Scope
This guideline is aimed at all Health care professionals involved in the care of infants within the Neonatal Service.

Aim
To provide evidence-based recommendations on the recognition and management of pulmonary haemorrhage (PH).

Key Points

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>Neonates who develop pulmonary haemorrhage are critically ill and require appropriate resuscitation.</td>
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</tbody>
</table>
| 2 | High frequency oscillatory ventilation may be useful as rescue therapy in neonates with massive pulmonary haemorrhage who are not responding to conventional ventilation.  
  Grade of Evidence: B |
| 3 | Administration of natural surfactant in neonates presenting with pulmonary haemorrhage may result in improvement of respiratory function.  
  Grade of Evidence: B |
| 4 | There is often associated hypovolemia and shock which may need prompt correction by packed cell transfusion and/or fresh frozen plasma (FFP).  
  Grade of Evidence: C |
| 5 | There is little available evidence on the effects of fluid restriction or the use of diuretics in babies who have suffered a pulmonary haemorrhage.  
  Grade of Evidence: C |

Related UHL documents:

<table>
<thead>
<tr>
<th>Document</th>
<th>ID Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red cell transfusion in Neonates</td>
<td>C165/2008</td>
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SUPPORTING INFORMATION

Background
PH is a rare but severe condition characterized by the acute onset of bleeding from the trachea or endotracheal tube, which is associated with cardiorespiratory deterioration, acute changes on the chest x-ray and a drop in the haematocrit. It is an acute event affecting preterm and term babies and if massive, can be life-threatening. It occurs in 12% of preterm infants weighing less than 1500 grams and has an overall incidence of 0.8-1.2 per 1000 live births (1).

Significant PH is most likely to represent haemorrhagic pulmonary oedema. This is thought to be due to an acute increase in the pulmonary capillary pressure which leads to pulmonary oedema and haemorrhage.

It occurs in 3-5% of preterms with respiratory distress syndrome (RDS) (2), who often have a patent ductus arteriosus (PDA) and have received surfactant therapy (3). PH is most commonly precipitated by acute left ventricular failure due to asphyxia, with coagulation disorders exacerbating the problem (4). It is also associated with intrauterine growth restriction, fluid overload, oxygen toxicity, severe hypothermia and urea cycle defects accompanied by hyperammonaemia (5).

A literature review revealed a paucity of high-quality evidence pertaining to the management of PH. Most observations have been based on observational cohort studies, case series and reports. The acute, unpredictable, catastrophic and potentially life-threatening nature of PH may explain the difficulty in recruiting the required numbers to randomized controlled trials.

Diagnosis

Clinical
PH is usually diagnosed clinically, although only a small percentage of PH evident at autopsy are manifest clinically (5). It often presents on day 2-4 of life. History should focus on identification of predisposing risk factors (infection, PDA), whilst examination reveals pink or red frothy fluid in the airway. The baby is often acutely unwell, hypoxic, in severe respiratory distress, bradycardic, collapsed, pale and shocked. If ventilated, there may be haemorrhagic fluid in the trachea with cardiorespiratory decompensation. It is important to remember that recent/traumatic intubation may also lead to small amounts of blood-tinged fluid on suctioning of the endotracheal tube, which should not be mistaken for pulmonary haemorrhage. If not ventilated, the baby may be apneic with blood-tinged fluid seen on laryngoscopy.

Radiological
Radiological changes may be acute but non-specific. A chest x-ray may show focal (patchy infiltrates, fluffy opacities, nodular densities or focal ground-glass opacities) or massive (lung field ‘whiteout’ with air bronchograms) changes.

Laboratory
Haematocrit of the haemorrhagic oedema fluid is usually <10%. If this is higher, pulmonary haemorrhagic oedema is unlikely and the blood may be traumatic in nature,
due to disseminated intravascular coagulopathy (DIC) or swallowed maternal blood.

**Investigations**

Investigations address cardiopulmonary compromise associated with acidosis (metabolic or mixed), a deficit in haematocrit and a possible coagulopathy.

- Full Blood Count
- Crossmatch
- Coagulation screen (often not causal)
- Blood gas (hypoxia, hypercarbia, metabolic acidosis)
- Biochemical profile
- C-reactive Protein (CRP)
- Blood culture
- Cranial ultrasound scan – intraventricular haemorrhage may be an association
- Echocardiography – to assess PDA and left ventricular function

**Management** (Appendix 1)

PH can be associated with high mortality and these babies are usually very sick. Massive PH can be life-threatening. Aim to prevent exsanguination whilst ensuring simultaneous gas exchange (6).

**Always inform the Consultant Neonatologist if suspecting or treating a baby for PH.**

Resuscitation is key – follow the principles of ‘ABC’.
- Restore haemodynamic stability.
- Correct acidosis.
- Consider the possibility of sepsis.

**Ventilatory Strategy:**

1) All babies must be mechanically ventilated, with oxygen administration guided by oxygen saturation.

2) Suctioning of the airway as required to remove haemorrhagic fluid, but limit aggressive suctioning (5).

3) During massive PH, the view of the vocal cords may be obscured, thus leading to difficulty with endotracheal intubation. If the baby is already intubated, **do not remove the endotracheal tube** unless it is blocked. If the baby needs intubation, this can be technically difficult due to the presence of haemorrhagic fluid/blood in the trachea and airways. In such conditions use of Boogie from the difficult airway kit can be useful(7)

Ventilatory strategies must include providing high mean airway pressures, which may need high PIP (up to 30cm of water may be necessary, guided by chest movement and blood gases) and high PEEP (6-8 cm of water) to provide tamponade of the high pulmonary capillary pressures by distending the airways (8).

4) **Regarding High Frequency Oscillatory Ventilation (HFOV):**
In babies with massive PH and severe respiratory failure, which is not responding to conventional ventilation, consider the use of HFOV after discussion with a Consultant Neonatologist.

There is some evidence, in the form of observational cohort studies (9,10) involving small numbers, showing a statistically significant decrease in oxygenation indices and oxygen requirements in the babies who responded to the use of HFOV as rescue therapy. In view of the lack of randomized controlled trials, it is uncertain whether providing a high mean airway pressure whilst limiting tidal volume excursions with HFOV is superior to conventional ventilation in minimizing interstitial and alveolar fluid accumulation (5). HFOV should be considered as rescue therapy after discussion with a Consultant Neonatologist.

5) Paralysis and/or sedation may be necessary if the infant is not synchronizing with the ventilator and adequate control is required.

6) **Regarding the use of Surfactant:**
Consider the use of a single dose of surfactant (Curosurf: dose 100-200 mg/kg, give the dose i.e. 120 mg/240 mg/360 mg/480 mg after rounding off to the higher value) in babies with difficult ventilation after discussion with a Consultant Neonatologist.

There have been association between PH and surfactant (11-15). Paradoxically, surfactant has been used as adjuvant therapy in PH. Administration of curosurf in neonates presenting with pulmonary haemorrhage may result in improvement of respiratory function.(16-20) A Cochrane Systematic Review (21) concluded that although there was potential benefit of surfactant in the management of PH, there was an inability to make recommendations in the absence of randomized controlled trials.

**Cardiovascular Support**
PH may be associated with hypotension and anaemia. This needs prompt recognition and may need management by volume replacement in the form of blood products (packed red cells) and may also involve the use of inotropes.

**Fluid management**
There is very little evidence on guidance regarding fluid management or the use of diuretics and their effects in babies who have suffered a PH. Restricted fluid intake has been shown in a Cochrane review (22) to reduce the risks of patent ductus arteriosus. This may indirectly improve the situation during PH. A general approach of fluid overload avoidance would be wise in such cases. Further assessment of the presence of a PDA and its subsequent management would be required.

**Coagulopathy**
The role of coagulopathy in babies who develop PH is not clear. PH is rarely seen in babies with disseminated intravascular coagulopathy (DIC), thrombocytopenia, haemorrhagic disease of the newborn or haemophilia (23). However, secondary DIC may occur after a massive PH. If clotting parameters are found to be deranged, fresh frozen plasma can be used for volume replacement.
Other interventions
Administration of endotracheal adrenaline has been in used in PH (6, 24), most often with a dose of 0.1ml/kg (of 1 in 10,000 dilution) (6). This treatment may be considered, but is controversial because there are no controlled trials which have shown a benefit (6).

Long-term complications
Mortality in babies who develop massive PH is high (approximately 50%), especially in those of lower birth weight and gestational age. There seems to be an increased risk of pulmonary or neurodevelopmental complications but this did not reach statistically significant levels (25). It is difficult to ascertain whether PH itself causes a poor outcome or whether it is a marker for poor outcome in very low birth weight infants who are treated with surfactant (26).
Appendix 1

Management of PH in a Neonate

Assess the clinical condition of the baby
- Respiratory distress
- Apnoea
- Pallor
- Bradycardia
- Shock
- Blood stained fluid in the trachea
Can be potentially life threatening

Investigations
- Full blood count
- Crossmatch
- Coagulation screen
- Biochemical profile
- CRP
- Blood culture
- Blood gas
- Chest X-ray
- Cranial USS
- Echo (if available—to assess for PDA and left ventricular function)

Management
- Resuscitate: ‘ABC’
- Inform Consultant Neonatologist if you suspect or treating for Pulmonary Hemorrhage
- Suction airway as required
- Ventilate: Start with conventional ventilation
  - Consider high PEEP (upto 6-8 cm of water)
  - Consider high PIP (ensure good chest movement)
  - Consider HFOV (if conventional unsuccessful)
- May need sedation and/or muscle relaxants (atracurium)
- Treat hypovolemia and maintain blood pressure (may need to use inotropes)
- Transfusion of blood products (FFP, packed red cells) if evidence of coagulopathy or anemia
- Fluid management: need careful fluid management in order to avoid fluid overload
- Consider use of Surfactant (100-200 mg/kg single dose)
  - If ventilate difficult – discuss with Consultant
  - Intravenous antibiotics
References

7. Managing the Difficult Airway in the Neonate - A Framework for Practice. BAPM 2020

Audit Standards

1. A Consultant Neonatologist will be consulted at the time a PH is suspected or being treated (100%)

2. All infants that have a PH will have appropriate ventilatory management (100%)

Guideline development

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>April 2011</td>
<td>Original guideline ratified</td>
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<tr>
<td>April 2016</td>
<td>Review by guidelines lead (REM) – no significant changes</td>
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<tr>
<td>April 2016</td>
<td>Neonatal Guidelines Meeting</td>
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<tr>
<td>April 2016</td>
<td>Neonatal Governance Meeting (ratified for 1 year) – pending further review</td>
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<tr>
<td>July 2017</td>
<td>Neonatal Guidelines Meeting (reviewed by guidelines lead REM)</td>
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