Respiratory Failure in Neonates

a management pathway
Respiratory Failure in Neonates
Management Pathway

Definition
This guideline applies to infants in the neonatal unit with severe respiratory failure. Severe respiratory failure can be defined as persistent hypoxaemia or hypercapnia despite surfactant therapy and ‘maximal’ conventional ventilation.

The severity of respiratory (oxygenation) failure can be estimated by calculating the Oxygenation Index (OI).

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\text{Oxygenation Index (OI)} = \frac{(\text{FiO}_2 \times \text{Mean Airway Pressure} \times 100)}{\text{PaO}_2 \, \text{(in kPa)} \times 7.5}
\]

(note PaO\(_2\) must be from an arterial sample; FiO\(_2\) is in the range 0 to 1)

Consider transfer to a specialist centre (or advanced management if already in a specialist centre) when a ventilated infant meets, or is approaching these criteria:

- Preterm infant (≤ 34 weeks of gestation):
  - (a) OI > 15 and / or
  - (b) PaCO\(_2\) > 8 kPa (60 mmHg) with pH < 7.2

- Term or near-term infant (> 34 weeks of gestation):
  - (a) OI > 25 and / or
  - (b) PaCO\(_2\) > 8 kPa (60 mmHg) with pH < 7.2

Action
1. Basic management of respiratory failure (see below)
2. If infant meets, or is approaching these criteria above:
   a. Contact specialist centre
   b. Contact cot bureau to arrange transfer to specialist centre
3. Advanced management of severe respiratory failure (see flowsheet)

Timing and discussion of transfer to a specialist centre
Babies with evolving or established respiratory failure should be cared for in an appropriate centre offering the necessary specialist expertise and equipment. Arrangements for transfer must be made allowing sufficient time for assessment, stabilisation and transport before a baby’s condition deteriorates to the extent that transfer is no longer safe.

If it is clear that a baby is approaching these thresholds, the specialist centre should be contacted in advance for advice regarding management and transfer.
Basic management of respiratory failure in the ventilated neonate

1. Babies with respiratory failure should be appropriately monitored with continuous monitoring of heart rate, respiratory rate, arterial oxygen saturation and blood pressure (through an indwelling arterial line).

2. Compare pre- and post-ductal oxygen saturations if there is difficulty with oxygenation.

3. Surfactant replacement therapy should be provided for all infants, term or preterm, who may have primary or secondary surfactant deficiency/inactivation (eg. RDS, congenital pneumonia or meconium aspiration syndrome).

4. Ventilatory support should be optimised and guided by chest x-ray and arterial blood gases. Attention should focus on avoidance of under or over-inflation, establishing synchrony between baby and ventilator and prompt diagnosis and treatment of air leaks.

5. Neuromuscular paralysis should not be considered routine, but should be used selectively in babies who remain asynchronous with the ventilator despite adequate sedation/analgesia. The primary purpose of any sedation/analgesia is to promote synchrony and not to induce apnoea.

6. Cardiovascular status should be monitored and cardiovascular insufficiency treated according to local guidelines.

7. Ensure that the baby’s haemoglobin concentration is > 120 g/L and treat metabolic acidaemia using sodium bicarbonate, after ensuring adequate ventilation.

8. The oxygenation index should be calculated as a guide to disease severity in all infants with respiratory failure with a FiO₂ ≥ 0.75.
Advanced management of severe respiratory failure
(See separate section on congenital diaphragmatic hernia below)

Severe Respiratory Failure

CXR +/- echo

Pre/post ductal SpO₂ *

Predominantly

intrapulmonary shunting

Consider

1. Treatment with extra ‘rescue’ surfactant
2. Treatment with Inhaled Nitric Oxide

Predominantly

extrapulmonary shunting *

Transfer to Specialist Centre

Consider need for ECMO **

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* a pre-post ductal SpO₂ gradient of ≥ 5% should be considered a significant finding supportive of a right to left extra-pulmonary ductal shunt.

* > 50% right to left shunt across foramen ovale or ductus arteriosus

** Criteria for transfer to ECMO centre (need to meet all of these)
- Evidence of severe cardio-respiratory failure (e.g. OI of ≥ 40);
- Gestational age ≥ 35 weeks;
- Weight ≥ 2000 g;
- Age < 28 days;
- Absence of uncontrolled bleeding disorder;
- Absence of lethal congenital anomaly or a congenital or acquired neurological disorder;
- High pressure ventilation < 10 days;
- Potentially reversible lung disease.
Transfer to an ECMO centre
A baby with evolving severe respiratory failure will usually be transferred first to a local specialist centre for treatment prior to consideration of suitability for ECMO. Always contact the specialist centre and transport team prior to considering referral of a baby for ECMO.
Discussion with the ECMO co-ordinator at one of the four UK ECMO centres is appropriate in a baby who fails to respond to conventional ventilatory support (and additional therapies such as iNO, HFOV and/or surfactant, as indicated) and meets the above criteria for ECMO eligibility:

Congenital diaphragmatic hernia (CDH)
Severe respiratory failure related to CDH represents a special situation which requires a specific approach to clinical management. Although a number of therapies have been used to treat neonates with CDH, there is no evidence from randomised controlled trials demonstrating any meaningful clinical benefit. Specifically, there is insufficient evidence to recommend the routine use of iNO, HFOV, surfactant or ECMO in the management of CDH. Current practice is based on a strategy that promotes ‘gentle ventilation’ [7]:

1. Basic cardiorespiratory management:
   a) Establish secure, reliable venous and arterial access (ideally umbilical venous and arterial catheters).
   b) Initially provide sedation with intravenous opiates only. Use paralysis selectively - consider paralysis in babies who fail to respond to basic ventilatory management (as above) and for transfer to specialist centre.
   c) Cardiovascular status should be monitored and cardiovascular insufficiency treated according to local guidelines.
   d) Consider surfactant administration.

2. Ventilation:
   a) Conventional mechanical ventilation (pressure limited time cycled ventilation).
   b) Aim for peak inspiratory pressure < 25 cmH₂O, peak end expiratory pressure 3-5, rate 40-60/minute, inspiratory time (Ti) 0.3s. If tidal volume measurements are available, aim to maintain tidal volume < 5 ml/kg.

3. Gas exchange parameters:
   a) Accept for pre-ductal SpO₂ ≥ 85% and post-ductal SpO₂ ≥ 75%.
   b) Accept PaCO₂ up to 8 kPa (60 mmHg), as long as pH ≥ 7.25.

Babies with CDH will need transfer to a specialist centre following initial stabilisation. The specialist centre will need to be contacted and will advise regarding further management. Ideally, transfer to Alder Hey paediatric intensive care unit (PICU) is preferable.
Background information
The likelihood of dying increases with increasing OI (eg. 50% of preterm infants with an OI > 20 will die).
Failure of CO₂ elimination is rarely observed in the absence of a defect in oxygenation. Hypercapnia is defined as a PaCO₂ > 8kPa (60 mmHg) in conjunction with a respiratory acidaemia (pH ≤ 7.2).

Newborn infants with severe respiratory disease are at high risk of dying from respiratory failure or developing chronic lung disease (CLD).

A number of treatment strategies are available for managing newborn infants with severe respiratory failure, but as yet remain unproven in many situations. These include
- inhaled nitric oxide (iNO),
- high frequency oscillatory ventilation (HFOV),
- ‘extra’ doses of surfactant, and
- extra-corporeal membrane oxygenation (ECMO).

Inhaled nitric oxide
Randomised controlled trials have demonstrated that iNO is effective in reducing the need for ECMO without evidence of any long term adverse effects in mature infants (> 34 weeks) with hypoxaemic respiratory failure [1]. In preterm infants, iNO also appears to have some benefit with a reduction in death/BPD in heavier, more mature babies (> 1000g) but there are concerns that iNO therapy may be associated with an increased risk of periventricular haemorrhage and mortality in extremely preterm babies weighing < 1000g. [2]

High frequency oscillatory ventilation (HFOV)
HFOV improves short term oxygenation in some term and preterm infants with respiratory failure, but there is no convincing evidence of any longer term benefits [3, 4]. It may be particularly useful in hypoxaemic respiratory failure where the underlying diagnosis is primary lung disease and/or the chest x-ray suggests poor lung inflation and in treating babies with hypercapnic respiratory failure because of its effectiveness in eliminating CO₂. However, there are some concerns about an increased risk of periventricular haemorrhage in preterm infants treated with rescue HFOV [4].

Extra doses of surfactant
The use of extra ‘rescue’ doses of surfactant is widely practised but there is a lack of evidence to support the efficacy of this, except in babies with meconium aspiration syndrome in whom treatment with 3-4 doses of natural surfactant (total dose 450-600 mg/kg) is associated with a decrease in the need for ECMO [5].

ECMO
Although ECMO reduces the risk of death in severe respiratory failure, it is only applicable to babies ≥ 35 weeks of gestation and weighing ≥ 2000g [6].
References


