# Manual Hyperinflation of Adult Patients in Critical Care

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**Responsible Directorate:**

Acute Hospital Services

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N/A

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Policy, Standards and Guidelines Committee

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**NHSCT Mission Statement**

To provide for all the quality of services we would expect for our families and ourselves
Manual Hyperinflation of Adult Patients in Critical Care

Guideline

(Adopted CCaNNI Guideline)
Guideline

Manual Hyperinflation of Adult Patients in Critical Care

1. The purpose/objective of the standard/guideline:
   To support safe, effective and appropriate use of manual hyperinflation in adult patients in Critical Care.

2. Intended target population:
   Physiotherapy and nursing staff working within critical care.

3. Time Scale for Implementation
   Immediate implementation

4. Resource Implications
   Guideline achieved within available resources

5. Financial disclosures/conflicts of interest
   None

This document has been produced by Allied Health Professional Forum on behalf of the Critical Care Network Northern Ireland
Guideline

Manual Hyperinflation of Adult Patients in Intensive Care

1.0 Introduction

Critically ill patients in intensive care may require intubation and mechanical ventilation. Endotracheal and tracheostomy tubes bypass the body’s natural humidification, filtering and warming system resulting in the need for these to be provided artificially. These systems may not always be sufficient and as a result patients may develop tenacious secretions which are difficult to clear. Intubation also inhibits the normal cough mechanism. This is compounded further by the use of sedation to tolerate intubation and mechanical ventilation, thereby reducing a patient’s ability to cough and clear secretions.

Mechanical ventilation also alters the physiology of patients including a reduction in functional residual capacity, decreased lung compliance, ventilation/perfusion mismatching and decreased lung surfactant (Jones, 1997).

Ventilated patients have a high risk of developing ventilator associated pneumonia through aspiration of contaminated secretions into the lower airway or by bacterial colonisation of the airways (Choi and Jones, 2005). This may lead to longer stays in intensive care, increased morbidity and mortality and subsequently higher costs (Denehy, 1999).

Intubated and ventilated patients usually require regular respiratory physiotherapy to minimise secretion retention, maximise oxygenation and re-expand atelectic lung segments (Cielsa, 1996). Physiotherapy is also used to prevent complications by improving mucociliary clearance and alveolar expansion (Jones, 1997).

2.0 Background

MHI involves some or all of a number of components, including disconnecting the patient from the ventilator and inflating the lungs with larger volumes than the ventilator breaths, using resuscitation bag (Robson, 1996). MHI consists of a slow deep (usually unmeasured) inspiration, an inspiratory hold to utilise collateral ventilation, and quick release of the bag to increase the expiratory flow rate (King and Morrell, 1992).

Atelectasis is a common problem in ventilated patients and if prolonged may lead to hypoxaemia and pulmonary infection (Jones, 1997). Loss of lung volume and atelectasis could lead to a reduction in lung compliance, which in turn makes the
patient more difficult to ventilate (Oh, 1988). Lung compliance is considered an important clinical parameter in ventilated patients and may also be a clinical predictor of mortality in patients with significant respiratory failure (Hodgson et al, 2000).

Positive end expiratory pressure (PEEP) is commonly used in the treatment of ventilated patients and physiotherapists reported that PEEP levels of more than 10 cmH\textsubscript{2}O were considered as a reason for caution or contraindication to MHI (Hodgson et al, 1999). When performing MHI the patient is disconnected from the ventilator resulting in loss of PEEP and subsequent de-recruitment. PEEP is used for recruitment and splints open the alveoli and increases functional residual capacity. This results in improved oxygenation, prevention of atelectasis and improved lung compliance (Paratz et al, 2002). If MHI is to be used for recruitment then PEEP could be incorporated into the bagging circuit. Improved oxygenation is most commonly measured by arterial blood gases, specifically \( \text{PaO}_2 \), the ratio of partial pressure of oxygen in arterial blood to the fraction of inspired oxygen (\( \text{PaO}_2 : \text{FiO}_2 \)) and oxygen saturation.

Air flow follows the path of least resistance and the additional tidal volume delivered during MHI is likely to reach the most compliant areas of the lungs, expanding normal rather than collapsed alveoli. MHI may help re-inflate collapsed alveoli through collateral channels of ventilation and through interdependence (Stiller et al, 2000). As well as improved oxygenation, chest x-rays are commonly used as an outcome measure for resolution of atelectasis.

Volume restoration is also important in secretion clearance as air flow through the airways is required to achieve an effective cough (Maxwell and Ellis, 1998). MHI is believed to improve the movement of pulmonary secretions towards central airways and mimic a cough by generating increased expiratory flow rates (Stiller et al, 2000). Secretion clearance is an important outcome of MHI. Flow rates generated during MHI are also of significance as they influence secretion clearance.

High peak airway pressures have been reported as a contraindication or precaution to MHI. There is debate surrounding the maximum safe level of PIP during MHI, but it is perceived that high levels of PIP may cause barotrauma (Hodgson et al, 1999). However, PIP is a product of inspiratory flow and predominantly proximal airway resistance. Arguably the proximal airways with their cartilaginous structure are less prone to damage than the distal lung parenchyma. Plateau pressure is often used as a surrogate for the pressures experienced by the distal lung, and may be a more appropriate focus of concern than PIP.

As MHI delivers increased tidal volumes (TVs) it may cause large fluctuations in intrathoracic pressure and could potentially cause significant haemodynamic changes (Stiller et al, 2000). Therefore haemodynamic variables should be
monitored during MHI to observe significant changes. Heart rate (HR), blood pressure (BP) and cardiac output (CO) are the most commonly monitored variables in clinical practice. MHI has also been shown to increase Intra Cranial Pressure (ICP) and mean arterial pressure significantly for neurosurgical patients. The mean increases seen in ICP and mean arterial pressure were < 5 mm Hg, and CPP was not altered significantly.

3.0 Prerequisite Requirements

Only staffs trained in MHI and deemed competent are permitted to perform MHI.

On-call physiotherapy staffs undergo training which includes theory and practice of MHI and all staff complete on-call competency framework with a senior member of the respiratory team, which includes a section on MHI.

All nursing staff will have completed Respiratory Care competency such as Core Skill 5 contained in Core Skills and Knowledge Preceptorship

4.0 Hierarchy of Evidence

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>TYPE OF EVIDENCE</th>
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<tbody>
<tr>
<td>Ia</td>
<td>Evidence from systematic reviews or meta-analysis of randomised controlled trials</td>
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<tr>
<td>Ib</td>
<td>Evidence from at least one randomised controlled trial</td>
</tr>
<tr>
<td>IIa</td>
<td>Evidence from at least one controlled study without randomisation</td>
</tr>
<tr>
<td>IIb</td>
<td>Evidence from at least one other type of quasi-experimental study</td>
</tr>
<tr>
<td>III</td>
<td>Evidence from non-experimental descriptive studies, such as comparative studies, correlation studies and case-control studies</td>
</tr>
<tr>
<td>IV</td>
<td>Evidence from expert committee reports or opinions and / or clinical experience of respected authorities</td>
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</tbody>
</table>

Despite the many theoretical aims of MHI, there are few definitive studies to support its routine use. Furthermore, the published research is often difficult to interpret, as various combinations of machine hyperinflation and MHI, with and without changes in the FIO$_2$, have been compared. Despite this many physicians can point to anecdotal benefits for patients for example improvements in lung compliance and oxygenation for up to 2 hours after treatment have been noted when manual hyperventilation is performed by an experienced physiotherapist in an appropriate patient.
5.0 **Indications**

Quality of Evidence
Improve oxygenation Level 1b (Patman et al, 2000)
Secretion clearance Level 1b (Hodgson et al, 2000)
Improve lung compliance Level 1b (Choi and Jones, 2005)
Reversal of atelectasis Level 1b (McCarren and Chow, 1998)

6.0 **Precautions**

If a precaution exists this should be discussed with Critical Care medical staff for clarification and the risk/benefit ratio should be assessed for each individual patient.

(Quality of Evidence Level III or IV)
Large emphysematous bullae
Subcutaneous emphysema
Undrained pneumothorax
Open bronchopulmonary fistula
Inverse ratio ventilation
PEEP > 10cmH$_2$O
Bronchospasm
Systolic BP ≤ 80mmHg
Cardiovascular instability
Agitation / aggression
Acute head injury
Recent lung surgery with bronchial resection
Large air leak
Peak airway pressures > 40-50cmH$_2$O

7.0 **Equipment**

Mapelson C circuit
Oxygen supply
Reservoir bag
Infection control measures – Apron, gloves, protective eye wear and mask (if required)
Bacterial filter (if used)

8.0 **Procedure**

1. Wash hands; wear disposable apron, gloves and additional PPE as required.
2. Perform thorough assessment – indications / precautions for MHI.
4. Where possible gain consent from patient.
5. Attach Mapelson C circuit to oxygen flow meter and set flow rate at 15L/min.
6. A PEEP valve may be used when the patient is on a PEEP > 10cmH₂O and shows clinical signs of desaturation.
7. Disconnect patient from the ventilator, attach the bagging circuit to the catheter mount, attach the reservoir bag to the ventilator tubing and mute the alarm or switch the ventilator to standby as per local policy in the Unit.
8. Using 1 or 2 hands, co-ordinate the delivery of the breaths with any respiratory efforts of the patient. Allow the patient to acclimatise by using small TV’s initially and then aim to deliver a TV estimated at 1.5 times the current TV of the ventilator breaths by adjusting the valve in the circuit.
9. Care should be taken to minimise movement of the endotracheal or tracheostomy tube during MHI.
10. Perform slow deep inspiration aiming to achieve a peak inspiratory pressure of 40 cmH₂O.
11. Hold the breath for 3s at the end of inspiration followed by rapid release of the bag.
12. If the patient remains stable, use 6-8 MHI breaths and suction when indicated.
13. Repeat the cycle of MHI until secretions have been cleared or breath sounds have improved on auscultation.
14. Reconnect the patient to the ventilator – if the ventilator has been turned off ensure it has been switched on
   • Reset the alarm as required
   • Check the patient is on the correct mode of ventilation
   • Check that oxygen saturations are within normal limits
   • Observe the patient’s TV and respiratory rate
   • Re-assess.
   • Handover to nursing staff
15. Document that the patient is reconnected to the ventilator as above and handover has been given to nursing staff

9.0 Termination of MHI

1. When outcomes are achieved.
2. Patient becomes cardiovascularily unstable.
3. Patient becomes agitated and treatment is ineffective.

Assessment of efficacy

1. Oxygenation – oxygen saturations, PaO₂ and PaO₂ : FiO₂ (Quality of Evidence Level 1b).
2. Secretion clearance – sputum (Quality of Evidence 1b).
3. Lung compliance – ventilator parameters (Quality of Evidence 1b).
4. Atelectasis – auscultation and CXR (Quality of Evidence Level 1b)
5. Cardiovascular stability – HR, BP, CO (Quality of Evidence Level 1b).

10.0 Infection Control

1. As per hospital policy: wash hands before and after treatment, use gloves and plastic apron and discard appropriately following treatment. Wear goggles and/or mask as appropriate.
2. Change the bagging circuit weekly for longer-term patients or sooner if there are signs of contamination.
3. Change the bacterial filters on a daily basis.

11.0 Instillation of saline

The use of saline has not been substantiated and should not be used routinely but rather based on clinical assessment to assist in the removal of tenacious secretions which cannot be cleared with MHI and suction alone.

12.0 Reference List


Primum Non Nocere : Manual ventilation and risk of barotrauma Respiratory Care March 2005 338-9