SEVERE RESPIRATORY FAILURE (ARDS) BUNDLE

Revised October 2013
Management of Severe Respiratory Failure

Background
In response to the ‘Influenza A H1N1 pandemic of 2009/10 the Department of Health established an expert group, chaired by Dr Judith Hulf (Ex President of the Royal College of Anaesthetists) to “develop clinical guidance for the management of severe respiratory failure with particular reference to refractory hypoxia”.

The group reported its recommendations on December 17th 2010, in a document1 entitled: ‘Management of Severe Refractory Hypoxic Respiratory Failure in Critical Care in the UK in 2010. Report from the UK Expert Group.’

The Expert Group recommended that all Level 3 units will offer;
- lung protective ventilation
- ventilator care bundles
- prone ventilation, weaning from short term mechanical ventilation and
- associated rehabilitation following critical illness

The North Wales Critical care Network therefore devised guidance in relation to a ‘Severe Respiratory Failure (ARDS) Bundle. Since it’s approval studies have provided new evidence hence this updated version.

Aims
The aim of this document therefore is;
1) to provide consistency across the North Wales Network region for patients with severe respiratory failure
2) to provide evidenced based management of ventilated patients with severe respiratory failure and
3) to provide clinical guidance for patients requiring additional respiratory support.

Management of patients with severe respiratory failure includes the following elements; from these elements a Bundle has been devised (see page 12 for Quick Guide).

- Definition, Diagnosis and Scoring
- General Supportive Measures
  - (Ventilator) care bundles
  - Identify and Treat the Underlying Cause and Antibiotics/Antivirals
  - Nutrition
  - Fluid Balance
- Non Ventilatory Management
  - Sedation/paralysis
  - Physiotherapy
  - Prone therapy
  - Prostacyclin
  - Recruitment Manoeuvres
  - Rotational therapy
- Ventilatory Management
  - Lung Protective Ventilation; Tidal volumes and Plateau Pressure
  - Extracorporeal Membrane Oxygenation (ECMO)
  - Other strategies
**Definition, Diagnosis and Scoring**

**Bundle Element 1: Define, diagnose and investigate**
The principles of treating ARDS are providing good supportive care and maintaining oxygenation while diagnosing and treating the underlying cause.

Since the diagnosis of acute respiratory distress syndrome (ARDS) is based on clinical criteria rather than a pathological diagnosis, ARDS should be considered in all critically ill patients. If patients develop new bilateral infiltrates on CXR, they may have or may be developing ARDS.

1. **Definition and Diagnosis**

   P/F ratio <40 (see below for scoring)

   The Berlin definition of ARDS²

   **Timing**
   Within 1 week of a known clinical insult or new/worsening respiratory symptoms

   **Chest imaging**
   Bilateral opacities – not fully explained by effusions, lobar/lung collapse, or nodules

   **Origin of oedema**
   Respiratory failure not fully explained by cardiac failure or fluid overload;
   Need objective assessment (e.g. echocardiography) to exclude hydrostatic oedema if no risk factor present

2. **Scoring**

   P/F ratio: PaO₂ (in kPa) divided by FiO₂ – Appendix 1

<table>
<thead>
<tr>
<th>Oxygenation</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<tbody>
<tr>
<td>P/F ratio</td>
<td>26.7&lt;PₐO₂/FiO₂ ≤ 40</td>
<td>13.3&lt;PₐO₂/FiO₂ ≤ 26.7</td>
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<tr>
<td>PEEP or CPAP</td>
<td>≥ 5cmH₂O</td>
<td>≥ 5cmH₂O</td>
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</table>

**ACTION:** Measure and record P/F Ratios on all ventilated patients. (NB this is also on the blood gas print out).

**ACTION:** Assess for ARDS Criteria if P/F ratio (in kPa) <26.7 (ARDS) – Record in Patient’s Notes.

3. **Investigations**

   - **Echocardiogram (ECHO)**
     Distinguishing pulmonary oedema due to ARDS from hydrostatic or cardiogenic pulmonary oedema can be challenging in critically ill patients. Echocardiography is an easy non-invasive test to obtain hemodynamic information.

   **ACTION:** Consider ECHO to exclude cardiac failure or cardiogenic component

   - **Cardiac Output (C.O.) Monitoring**
     In ARDS cardiac output can be decreased due to several causes including septic shock, sepsis related myocardial dysfunction, cardiac events or effect of medical treatments (high ventilation pressures, PEEP, or inversed inspiratory:expiratory ratios). Thus monitoring of cardiac output and filling pressures are important.

   **ACTION:** Consider C.O. measurement to help in the diagnosis and C.O. monitoring during ARDS management.

   - **Non-Bronchoscopic Lavage (NBL)**
     NBL is an invaluable diagnostic tool. It is a simple, safe and effective method of rapidly identifying and evaluating ventilated patients with (potential) pneumonia³.

   - **Bronchoalveolar lavage (BAL)**
     BAL is one of the best tools to establish the diagnosis of bacterial ventilator-associated pneumonia⁴. BAL is recommended in patients with ARDS due to suspected pneumonia and those without a defined predisposing condition.

   **ACTION:** Perform NBL on all ventilated admissions to critical care. Consider BAL at clinical discretion.
- Investigate the cause of ARDS
  This may include surgical review, septic screen, abdominal or chest U/S or CT scan etc.

**ACTION:** Consider the common risk factors for ARDS

**Risk factors**
- Pneumonia
- Non-pulmonary sepsis
- Aspiration of gastric contents
- Major trauma
- Pulmonary contusion
- Pancreatitis
- Inhalation injury
- Severe burns
- Non-cardiogenic shock
- Drug overdose
- Multiple transfusions or transfusion-associated acute lung injury (TRALI)
- Pulmonary vasculitis
- Drowning
GENERAL SUPPORTIVE MEASURES

Bundle Element 2: Provide general supportive measures

1. Ventilator Care Bundles and other Care Bundles

Care bundles are known to improve the outcomes of critical care patients. Ventilator care bundles are used on all ventilated patients in all three Critical Care units across BCUHB; these are frequently audited with excellent compliance. Compliance in BCUHB is demonstrated by a reduction of VAP (Ventilator Associated Pneumonia) in the last few years.

Full compliance with other care bundles is also of utmost importance.

**ACTION:** Comply with all bundles; ventilator, sepsis, nutrition, central line and others as appropriate, for example tracheostomy.

2. Treat the Underlying Cause

If the suspected underlying cause of ARDS is infection, then the source should be identified and treated. Early broad spectrum antibiotics should be started immediately with consideration given to the requirement for antivirals.

**ACTION:** Commence early IV broad spectrum antibiotics; consider antivirals.

3. Nutrition

Nutritional support is an essential component in critical care. Malnutrition has been associated with poor outcomes among patients in intensive care units (ICUs), as indicated by increased morbidity, mortality, and length of stay.

Unless contraindicated, nutrition should be commenced early, (within 24-48 hours after admission to ICU), in all mechanically ventilated patients (medical, surgical, trauma) provided that the patients are adequately resuscitated and haemodynamically stable.

**ACTION:** Commence early feeding: refer to and follow BCUHB’s Critical Care Nutrition Bundle/guidance for all critical care patients:


4. Fluid Management

Patients with ARDS have noncardiogenic pulmonary oedema as a hallmark of their disease process. Intravenous fluid management in these patients thus poses important challenges. On one hand, intravenous fluids are critical to maintain appropriate intravascular volume to assure haemodynamic stability and vital organ perfusion in patients with compromised gas exchange. On the other hand, excessive fluid administration can worsen the lung oedema, further impairing gas exchange.

The National Institutes of Health (NIH) ARDS Network launched the FACTT study (Fluid and Catheter Therapy Trial). The goals of the study were to assess the safety and efficacy of ‘fluid conservative’ vs. ‘fluid liberal’ management strategies on lung function, non-pulmonary organ function, as well as mortality and the need for mechanical ventilation.

The investigators concluded that "although the study did not detect a difference in mortality, the conservative fluid strategy improved lung function and shortened the duration of mechanical ventilation and intensive care stay, without increasing nonpulmonary organ failures. These results support the use of a conservative fluid management strategy in ARDS patients." Referring to the FACTT study Mackay and Al-Haddad recommend a conservative fluid regime as a low cost, low risk intervention that could lead to improvement in clinically important outcomes.

**ACTION:** Aim for an even or a negative fluid balance after the initial fluid resuscitation. If patient develops signs of acute renal failure consider early Renal Replacement Therapy.
Bundle Element 3: Optimise non-ventilatory management

i. Sedation/paralysis

The use of paralytics is far less commonplace that it was a decade ago. A recent study\(^6\) however noted that in patients with severe ARDS, early administration of a neuromuscular blocking agent improved the adjusted 90-day survival and increased the time off the ventilator without increasing muscle weakness.

Interestingly about 40% of these patients were concurrently receiving corticosteroids for septic shock; potentially a high-risk group in terms of the risk for myopathy or muscle weakness following a very acute illness. In the end, what the authors saw was that in the adjusted analysis for survival, there was actually a survival advantage with the use of a neuromuscular blocker. Overall, the mortality rate was about 41% in the patients randomised to placebo vs. about 32% or 31% in the patients randomised to the active intervention. The absolute risk reduction was about 10%.

Questions have been raised however as to the potential mechanism for the benefit associated with a muscle relaxant. An editorial\(^9\) noted that it could potentially be due to an anti-inflammatory effect of the paralytic, or to a decrease in barotrauma.

In this one study giving a muscle relaxant over a two day period, whilst utilising ventilator management strategies, dropped the adjusted 90 day mortality by almost a third (crude rate 31.6% versus 40.7%, adjusted P=0.004).


ii. Physiotherapy\(^{10-12}\)

The main aim of physiotherapy is to optimise oxygenation and oxygen transport in respiratory failure cases and assist in the treatment of any underlying issues such as atelectasis or secretions retention/plugging.

Once ventilated, physiotherapy options with severe respiratory failure are:

- **Positioning advice and assistance.**
  - Based on auscultation, palpation and other objective findings e.g. CXR.
  - May be difficult depending on patient’s condition.
  - Main aim is to increase area of ventilation/perfusion to increase oxygenation.

- **Airway clearance/secretion removal.**
  - There are many methods of doing this; however they depend on the patient’s condition, oxygen requirements and potential benefits weighed up against potential risks.
  - The main aim is to facilitate secretion transport and improve airway compliance, in a bid to improve oxygenation.
  - Techniques include:
    - Manual techniques, including shaking and vibrations of the chest wall.
    - Manual hyperinflation.
    - Suction, in combination with above points.
    - Postural drainage.

**ACTION:** Provide physiotherapy, as tolerated, to enhance the removal of secretions and to improve gas exchange.

- **Rehabilitation**

  Consideration needs to be given to passive range of movement of limbs to prevent deconditioning and other ICU/ventilator based neuromuscular complications.

  Prolonged ventilation in critical care is associated with impaired health related quality of life up to three years after discharge, even when patients are living independently at home\(^{13}\) and persistent functional disability has been demonstrated over one year following discharge in ARDS patients\(^{14}\).
**ACTION:** Develop a rehabilitation plan whilst in Critical Care and commence rehab as soon as is practicable; follow BCUHB’s rehabilitation guidance.

iii. **Prone Ventilation**
A lung-protective strategy that has been successfully utilised to improve oxygenation in mechanically ventilated patients with ARDS is prone positioning. Changing the patient position to prone position can improve the distribution of perfusion to ventilated lung regions, decreasing intrapulmonary shunt and improving oxygenation\(^\text{15}\). More recently it has been shown that early application of prolonged prone positioning significantly decreased mortality\(^\text{16}\).

Once a diagnosis of ARDS is made the authors advocate early proning\(^\text{16}\); prone for 16 hours, stop proning if there are complications, then turn patient supine for four hours (see strategy for prone positioning next page).

**ACTION:** Use prone therapy for severe ARDS patients with no improvement in gas exchange; follow ‘guidelines for prone positioning – patient safety’ – Appendix 2 – [Adapted] Glenfield protocol.

iv. **Prostacyclin**
Prostacyclins cause pulmonary vasodilatation and are used to treat patients with primary pulmonary hypertension. Nebulised prostacyclin (PGI2) has comparable effects in improving oxygenation, pulmonary vasodilatation and shunt reduction when compared with inhaled NO\(^\text{17}\). Improved oxygenation has been seen in a paediatric study\(^\text{18}\), but this has not yet been demonstrated in adult patients with ARDS.

**ACTION:** Consider a trial of nebulised Prostacyclin for refractory hypoxia with increasing FiO\(_2\) and PEEP requirements.

**How to use: Nebulisation of Epoprostenol for Severe Acute Hypoxic Failure**

- Reconstitute 500mcg of Epoprostenol into 50ml of glycine buffer diluent provided.
- Baseline commencing dose of 5ng/kg/minute [can go to 50ng/kg/min]

**Dosage:**
- Dose required [ng/kg/min] x Wt[kg] x 0.006ml/hour
- Attach to syringe driver. Starting rate = 2.5ml/hour (equiv to 5ng/kg/min for 70 kg patient)
- Syringe driver is attached to epidural catheter through sealed “bung” which is then inserted into nebuliser chamber. The epidural catheter then sits in nebuliser chamber.
- This is then inserted into ventilator circuit and nebulisation is commenced from ventilator and run constantly.
- Dosage can then be increased with assessment of clinical improvement.

v. **Recruitment Manoeuvres**
The aim of ‘Recruitment Manoeuvres’ is to promote reopening of collapsed alveoli by a sustained but controlled rise in transalveolar pressure.

A review of ventilator strategies for severe hypoxic respiratory failure\(^\text{19}\), expressed concerns that while improvements in oxygenation have been reported, no RCTs have shown a mortality benefit. The authors reported that while some studies with a lung-protective strategy incorporated into the recruitment study, reported a survival benefit others did not show any mortality benefit. This review did not therefore recommend the routine use of recruitment manoeuvres. It also urges caution if using them in patients who are haemodynamically unstable and or at risk of barotrauma. However, it also notes that some patients with life-threatening refractory hypoxia may show dramatic improvement in oxygenation with recruitment. If such an improvement does occur, the authors then recommend the use of higher PEEP values to maintain recruitment.

Another review\(^\text{20}\) also expressed concerns; reduction in venous return and subsequent hypotension was highlighted. The authors stated that “despite multiple clinical trials, there has not been a clear signal that recruitment manoeuvres provide benefit”.

**ACTION:** Consider the use of recruitment manoeuvres where applicable and safe to do so.
1. In a Pressure Control mode set a PEEP level of 25 – 30 cmH₂O with an inspiratory pressure of 10 -15 cmH₂O, to have a peak inspiratory pressure of ~ 45 cmH₂O.
2. This setting is then used for 2 minutes
3. Higher baseline PEEP should then be considered to ensure recruitment is maintained.

vi. Rotational therapy

Immobility is deleterious therefore rotational therapy has some value for managing pulmonary complications in ICU especially with those patients that do not tolerate manual turning or are too obese to turn safely.

The effective degree of rotation appears to be 40° though according this can be poorly tolerated by more awake patients as they feel they are falling out of bed. A secondary benefit of kinetic therapy in patients who do not tolerate manual turning could also be skin integrity preservation as evidently rotation to 40° relieves pressure off the sacrum.

ACTION: Consider the use rotational therapy for patients who do not tolerate manual turning or are too obese to turn safely.

**Suggested Strategy for Prone Positioning in Severe ARDS**

<table>
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<th>Prone positioning</th>
<th>Stop proning if complications</th>
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<td>16 hours</td>
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<tr>
<th>Supine</th>
<th>If deterioration in P/F or saturation at any time while supine:</th>
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<tr>
<td>4 hours</td>
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</table>

Check criteria for severe ARDS?
P/F < 20 with FiO₂ > 0.6 and PEEP > 5

No
- Stay supine.
- Return to prone session if deterioration

Yes
- Start another proning session
- If rapid deterioration on returning to supine after last prone session, increase duration of next prone session

Stop proning when:
- P/F > 20 after 4 hours supine
- Complication during previous proning session causing it to be interrupted
- If P/F decreases by 20% at start of proning (compared with supine just before proning) on 2 consecutive sessions.
To see a video of Prone Positioning of Patients with the Acute Respiratory Distress Syndrome visit http://www.nejm.org/doi/full/10.1056/NEJMoa1214103
VENTILATORY MANAGEMENT

Bundle Element 4
Optimise ventilatory management

1. Lung protective ventilation; Tidal volumes and Plateau Pressure
Lung-protective mechanical ventilation strategies are designed to prevent injury from overdistention by using lower tidal volumes and lower inspiratory pressures.

The Cochrane Systematic Review\(^{25}\) "Lung protective ventilation strategy for the acute respiratory distress syndrome" reviewed six trials involving 1297 intubated patients in an ICU setting who were randomised to receive either conventional mechanical ventilation or a "lung protective" ventilation strategy. Lung protective ventilation was defined as providing a tidal volume of 7ml/kg or less with plateau pressure of 30cmH\(_2\)O or less. There was a significant all cause mortality benefit in favour of lung protective ventilation at the end of the follow-up period for each trial.

A trial in patients with respiratory failure also demonstrated low Vt ventilation to be protective, preventing lung injury and associated with a reduction in the release of inflammatory cytokines\(^{26}\). This study was stopped early due to an increased incidence of lung injury in patients ventilated with higher Vt.

Protective ventilation lung strategy:

i. Measure patients height and calculate Ideal Body Weight (IBW); if height cannot be obtained use forearm (ulna) length\(^{27}\) - Appendix 3
ii. Utilise lung protective strategies – aim for: PaO\(_2\) 7-9kPa or SpO\(_2\) >88%
iii. Avoid over distention: Vt=6mls/kg based on IBW, Volume control is the suggested method of ventilation\(^{16}\)
iv. Limit plateau pressure <30cmsH\(_2\)O - Appendix 3
v. FiO\(_2\) and PEEP titration

<table>
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<tr>
<th>FiO(_2)</th>
<th>0.3</th>
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<td>10-14</td>
<td>14</td>
<td>14-18</td>
<td>18-24</td>
</tr>
</tbody>
</table>

vi. Accept hypercapnia to achieve goals (1) and (2), providing pH is >7.15
vii. Mode of ventilation is less important than attending to goals 1 – 3

ACTION: Utilise lung protective strategies (ensuring Vt=6mls/kg/IBW).

2. High-Frequency Oscillatory Ventilation (HFOV)
HFOV was previously thought to prevent secondary lung injury. Two recent multi-centre studies OSCILLATE\(^{28}\) and OSCAR\(^{29}\), however did not demonstrate improved outcomes for patients with ARDS receiving HFOV. In fact, in the Canadian (OSCILLATE) randomised controlled trial study it was found that for adults with moderate to severe ARDS, early application of HFOV, as compared with a ventilation strategy of low tidal volume and high positive end expiratory pressure, did not reduce, and may increase, in-hospital mortality. These two studies do however reinforce the importance of conventional lung protective ventilation in managing patients with ARDS.

ACTION: HFOV does not form part of this guideline.

2a. Extracorporeal CO2 removal device

ACTION: ECCO\(_2\)R does not form part of this guideline.

3. Extracorporeal Membrane Oxygenation (ECMO)
The CESAR trial\(^{30}\) evaluated the clinical and cost effectiveness of ECMO for adults with severe respiratory failure. This multicentre trial randomised 180 adults to receive either conventional ventilatory support or transfer to the specialist centre for consideration for ECMO. The primary outcome measure was survival without severe disability. This was 16% higher for patients in the ECMO referral group over conventional management, suggesting that one additional patient would benefit for every 6 patients treated.
A Lancet editorial highlighted that a major limitation of the CESAR study was the lack of standardisation in conventional management techniques provided to patients in the control group, due to a lack of agreement amongst participating hospitals on what constituted ‘optimal’ care. However, it is considered that this study represents the most comprehensive randomised controlled trial undertaken on adult respiratory ECMO and it also reported a survival benefit for patients referred to an ECMO centre compared to those who received conventional management.

Irrespective of the underlying cause, all ECMO practitioners agree that its use is only valid in the context of a disease process which is potentially recoverable and which is unresponsive to conventional intensive care procedures. Experts who provide ECMO however emphasise the importance of viewing respiratory ECMO as one of a range of interventions to provide respiratory support for patients with potentially reversible conditions, when conventional ventilation has not proved either possible or effective.

ECMO should be considered as a positive intervention at an appropriate time during the patient care pathway, rather than as a ‘last resort’ intervention in an attempt to rescue a patient who is dying as outcomes are likely to be poor. The optimal time for instituting ECMO treatment in an individual patient is therefore unclear. Most specialists argue that early referral is preferred, to minimise lung damage, and previous evidence suggested outcomes were poor in patients who had been ventilated for more than a week. Some units now consider this too restrictive.

It should be noted that the CESAR trial was conducted prior to the H1N1 pandemic.

**ACTION:** Consider early discussions and referral of patients with refractory hypoxaemia for ECMO.
## Quick Guide for Severe Respiratory Bundle – For Adults in Critical Care

### Element 1: Define, diagnose and investigate

**Aims**
- Measure and record P/F Ratios on all patients – Appendix 1
- Assess criteria for ARDS if P/F <26.7kPa:
  - Acute onset from a recognised etiology
  - Bilateral infiltrates on a CXR
  - The absence of heart failure
- Record in Notes
- Perform NBL on all ventilated admissions to critical care. Consider BAL where indicated.
- Consider C.O. monitoring as indicated
- Consider risk factors

**Rationale**
- Early diagnosis of ARDS is important and should be considered in all critically ill patients.
- Distinguishing ARDS from other causes of pulmonary oedema can be challenging; echocardiography can be used to exclude cardiac failure.
- BAL is recommended in patients with ARDS due to suspected pneumonia and those without a defined predisposing condition. In ARDS cardiac output can be decreased due to sepsis and ventilation pressures thus monitoring of cardiac output and filling pressures are important.

**Exclusion**
- Pts with heart failure.
- Terminal care. EOL pathway

**Audit Points**
- Is there an attempt to obtain a prompt diagnosis?
- Did all ventilated have P/F ratios recorded?
- When P/F ratios <26.7 was criteria for ARDS assessed and documented?
- Did pts have NBLs performed?

### Element 2: Provide general supportive measures

**Aims**
- Comply with all bundles;
  - ventilator
  - sepsis (inc antivirals)
  - nutrition
  - central line and others as appropriate, for example tracheostomy
- Aim for an even or a negative fluid balance after the initial fluid resuscitation. If patient develops signs of acute renal failure consider early Renal Replacement Therapy.

**Rationale**
- If the suspected underlying cause of ARDS is infection, then the source should be identified and treated. Early broad spectrum antibiotics should be started immediately with consideration given to the requirement for antivirals.
- Malnutrition has been associated with poor outcomes among patients in ICUs, as indicated by increased morbidity, mortality, and length of stay.
- A conservative fluid strategy improves lung function and shortens the duration of mechanical ventilation and ICU stay, without increasing nonpulmonary organ failures in ARDS patients.

**Contraindications**
- Terminal care. EOL pathway

**Audit Points**
- Are general supportive measures provided?
- For ARDS patients: Is there [all] bundle compliance.
- Was there a plan for fluid management?

### Element 3: Optimise non-ventilatory management

**Aims**
- Consider the use of paralysing agents in the first 48 hours, whilst utilising ventilator management strategies. Review daily thereafter.
- Consider prone therapy for ARDS patients with no improvement in gas exchange - Appendix 2
- Consider a trial of nebulised Prostacyclin for refractory hypoxia with increasing FiO2 and PEEP requirements – see pg 7 for ‘how to use’.
- Consider the use of recruitment manoeuvres where applicable and safe to do so see page 6 for ‘how to do’
- Consider the use rotational therapy for patients who do

**Rationale**
- In patients with severe ARDS, early administration of a neuromuscular blocking agent improved the adjusted 90-day survival and increased the time off the ventilator without increasing muscle weakness.
- Changing the patient position to prone position can improve the distribution of perfusion to ventilated lung regions, decreasing intrapulmonary shunt and improving oxygenation.
- Recruitment Manoeuvres may promote reopening of collapsed alveoli by a sustained but controlled rise in transalveolar pressure. Nebulised prostacyclin has comparable effects in improving oxygenation, pulmonary vasodilatation and shunt reduction when

**Contraindications**
- Terminal care. EOL pathway

**Audit Points**
- Is non-ventilatory management optimised?
- Was there a sedation / paralysis plan?
- Was prone therapy considered?
- Were recruitment manoeuvres considered?
<table>
<thead>
<tr>
<th>Element 4: Optimise ventilatory management</th>
<th>Optimised delivery - ventilatory measures:</th>
<th>Lung-protective strategies aim to prevent injury from overdistention by using lower tidal volumes and lower inspiratory pressures. There is a significant all cause mortality benefit in favour of lung protective ventilation. ECMO centres report a survival benefit for patients referred for ECMO compared to those who received conventional management.</th>
</tr>
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<tbody>
<tr>
<td>i. Calculate IBW - Appendix 3</td>
<td>Lung-protective strategies aim to prevent injury from overdistention by using lower tidal volumes and lower inspiratory pressures. There is a significant all cause mortality benefit in favour of lung protective ventilation. ECMO centres report a survival benefit for patients referred for ECMO compared to those who received conventional management.</td>
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References:


## Appendix 1

### PaO₂/FiO₂ Ratios

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Appendix 2

Guidelines for prone positioning – patient safety

1) Purpose
   a. These guidelines are to ensure the safety of the adult patient moved in to the prone position and managed whilst in the prone.

2) Indications / Contraindications
   a. Contraindications
      i. Raised intracranial pressure
      ii. Known or suspected spinal injury
      iii. Pathological abdominal distension
      iv. Pregnancy 2nd, 3rd trimester
      v. Recent abdominal surgery, with risk of wound dehiscence
      vi. Within 24 of formation of tracheostomy (risk of bleeding)
   b. Indications
      i. Refractory hypoxaemia
      ii. No improvement in chest radiograph with evidence of collapse and infiltrates
      iii. Following MDT discussion

3) Principles
   a. The safety of the patient during the procedure is paramount.
   b. The patient should only be turned prone on consultant/MDT instructions.
   c. All staff performing procedure should be aware of protocol.
   d. The timing of the turn should coincide with maximum staff availability
   e. Any potential contraindications should be identified and risk/benefit analysis carried out
   f. Minimum of 6 members of staff should be present, 1 at top and bottom, 2 either side.
   g. Assess the need for further staff on individual patient basis.

4) Procedure
   a. Pre-move
      i. The procedure should be explained to the patient as far as understanding allows.
      ii. The turn should be explained to family etc
      iii. A pre-move arterial blood gas should be obtained
      iv. Disconnect any non-essential infusions
      v. Ensure all intravenous lines, chest drainage tubes, urinary catheters etc are of adequate length to lay from either the head or foot of the bed and are secure
      vi. Remove ECG electrodes from chest
      vii. Remove all non essential monitoring
      viii. Bed should be adjusted to suitable height.
      ix. Assess load as with any moving and handling procedure.
      x. Condition of patient’s skin should be assessed and documented before turn. Appropriate preventative dressings should be applied
      xi. Adequate sedation should be achieved and paralysing agents administered if appropriate
      xii. ET and oral suction performed and ET tube or tracheostomy secured. The position of the ET tube should be noted (length at lips)
      xiii. An in line suction catheter should be in place
      xiv. Eye and mouth care to be performed, and lacrilube instilled.
      xv. NG feed should be stopped and NG tube aspirated.
      xvi. Chest drains should be placed at bottom of bed with tubing between legs if this is not possible then drains should be disconnected but not clamped
      xvii. All lines should be placed between legs or underneath torso
      xviii. Put bed on to max inflate mode and slide sheet should be placed under the bottom sheet using a minimum of 3 people
      xix. The patients left arm should be placed under his/her left hip and the head positioned to face towards the ventilator, usually to the left.
      xx. Pre move check list completed. (See Appendix 1 for pre move check list)

   b. Move
i. Two members of staff at either side of patient.
ii. 2 pillows should be placed on top of the patient one over the upper chest and the other over the iliac crest.
iii. A sheet should be placed on top of the patient and rolled together at the sides with the sheet under the patient (Cornish pasty style).
iv. The face should be left exposed, with the top of the sheet folded to ensure it’s in the correct position following the turn.
v. The 2 people at the same side of the bed as the ventilator will pull the rolled patient towards them, holding on to rolled sheets whilst the 2 people on the other side will push.
vi. Using the same manoeuvre the patient is then turned onto their left side.
vii. The patient is then placed on their front, the 2 people on the side of the ventilator will be holding the side of the Cornish pasty under the patient and will pull through whilst the other 2 will be holding the side of the Cornish pasty on top of the patient and will pull over.
viii. During this time the person at the top will be guiding the head and ensuring patency of the airway. (See Appendix 2 for diagram of move)

c. Post Move
i. Check airway remains maintained.
ii. Ensure all monitoring is replaced.
iii. Assess haemodynamic status of patient.
iv. Reconnect chest drains.
v. Recommence all infusions.
vi. Ensure pillows in correct place to avert pressure away from scrotum and breasts and there is an unrestricted abdomen to allow the passive movement of the diaphragm and the downward displacement of abdominal contents.
vii. The shoulders should fall slightly forwards.
viii. A pillow may be place under the shins to give slight flexion at the knees and ankles.
ix. Ensure the bed is on an appropriate mode.
x. The patient’s arm should be placed in the crawl position (elbow flexed and shoulder abducted) with the head facing the prominent arm.
xii. A small roll can be place under the hand to allow flexion of the fingers. The other arm can also be placed in this position or allowed to rest at the patient’s side.
xii. Arterial blood gas should be performed 20 minutes following manoeuvre.
xiii. Complete post move check list. (See Appendix 3 for post move checklist)

d. Ongoing Management
i. NG feeding should be recommenced as per present protocol.
ii. Protection, in the form of an absorbent sheet, should be place beneath the face and changed as soon as it becomes wet.
iii. The patients head and arm position should be altered every 2-3 hours to prevent pressure ulcers forming on the cheeks, ears and neck.
iv. A modified rotation setting may be used, but no more than a 15 degree turn. Alternatively a slight turn may be achieved by modifying pillow position.
v. The bed should be tilted into the reverse trendelenburg position (head tilted slightly up) to reduce intraocular pressure and to reduce venous congestion in the head.
vi. Lacrilube should be applied to the eyes as prescribed 6 hourly to prevent corneal drying and abrasions.
vii. Closed circuit suction should be used.
viii. Length of time in prone position can vary from 6 hours to 18 hours therefore this will be dependent on consultant/MDT’s instructions.

5) Returning Supine
a. The procedure for turning prone should be reversed to turn supine.
b. Pre move steps should still be taken.
### Pre move checklist

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<thead>
<tr>
<th>Date:</th>
<th>Sign</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required personnel present</td>
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<td></td>
</tr>
<tr>
<td>Medical staff</td>
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<tr>
<td>Family aware</td>
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<td></td>
</tr>
<tr>
<td>Arterial blood gas performed</td>
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<td></td>
</tr>
<tr>
<td>Adequate tubing length</td>
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<tr>
<td>Non essential infusions disconnected</td>
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<td></td>
</tr>
<tr>
<td>All remaining infusions from head or foot of bed</td>
<td></td>
<td></td>
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<tr>
<td>Eye and mouth care performed</td>
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<td></td>
</tr>
<tr>
<td>ET/ oral suction performed</td>
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<td></td>
</tr>
<tr>
<td>In line suction in place</td>
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<td></td>
</tr>
<tr>
<td>ET/ tracheostomy secured</td>
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<td></td>
</tr>
<tr>
<td>Length at lips recorded:</td>
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<tr>
<td>Electrodes and non essential monitoring removed</td>
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<td></td>
</tr>
<tr>
<td>Chest drains at bottom of bed or disconnected</td>
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<td></td>
</tr>
<tr>
<td>NG feed off and tube aspirated</td>
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<td></td>
</tr>
<tr>
<td>Assessment as per handling and moving guidelines</td>
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<td></td>
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<tr>
<td>Bed on max inflate</td>
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<td>Pillows in place</td>
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<td>Sedation assessed</td>
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### Post move checklist

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<th>Date:</th>
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<td>Monitoring recommenced</td>
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<td>Haemodynamically stable</td>
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<tr>
<td>All infusions recommenced</td>
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<tr>
<td>Check position of pillows</td>
<td></td>
<td></td>
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<tr>
<td>Reverse trendelenburg bed position</td>
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<tr>
<td>Recomence feed</td>
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<tr>
<td>Perform arterial blood gas</td>
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</table>
ET secure

Ng aspirated and spigotted

Monitoring removed

Drains to bottom of bed, tubing alongside patient

Infusion lines leaving from foot of bed (top if a neck line in situ)

Urinary catheter out between legs to foot of bed

Pillows across chest and pelvis, allowing unrestricted abdominal movement
Top and bottom sheet rolled together tightly at edges (cornish pasty)

Top edge of sheet Z folded to allow access to ET, with top edge remaining accessible

Dr/Snr Nurse supporting ET

Sliding the patient to the edge of the bed, with the slide sheet in place, towards the ventilator
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SOK Revised Oct 2013
Arm flexed

Pillows need to be adjusted to allow unrestricted movement of diaphragm

Circuit secured
Appendix 3  

**Ideal Body Weight.**

To define the ideal tidal volume the ideal body weight has to be determined. The calculation of the ideal body weight of an adult is based on the body height. If height cannot be obtained use the forearm (ulna) length.

**Estimating height from ulna length**

Measure between the point of the elbow (olecranon process) and the midpoint of the prominent bone of the wrist (styloid process) (left side if possible).

<table>
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<th>Height (m)</th>
<th>IBW (kg) women = 45.5 + 0.91 (height [cm] - 152.4)</th>
<th>For example: Height 167cms - 152.4 = 14.6</th>
<th>14.6 x 0.91 = 13.286</th>
<th>13.286 + 45.5 = 58.786 (Rounded) = 59kgs</th>
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**IBW (kg) men = 50 + 0.91 (height [cm] - 152.4)**

For example: Height 177cms - 152.4 = 24.6
24.6 x 0.91 = 22.386
22.386 + 50 = 72.386
(Rounded) = 73kgs

---

Recommendation/adjustment for the tidal volume on the ventilator:

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<th>Height (cm)</th>
<th>IBW (kg) Women</th>
<th>‘Protective’* V&lt;sub&gt;T&lt;/sub&gt; = 6ml/kg IBW</th>
<th>IBW (kg) Men</th>
<th>‘Protective’* V&lt;sub&gt;T&lt;/sub&gt; = 6ml/kg IBW</th>
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SOK Revised Oct 2013
Stated values are rounded.

*Protective

Appendix 4: Check list

P/F < 40

- Check diagnosis criteria for ARDS:
- Start ventilating using Lung Protection Strategy (LPS)
- Perform NBL; consider BAL
- Identify the cause: septic screen, U/S, CT, surgical review
- Treat the cause: ATB, antiviral, surgery, drainage
- Apply all relevant care bundles

24 hours

P/F < 26.7

- Confirm criteria for ARDS: CXR, P/F ratio, Echo/CO, aetiology.
- Continue LPS; lower PaO2 / Saturation target
- Sedation and paralysis
- Fluid management:
  - Even or negative fluid balance if not in resuscitation phase
  - Invasive CVS monitoring / echo to identify myocardial dysfunction and optimise fluid balance
  - Consider early RRT if development of ARF
- Continue treating the cause. Review microbiology
- Physiotherapy. Consider Rotational therapy

48 hours

No improvement / worsening

- Continue and optimise support: LPS, fluid management, RRT, CO monitoring, physio
- Consider prone therapy
- Continue treating the cause. Review microbiology, surgical review, Radiological investigation
- Consider:
  - Recruitment Manoeuvre
  - Prostacyclin
- Discuss with ECMO centre for advice or transfer consideration

No improvement / worsening

- Continue treatment
- Review ECMO, consider transfer