

VENTILATOR HYPERINFLATION

******This document is intended to be used as an information resource only – it is not intended to be used as a policy document/practice guideline. Before incorporating the use of Ventilator Hyperinflation into your physiotherapy team's patient management, it is strongly recommended that you create an approved policy document/practice guideline in conjunction with the medical and nursing teams. This should be approved by the appropriate hospital department before use******

AIMS

- To address impaired airway clearance and reduced lung volumes

Specifically, when aiming to mobilise secretions, there are three flow rate characteristics that are to be aimed for:

- Expiratory flow rate bias where Peak Inspiratory Flow Rate is less than 90% of Peak Expiratory Flow Rate
- Peak Expiratory Flow Rate of 40 l/min
- Peak Expiratory Flow Rate at least 17 l/min greater than Peak Inspiratory Flow Rate

INDICATIONS

Intubated and mechanically ventilated patients with poor compliance, impaired secretion clearance and/or atelectasis

TOTAL CONTRAINDICATIONS

- Undrained pneumothorax
- Severe bronchospasm
- Head injury with Intra-Cranial Pressure > 25 mmHg
- Severe hypotension
- Subcutaneous emphysema

RELATIVE CONTRAINDICATIONS

- Tumour/obstruction (risk of gas trapping/trauma)
- Emphysematous bullae (risk of pneumothorax)
- Peak inspiratory pressure > 30 cm H₂O (won't be effective due to small change in tidal volumes before pressure limit reached)
- Recent oesophageal/lung surgery (potential for anastomotic compromise)
- COPD exacerbation (increase of airway inflammation and irritation)
- Bronchospasm (increase of airway inflammation and irritation)
- ARDS (increased risk of pneumothorax/barotrauma)
- Raised ICP (normal = 5 – 15 mmHg) (increased intrathoracic pressure can compromise MAP and thus CPP)
- Hypotension (risk of reduced venous return)
- CVS instability/arrhythmias (risk of reduced venous return)
- Acute head injury (increased intrathoracic pressure can compromise MAP and thus CPP)

- Unexplained haemoptysis (may indicate acute trauma to lung parenchyma)
- Increased respiratory rate (difficulty in coordinating technique)
- Coughing on ventilator (generation of high intrapulmonary pressure)
- Large undrained pleural effusion (risk of barotrauma)

PRE-PROCEDURE ASSESSMENT

In addition to your standard physiotherapy assessment, you should:

- Assess the suitability for hyperinflation procedure
- Assess for any contraindications
- Calculate desired tidal volume (15ml/kg based on lean body mass). Lean body mass:
 - Calculated as BMI of 25 for those with BMI 25 and above
 - Calculated using patient's actual mass for those with BMI less than 25
- Make note of:
 - Current ventilatory setting including mode, specific parameters and alarm parameters
 - Minute ventilation
 - End-tidal carbon dioxide
 - Oxygen saturations
 - Peak inspiratory pressure
 - Lung compliance (static or dynamic)
 - Cardiovascular status of patient (heart rate, rhythm, blood pressure, mean arterial pressure)

CALCULATING LUNG COMPLIANCE

Lung compliance is the ease with which the lungs stretch/expand.

Static compliance is defined as the change in volume for a defined change in pressure in the lungs, and dynamic compliance is the compliance of the lung tissue during movement of air. Static compliance is generally deemed to be more accurate as it removes airflow resistance as a variable.

Normal compliance is 50-100ml/cmH₂O.

Dynamic lung compliance is measured using the following equation:

$$\frac{\text{Exhaled tidal volume}}{(\text{Peak inspiratory pressure} - \text{PEEP})}$$

Static lung compliance is measured using the following equation:

$$\frac{\text{Exhaled tidal volume}}{(\text{Plateau pressure} - \text{PEEP})}$$

To get a reading of plateau pressure, it is necessary to perform an inspiratory hold at end-inspiration.

RECOMMENDED PROCEDURE

Use SIMV-VC mode.

Alarms:

- Increase tidal volume alarm to maximum target volume (15ml/kg) + 300ml
- Change peak pressure alarm to 35 cmH₂O

Parameters:

- FiO₂ – no change from pre-treatment parameters
- Inspiratory time – increase to 3 seconds (can increase up to 5 seconds)
- Respiratory rate – decrease to 8 breaths per minute (can decrease to 6 breaths per minute)
- Tidal volume – increase in 200ml increments until target achieved (ensuring to keep under upper pressure limit of 35 cmH₂O)

Deliver 6-8 breaths at target tidal volume per set, returning to baseline ventilation settings between each set.

Ensure ventilator settings are returned to baseline after finish of treatment and ask nursing staff to verify settings are correct

Monitor for:

- Minute ventilation (try to maintain as per pre-treatment throughout)
- End-tidal carbon dioxide (try to maintain as per pre-treatment throughout)
- Blood pressure
- Oxygen saturations
- Patient distress
- Peak airway pressures
- Intracranial pressure (if being monitored)
- Inspiratory and Expiratory flow rates

Troubleshooting:

- Alarms may sound due to changes in inspiratory: expiratory ratio – if so, reduce respiratory rate and increase inspiratory time more gradually
- If peak pressure is high before target volume reached, increase inspiratory time and reduce respiratory rate.

ADVANTAGES OF VHI WHEN COMPARED TO MHI

- Maintenance of PEEP and thus prevention of 'derecruitment' of alveoli
- Accurate control of ventilation parameters
- Reproducibility of technique – remember that MHI has been demonstrated to have significant inconsistencies in application of technique
- Reduced infection control risk to patient and to staff as no requirement to disconnect ventilator circuit

- Only one person is required to administer, compared to two with MHI if using in conjunction with other techniques (e.g. suctioning or manual techniques)
- Cost savings due to less staff requirements, and also equipment savings, as it uses no extra equipment

WHAT DOES THE EVIDENCE SAY?

Studies comparing MHI to VHI have found no statistically significant differences between techniques when comparing for:

- Secretion clearance
- Static and dynamic compliance
- Oxygenation
- Cardiovascular stability

It appears VHI is as safe and effective as MHI, but with many advantages as detailed above.

HOWEVER, there are very few studies, with low numbers of subjects (poor power), high levels of bias (crossover trials rather than RCTs), and no studies looking at any effects longer than 30 minutes after treatment.

It is not clear if either VHI or MHI have any long-term positive outcomes, but VHI is safe and effective in the short-term management of secretions, and can provide short-term gains in lung compliance.

REFERENCES

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