
<tr>
<td><strong>Persistent pulmonary hypertension</strong></td>
<td>Late preterm, term, post-term</td>
<td>Within 24 hours of birth</td>
<td>Abnormalities of pulmonary vasculature  • Underdevelopment (e.g. diaphragmatic hernia)  • Maldevelopment (e.g. CHD, MAS)  • Maladaptation (e.g. post-term birth, caesarean birth, LGA)</td>
<td>Intrauterine and perinatal asphyxia SSRI exposure PPROM</td>
<td>Worsening respiratory distress and cyanosis despite high F.O₂</td>
<td>Normal or reflects underlying respiratory disease Severe hypoxaemia Normal/mild hypercarbia Metabolic acidosis</td>
</tr>
</tbody>
</table>
## Appendix B Pulmonary air leaks

<table>
<thead>
<tr>
<th>Type</th>
<th>Gestation</th>
<th>Description</th>
<th>Risk factors</th>
<th>Clinical features</th>
<th>X-ray features/blood gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pneumothorax</strong></td>
<td>Any</td>
<td>Occurs any time Extra pleural pressure exceeds intrapleural pressure</td>
<td>Infection Aspiration Lung deformity Ventilation causing barotrauma</td>
<td>May be asymptomatic Unexpected deterioration in oxygenation, ventilation or cardiovascular status On affected side:  • Chest asymmetry  • Decreased breath sounds  • Shift of heart sounds away</td>
<td>Air in pleural space, atelectasis with flattening of the diaphragm on the affected side, shift of mediastinum away from the pneumothorax</td>
</tr>
<tr>
<td><strong>Tension pneumothorax</strong></td>
<td>Any</td>
<td>Occurs any time Increases intrathoracic and central venous pressures Decreases venous return</td>
<td>IPPV</td>
<td>Rapid clinical deterioration Hypotension Bradycardia</td>
<td>Air in pleural space, atelectasis with flattening of the diaphragm on the affected side, shift of mediastinum away from the pneumothorax Hypoxaemia</td>
</tr>
<tr>
<td><strong>Pneumomediastinum</strong></td>
<td>Any</td>
<td>Air in the mediastinal space</td>
<td>IPPV with high peak airway pressure</td>
<td>Usually asymptomatic—may be detected by cardiac auscultation (distant heart sounds)</td>
<td>Radiolucent halo over the cardiac outline or retrosternal or mediastinal radiolucency (on lateral view Thymus gland lifted giving ‘angel wing’ or ‘spinnaker sail’ appearance</td>
</tr>
<tr>
<td><strong>Pneumopericardium</strong></td>
<td>Any</td>
<td>Air surrounding the pericardium</td>
<td>Active resuscitation Assisted ventilation in preterm baby</td>
<td>May cause cardiac tamponade</td>
<td>In AP view air surrounds the heart shadow within the pericardium</td>
</tr>
<tr>
<td><strong>PIE</strong></td>
<td>Any (commonly preterm)</td>
<td>Occurs usually within 96 hours of birth Air is trapped in the perivascular space</td>
<td>Preterm</td>
<td>Increasing hypoxaemia and hypercapnia</td>
<td>More common in very low birth weight ventilated babies</td>
</tr>
</tbody>
</table>
Acknowledgements

Queensland Clinical Guidelines gratefully acknowledge the contribution of Queensland clinicians and other stakeholders who participated throughout the guideline development process particularly:

Working Party Clinical Lead
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