Ventilator Hyperinflation by Physiotherapists Guideline

1. Purpose

Ventilator Hyperinflation (VHI) is a physiotherapy intervention that enables the deliverance of larger than baseline tidal volumes (Vt) via adjustment of the ventilator in the intubated and ventilated patient. Competency must be achieved prior to performing the technique (please refer to Appendix A).

The purpose of VHI is to improve the respiratory status of intubated, ventilated patients by the deliverance of larger than normal tidal volume breaths, utilising safe peak inspiratory pressure (PIP), without interruption to the desired positive end expiratory pressure (PEEP) and the oxygen supply. This enables recruitment of collapsed alveoli and clearance of secretions from the bronchi, thereby improving gas exchange.

2. Guideline

2.1 Indications

Ventilator Hyperinflation (VHI) is indicated in the **stable** ventilated patient when:

- secretion retention does not respond to suction and positioning.
- patients have PEEP dependency
- endotracheal suctioning required (prior/post treatment)
- patient has segmental/lobar atelectasis
- patient has poor cough mechanism.

2.2 Aims of VHI

The aim of performing VHI is to:

- aid in the resolution of atelectasis in the ventilated patient
- mobilise and assist removal of excessive bronchial secretions
- improve lung compliance
- assist with prevention of nosocomial pneumonia.

2.3 Contraindications

Any concerns about performing VHI on a patient should be discussed with the Senior Physiotherapist, Senior Medical Officer and or Senior Nursing Staff prior to commencing VHI.

Absolute

Condition	Rationale
Patients requiring nitric oxygen or prostaglandin infusion	Patient too unstable
Patients requiring Airway Pressure Release Ventilation (APRV)	Patient too unstable

Severe bronchospasm or gas trapping	Increased airway pressure will increase airway irritation and inflammatory response
Unexplained frank haemoptysis (physiotherapy may be appropriate once bleeding is controlled)	May be indicative of acute trauma to the lung parenchyma
Broncho pleural fistula	May exacerbate air leak
Undrained pneumothorax or intercostal catheter with an air leak / subcutaneous emphysema of unknown cause	May increase size of pneumothorax
Documented cystic lung changes (bullae/blebs) such as in severe chronic obstructive pulmonary disease with large emphysematous bullae or cavitating lung pathology (abscess, contusions, tumours)	Increases risk of pneumothorax
Peak airway pressure (Paw)>30cm H2O	High risk of barotrauma
Mean arterial blood pressure (MAP) <60mm Hg or Systolic <80mm Hg	Increased positive pressure in thoracic cavity compromises venous return – reduces cardiac output
Post insertion of central venous catheter prior to chest x-ray (CXR) clearance	Need to exclude iatrogenic pneumothorax post Central Venous Catheter (CVC) insertion
Post removal of chest drain prior to CXR clearance	Need to exclude pneumothorax
Head injury with intracranial pressure (ICP) > 18mmHg	Increasing intra-thoracic pressure can compromise mean arterial pressure and compromise cerebral perfusion pressure

Table 1: Absolute Contraindications

Relative

Condition	Rationale
Recent oesophageal or lung surgery e.g., oesophagectomy, lobectomy/pneumonectomy, long volume reduction surgery, diaphragmatic repair	High airway pressure may compromise the anastomosis.
Acute pulmonary oedema	Technique not indicated
Large undrained pleural effusion	High risk of barotrauma
Fractional oxygen (FiO2)>0.6	Pt may be too unstable to do VHI
High positive end expiratory pressure (PEEP)>10cm H2O	Generally, if the pt. requires a PEEP > 10 to maintain PaO2, they may be too unstable to do VHI. Also, with high PEEP there is a lower expiratory flow therefore less effective for airway clearance.
Pneumothorax with patent Intercostal Catheter (ICC)	Needs consultant clearance, risk of increasing pneumothorax
Severe coagulopathy	Increase risk in bleeding

Unexplained increase in respiratory rate	High respiratory rate makes it hard to co-ordinate breaths
Cardiovascular instability (CVS) instability/arrhythmias	Compromised venous return – further increases effort required to maintain adequate tissue perfusion
Significant inotropic requirement or a sudden increase in inotropes	Increased positive pressure in thoracic cavity compromises venous return – reduces cardiac output.

Table 2: Relative Contraindications

2.4 Physiological Effects of VHI

Potential positive effects of hyperinflation:
- collateral ventilation (slow sustained inspiration)
- alveolar interdependence
- prevention of loss on functional residual capacity (FRC)
- airway clearance (wet weight of sputum produced)
- enhanced improvements when combined with positioning
- improvements in gas exchange
- resolution of atelectasis
- improved static lung compliance and reduced airway resistance (Choi and Jones 2005, Hodgson et al 2000, Ahmed et al 2010).

Potential negative effects of hyperinflation:
- increased intrathoracic pressure
- increased pulmonary artery pressure
- decreased venous return, decreased ventricular preload and therefore decreased cardiac output
- decreased blood pressure
- increase in tidal volumes may decrease spontaneous ventilatory drive due to lowering of carbon dioxide levels during procedure
- barotrauma
- bronchospasm
- excessive coughing
- proximal airway occlusion caused by sputum plugging.

Potential benefits of VHI over MHI:
- less stressful to patient (nil Endotracheal Tube (ETT) manipulation or circuit disconnection)
- less potential for gas trapping
- no loss of PEEP which minimises alveolar de-recruitment and loss of FRC
- reduced risk of infection transmission (less breaks in the circuit)
- improved monitoring of volumes and flow profiles.

2.5 Decision making for VHI

Please complete the following, when applying VHI:
1. check for presence of any contraindications/precautions
2. assess patients baseline respiratory mechanics (including lung compliance, resting tidal volumes, spontaneous efforts) and indications for VHI

3. record all baseline ventilator settings and physiological measures
4. apply personal protective equipment as per infection control guidelines
5. explain the procedure to the patient and verbally cue throughout
6. optimise patient positioning for targeted treatment area
7. follow procedure for conducting VHI. Complete desired cycles and suction with appropriate re-assessment
8. monitor treatment effect as below. Continue to assess patient breathing pattern, effort and synchronicity throughout

2.6 VHI Procedural Guidelines

ATTENTION

When changing ventilator setting for VHI, there is no automated option to return the patient to the baseline mode of ventilation. It is therefore imperative that you record the settings parameters prior to commencing treatment, use options to limit setting changes whilst determining patient stability, monitor all observations carefully and be ready to return patient to baseline settings at all times

Plan for delivery of VHI:

1. record all baseline ventilator settings
2. measure the height of the patient and take note of body weight on admission.
3. calculate BMI (Body Mass Index) =Mass/Height^2
4. determine target tidal volume of 15ml/kg of ideal body weight (this is usually between 800-1400ml for most patients)
5. take note of pre-intervention ventilator mode, settings, alarm parameters, Vt, PIP, etCO2 and lung compliance over 3 ventilator cycles
6. select ventilation mode for VHI delivery- can be performed in either Volume-Controlled (VC) Synchronised Intermittent Mandatory Ventilation (SIMV) or Pressure-Controlled (PC) SIMV

VC SIMV (Volume-Controlled Synchronised Intermittent Mandatory Ventilation)

1. adjust Vt alarm to target Vt plus 300 mls (15ml/kg)
2. change Paw alarm to 35cm/H2O
3. reduce Respiratory Rate (RR) to 6-10/min- * lower frequencies may be more appropriate with patients on spontaneous modes of ventilation to assist with synchronisation and allow for spontaneous breath efforts between hyperinflation breaths *
4. increase Time (Ti): between 2-4 seconds as indicated based on patients lung pathology and pre-existing conditions
5. increase “T-Slope”: increasing the slope will allow for slower inspiratory time. Aim is to aid recruitment, improve synchrony and create bias towards expiratory flow to aid with secretion removal
6. increase Vt by 150-300mls increments until target volume achieved
7. aim for 8 breaths at target volume, include expiratory vibes or rib springs if indicated
8. aim for 3 sets of 6-10 VHI breathes if tolerable
9. monitor for patient stability. Synchronisation and treatment effect
10. return ventilator to pre-treatment parameters in the reverse order to above: Vt, followed by Ti, then RR and Ventilation Mode
11. physiotherapist to suction as required. This may occur following interruption of the VHI breaths or at the end of the cycle of breaths

12. repeat VHI cycles and suction as required. Ensure VHI cycles are completed with a recruitment breath rather than ending with suction to prevent de-recruitment
13. ensure the return of all parameters to pre-intervention (Ventilation mode, Vt, RR Ti FiO2 Paw & high Vt alarms)
14. document settings utilised and outcome measures

PC SIMV (Pressure-Controlled SIMV)

1. follow instructions 1-11 as above
2. increase Pressure "P-Insp". Usually this will be between 22cmH2O -30 cmH2O. Consider patient lung compliance and target TV. Aim should be to achieve target TV at lowest pressure required
3. continue to titrate Total inspiratory pressure (Pinsp) and Ti until desire treatment effect achieved (being mindful of safe parameters to reduce incidence of VILI)
4. aim for 8 breaths at target volume, include expiratory vibes or rib springs if indicated
5. aim for 3 sets of 6-10 VHI breathes if tolerable.
6. monitor for patient stability, synchronisation and treatment effect
7. return ventilator to pre-treatment parameters in the reverse order to above: P insp, followed by Ti, then RR and Ventilation Mode
8. physiotherapist to suction as required. This may occur following interruption of the VHI breaths or at the end of the cycle of breaths
9. repeat VHI cycles and suction as required. Ensure VHI cycles are completed with a recruitment breath rather than ending with suction to prevent de-recruitment
10. ensure the return of all parameters to pre intervention (Ventilation mode, Vt, RR Ti FiO2 Paw & high Vt alarms)
11. document settings utilised and outcome measures

2.7 Monitoring During VHI

It is very important to closely observe throughout the intervention the following:

Parameter	Rationale
CVS Stability	• Assess patient stability prior to commencing VHI. • Assess for potential negative effects/ decreases during VHI.
ICP/Cerebral Perfusion Pressure (CPP)	• Assess patient stability and suitability to commencing VHI. • Assess tolerance of VHI.
End-tidal Carbon Dioxide ($etCO_2$)	• Monitor throughout treatment. Take care if this decreases with VHI, as this will likely effect resumption of spontaneous breaths post VHI. Care also needs to be taken for those patients with acute brain injuries with a tight target range for $PaCO_2$ 25cmH_2O – 40cmH_2O.
Tidal Volume (Vt)	• Assist with assessment of lung compliance for baseline ventilation. • During VHI: determine treatment effectiveness and guide alteration of settings. • Post treatment: assess patient stability, lung recruitment, secretion clearance.
Peak Inspiratory Pressure (PIP)	• Indication of lung compliance. Assess in conjunction with tidal volume and driving pressure.

	• Post treatment: assess patient stability and treatment effect.
Frequency (F total)	• Determine baseline patient effort, WOB, assist with setting choices for synchronisation. • During VHI: continue to assess synchronisation,
Inspiratory: Expiratory ratio	• Aim to match I:E ratio. If there has been a focus on increased Ti with VHI setting, ensure time allowed for expiration.
Resistance (Rinsp)	• Total resistance imposed by the patient's airway as well as the artificial airway. Gives indication of resistance and may reduce with secretion removal. Note: Patients can create artefact and noise affecting accuracy with spontaneous breathing.
Static Lung compliance (Cstat)	• Gives an indication of lung compliance. Assist with determining VHI settings and treatment effect. Note: Patients can create artefact and noise affecting accuracy with spontaneous breathing.
Waveforms: Pressure and flow graphs	• Assess for any abnormalities in pressure/time graph or saw tooth pattern in flow/time graph (indicative of secretions or rain out in tubing)

Table 3: Monitoring during VHI

2.8 Evaluation/Outcome Measures

Document the following in the medical file as per Documentation - Clinical Practice Standard. Include all the following:

- ventilator mode
- patients position
- number of breaths delivered
- max volumes reached
- Insp. time/plateau time
- patients' response to treatment (static lung compliance, gas exchange, Oxygen Saturation (SpO2), sputum clearance, CXR/auscultation findings, wave forms, ICP/ETCO2 where indicated, CVS)
- any changes to medication management throughout
- adverse responses and action taken.
- plan for frequency and dosage of treatment

3. Roles and Responsibilities

The Senior Intensive Care Unit (**ICU) Physiotherapist** is responsible for continuous monitoring of appropriateness of information provided within this guideline They will also adhere to the utilisation of the VHI Assessment and Competency Checklist for assessment of other Physiotherapy staff (please refer to Appendix A).The Senior ICU Physiotherapist will audit Physiotherapy staff compliance, every six months.

Physiotherapy staff are responsible for reviewing this guideline, prior to completing the VHI Assessment and Competency Checklist (Appendix A).

All staff are required to comply with the directions in WACHS policies and procedures as per their roles and responsibilities. Guidelines are the recommended course of action for WACHS and staff are expected to use this information to guide practice. If staff are unsure which policies procedures and guidelines apply to their role or scope of practice, and/or are unsure of the application of directions they should consult their manager in the first instance.

4. Monitoring and Evaluation

Senior ICU Physiotherapist will complete ongoing monitoring and evaluation of this document, using evidence-based research and in conjunction with other ICU Senior Physiotherapists in W.A. Formal review of this guideline will be completed every five years, unless otherwise indicated.

5. References

SCGH Ventilator Hyperinflation Clinical Guidelines 2016

St George University, NHS V.H.I Guidelines 2016. Available from: http://www.gicu.sgul.ac.uk/resources-for-current-staff/respiratory-physiotherapy/Guidelines%20VHI%20v1.2%20June%202016.docx/view

Government of Western Australia East Metropolitan Health Service. Ventilation Hyperinflation Procedure (2017) Armadale Health Service, Perth, Western Australia

Government of Western Australia South Metropolitan Health Service. Physiotherapy Management of Organ Donors (Acute) Guideline (2018) Rockingham Peel Group, Rockingham, Western Australia

6. Definitions

Term	Definition
I: E Ratio	Inspiration: Expiration Ratio
Total inspiratory pressure	Total inspiratory pressure is PEEP plus Pressure support
Resistance	Resistance (Rinsp) imposed by patient's airway, as well as the artificial airway.
Ti	Inspiratory Time
T-Slope	Time taken to achieve desired pressure

7. Document Summary

Coverage	WACHS – Bunbury Regional Hospital
Audience	ICU Physiotherapists
Records Management	Clinical: Health Record Management Policy
Related Legislation	*Health Services Act 2016* (WA)
Related Mandatory Policies/Frameworks	• Clinical Governance, Safety and Quality Framework
Related WACHS Policy Documents	• Airway Suctioning Clinical Practice Standard • Aseptic Technique Policy • Clinical Observations and Assessments Clinical Practice Standard – physiological, neurological, fluid balance • Infection Prevention and Control Policy • Oxygen Therapy and Respiratory Devices – Adults Clinical Practice Standard • Personal Protective Equipment (PPE) Procedure • Recognising and Responding to Acute Deterioration (RRAD) Policy • Ventilation (Non-Invasive and Invasive Mechanical)- Clinical Practice Standard
Other Related Documents	• AHS Ventilator Hyperinflation Procedure • SCGH Application of Ventilator Hyperinflation by Physiotherapists' in Intensive Care Guidelines • Drager Ventilation Mini Manual
Related Forms	• Ventilator Hyperinflation Assessment and Competency Checklist – Bunbury Hospital (ICU) (Appendix A)
Related Training Packages	Nil
Aboriginal Health Impact Statement Declaration (ISD)	ISD Record ID: 3481
National Safety and Quality Health Service (NSQHS) Standards	1.07b, 3.01a, 8.01b
Aged Care Quality Standards	Nil
Chief Psychiatrist's Standards for Clinical Care	Nil
Other Standards	Nil

8. Document Control

Version	Published date	Current from	Summary of changes
2.00	15 April 2025	15 April 2025	• minor updates to streamline guideline • addition of competencies checklist

9. Approval

Policy Owner	Executive Director South West
Co-approver	Chief Operating Officer Executive Director Clinical Excellence
Contact	Coordinator of Physiotherapy
Business Unit	WACHS-SW, Bunbury Health Campus, Allied Health
EDRMS #	ED-CO-20-67381

This document can be made available in alternative formats on request.

Appendix A: Ventilator Hyperinflation Assessment and Competency Checklist – Bunbury Hospital (ICU)

Name of Physiotherapist being assessed: _____

You will be assessed for competency, marked **Competent (C) or Not Competent (NC)**, for each of the different Ventilation Modes during a minimum of **two** patient treatments (per mode). Competency in all criteria must be gained. Once assessed competent for a particular ventilation mode, application of Ventilator Hyperinflation may be undertaken for that respective mode.

Pre-Requisite:

□ Recognition of Prior Learning

□ Registered Physiotherapist as per Guidelines

□ Read and understood Ventilator Hyperinflation by Physiotherapists Guideline for Bunbury Hospital, as well as the WACHS Ventilation (Non-Invasive and Invasive Mechanical) - Clinical Practice Standard

Candidate's Declaration of readiness (must be completed prior to the assessment)

□ I have read and understood the details of the guidelines and standards above

□ I have been informed of the condition of the assessment and the appeals process

□ I agree that the details of the assessment will be forwarded to my line manager

Name: _____ **Signature:** _____ **Date:** _____

Assessment Criteria	**Simulation / Online Learning** Date: **D / C**		**SIMV-VC** Date: **D / C**		**SIMV-PC** Date: **D / C**		**CPAP-PS** Date: **D / C**	
	Prac 1	Prac 2	Prac 1	Prac 2	Prac 1	Prac 2	Prac 1	Prac 2
1. Discuss intervention with bedside nurse (and consultant, as required) to assess whether treatment is indicated.								
2. Confirm that there are no contraindications to technique								
3. Accurately identify patient's height, weight to calculate BMI and target Vt								
4. Patient is positioned appropriately, using appropriate clinical knowledge								
5. Baseline ventilator settings noted								
6. Explain intervention to patient, as appropriate								
7. PIP alarm adjusted to 35cmH2O / Vt adjusted appropriately								
9. Flow and airway pressure waveforms are displayed								
10. VHI is applied, as per procedural guideline								
11. Monitor MAP, SpO2, Vt, etCO2, MV, PIP, ICP/CPP (if available) throughout intervention								
12. Modify technique (as indicated)								
13. Perform appropriate number of reps and sets								
14. Terminate the treatment at the appropriate time								
15. Returns the settings (and alarms) to pre-treatment levels								
16. Reassess patient post-intervention (including auscultation)								

17. Evaluate outcome measures				
18. Document (as per procedural guideline)				

	Simulation		**SIMV**		**PS**		**PCV+**	
Result	C / NC	C / NC	C / NC	C / NC	C / NC	C / NC	C / NC	C / NC
Assessor Name & Date:								
I accept the decision and agree the assessment process was valid and fair □								
I wish to appeal against the assessment decision process □ Candidates Name, Date and Signature:								

Recommendations for further development if not competent:

Timeframe:

Competency Database □ Copy of Assessment Issued □