NCCU CLINICAL GUIDELINES
SECTION: 2

RESPIRATORY PROBLEMS AND MANAGEMENT

Section 2: Respiratory problems and management
Pressure support (PSV), Volume Guarantee (VG) and VIVE
Date created: June 2006
Date revised: Dec 2012
Review date: Dec 2015

Neonatology Clinical Care Unit Guidelines
King Edward Memorial/Princess Margaret Hospitals
Perth Western Australia
Authorisation & review by
Neonatal Coordinating Group

PRESSURE SUPPORT VENTILATION (PSV*)*

- Time cycled-pressure limited synchronised mode in which each spontaneous breath is supported like SIPPV and a back-up rate is set to maintain adequate support in case of apnoea.
- The patient determines the IT and ventilation rate.
- Check the flow vs time graph to ensure that the set inspiratory time is approximately 1.3 – 1.5 times the duration of the spontaneous inspiratory time (judged from when the inspiratory flow returns to zero).

ADVANTAGES

- Major difference: The ventilation stroke is terminated when the inspiratory flow drops to about 15% of the peak flow or after IT.
- This means that inspiratory hold is eliminated and the chance of active expiration against positive pressure is minimised.
- Allows the infant control over the end of inspiration, not just the beginning.
- Allows the infant to sigh, with pressure support given throughout the sigh, preventing atelectasis.
- Maintains optimal inspiratory time for a given patient and automatically adjusts to changes in time constants.
- Should reduce the risk of barotrauma and BP fluctuations (decrease IVH?).
- Can use with VG. Other ventilators also provide mixed PSV + SIMV/SIPPV modes.
- Need to set the maximum inspiratory time.

DISADVANTAGES

In the presence of severe atelectasis and insufficient respiratory drive, spontaneous inspiratory time may be insufficient to achieve adequate lung volume recruitment.

VOLUME GUARANTEE VENTILATION

Despite improvements in respiratory care, ventilator induced lung injury remains an important cause of morbidity and mortality in neonatal patients who require assisted ventilation. Mechanisms of ventilator induced lung injury include barotrauma, volutrauma, atelectotrauma (alveolar collapse and re expansion) and biotrauma (increased inflammation). Animal studies have shown that it is mainly changes in cyclic and distending lung volume and not pressure that cause lung injury.

Excessive tidal volumes can worsen clinical and pathological evolution of respiratory distress syndrome. Health care practices chosen during the first week of life may influence the incidence of bronchopulmonary dysplasia.

OPTIMAL TIDAL VOLUME

The primary goal of VG ventilation is to minimise volutrauma, but it also incorporates a feature to minimise the barotrauma because the operator sets the upper pressure limits. Volume guaranteed ventilation allows the ventilator to provide a set V_T responsive to changes in the patient compliance, resistance or respiratory drive. The ventilator will automatically adjust the inspiratory pressure to achieve the desired V_T. VG ventilation targets a specific volume of gas to be delivered by the ventilator, and inspiration ends when it has been delivered, within the limits of the existing ventilator settings. The pressure used to deliver the preset volume may increase to the preset maximum or decrease with improving lung compliance. In the Drager Babylog 8000+, it is based on an eight to ten breath average and is referenced to exhaled V_T.

ADVANTAGES OF VG VENTILATION INCLUDE

- Prevention of overdistension and volutrauma after surfactant treatment.
- Response to sudden changes in compliance and resistance.
- Automatic decrease of inspiratory pressure during weaning.
- Stabilization of tidal volume and minute ventilation.

PROTOCOL FOR VOLUME GUARANTEE VENTILATION

- Infants of any gestation with birth weight more than 500 grams who are being ventilated for RDS
- Recurrent apneas not responding to CPAP and other measures.
- Asphyxiated infants.
- Ventilation for other indications: still possible to use VG ventilation, but needs to be discussed with attending consultant to decide mode of ventilation.

SETTINGS

These settings are for ventilating an infant with RDS. If ventilating for other indications, discuss the ventilator settings with the neonatal consultant.

1. Start with SIPPV with VG
2. Set the initial TV 4.5 – 5 ml/kg. The initial PIP should be increased by no more than 4 from the previous value during ventilation without VG, or on a new infant, should be initially limited to 22 cmH_20).
3. The delivered PIP required to achieve this set TV is observed for 10 minutes.
4. Set the PIP limit at 20 percent above the observed pressure requirement.
5. Start with rates of 45 per minute and IT of 0.3 to 0.35 sec.
6. Review the flow graph and ensure that expiratory time is set at least long enough to allow flow to return to zero (at least 3 time constants are required to remove 95% of delivered volume from the lung)
7. Initial PEEP to be kept at 5 or 6 cmH_2O.
8. FiO_2 to maintain oxygen saturations target range between 88 % to 92 %.
9. Flow is set at 8 L/min but may need to be increased if high pressures are required or decreased if PSV is used. Adequacy of flow on SIPPV and SIMV can be checked by reviewing the pressure graph. A pressure plateau should be reached by the end of the first 1/2 of the inspiration. In PSV, The pressure plateau is reached at the end of inspiration.
10. Aim to alter $PaCO_2$ by inducing changes in minute ventilation (MV). This may require a change in set V_T or set RR or both, to achieve desired goal. Always aim for achievement of physiologically appropriate respiratory rates and tidal volumes. Remember that it is possible to achieve good gases but have inappropriate ventilator settings.

11. If $PaCO_2$ is above 60 mmHg AND RR is > 60-70 br/min - Increase the tidal volume by 0.3-0.5 mL/kg increments.
12. After each increment in set tidal volume, increase the set pressure limit to stay no more than 4-5 cmH_2O above the average delivered pressure (approximately 2 cmH_2O).
13. If the ventilator is unable to deliver the set tidal volume using the set pressure, then it will give alarm saying low tidal volume. In this situation, first check that flow is sufficient for the higher pressure (look at rise time on pressure slope) and increase flow by 1-2 l/min if necessary. If low tidal volume alarm continues, increase the set pressure by another 2 cmH_2O.
14. If $PaCO_2$ is above 60 mmHg AND RR is < 40-50 br/min - Increase the ventilation rates so as to give a higher minute volume with the same set tidal volume.
15. If $PaCO_2$ is between 45-60 mmHg - Check RR and Vt to ensure that these are appropriate for the infant. An infant breathing very fast with a Vt that is too small will be consuming unnecessarily high amounts of oxygen and will be prone to developing atelectotrauma (and on SIPPV also potentially developing airtrapping). Likewise, an infant breathing very slowly with high Vt may be incurring overdistension volutrauma.
16. If $PaCO_2$ is less than 45 mmHg - Reduce the tidal volume by 0.2-0.5ml/kg decrements till you reach a tidal volume of 3.5 – 5.0 ml/kg. It is advisable to observe the actual pressure needed over next 10 minutes and reduce set pressure limit by 1-2 cmH_2O every time the set V_T is reduced.

The following data is recorded:

- Set tidal volume / Average delivered tidal volume.
- Set / Actual respiratory rate
- Set MIT
- Actual minute volume
- Set pressure limit / Average actual delivered pressure (use trend tables to review this).
- % Spontaneous breaths.

WEANING FROM MECHANICAL VENTILATION ON VOLUME GUARANTEE

FOR LARGER INFANTS:

- Reduce the tidal volumes stepwise till target V_T (4.5 mL/kg-5.0 mL/kg) is reached.
- Change to SIMV+VG from SIPPV+VG.
- Reduce the rates to maintain $PaCO_2$ around 50 –55 mm Hg.
- Consider extubation when infant's set tidal volume is 4.5 mL/kg – 5.0mL/kg, set rates are 20-25/minute, and FiO_2 is less than 30%.

FOR SMALLER INFANTS:

- Reduce the tidal volumes stepwise till target V_T (3.5ml/kg-4.5ml/kg) is reached. V_T <4 mL should only be used in <26 w infants during acute initial phase (ie <2 w) of their illness.
- If changing to SIMV, follow protocol for larger infants with appropriate adjustments to set V_T
- If remaining on SIPPV (preferable for very small/immature infants on 2.5 mm and 3.0 mmID ETT):
- Stepwise (5-10 br/min per step) reduce the set backup rates to around 25- 30/min to encourage the infant to initiate and regulate its own breathing pattern.

- Gradually reduce peak inspiratory pressure limit to encourage the infant to take over as much of the work of breathing from the ventilator as possible (muscle conditioning).
- Consider extubation when infant's set tidal volume is 3.5 mL/kg – 4.5mL/kg, set rates are 25-30/minute, the baby is breathing regularly with a sustainable and physiologically appropriate breathing rate (40-60 min), maintaining $PaCO_2$ around 50 –55 mm Hg and FiO2 is less than 30 % (higher FiO_2 if has chronic lung disease).
- The rate volume ratio (RVR) is a useful monitoring tool for assessing how well an infant is coping with weaning procedures. If the RVR increases, this indicates decompensation. Do not use tidal volumes of <4 mL/kg unless infant is <26 w and <2 w old.

TROUBLESHOOTING WITH VOLUME GUARANTEE VENTILATION

The most common problems encountered are air leaks, flow sensor issues, alarms and limitations at very low volumes.

AIR LEAKS

Draeger Babylog 8000+ determines tidal volume by measuring the amount of air exhaled in each breath. Flow sensor for the Babylog 8000+ is located next to the infant in the ventilator circuit. The sensor will measure the volume of air exhaled each breath, recording flow and volume. If there is air leak more than 60 percent, the volume cannot be guaranteed with each breath. If the exhaled volume is low, the ventilator will increase the pressure with each breath in an effort to deliver the guaranteed volume.

Air leaks of more than 60% and unable to achieve acceptable gases - discuss with senior reg/consultant about ETT orientation, to consider taking the baby off volume guarantee or change of endotracheal tube to a bigger size.

FLOW SENSOR ISSUES

- If the flow sensor is removed for surfactant administration or any other reason, then ventilator will automatically revert to the conventional pressure limited time cycled mode of ventilation and will utilise the preset pressure limit as the PIP. Thus when the sensor is removed, the PIP will potentially be set at 15-20 percent higher than the pressure that is actually needed to provide the required V_T and the baby will receive an unnecessarily high V_T and potential volutrauma.
- If the flow sensor becomes dirty, it may incorrectly read tidal volume, and provide widely variable pressures to reach target volumes. If flow vs. time waveform appears noisy, and secretions are cleared from tubing/circuitry, consider replacing flow sensor.

ALARMS

Low minute volume alarm:

- Do a blood gas analysis. If there is respiratory acidosis, check for appropriate respiratory rate and VT and make adjustments if necessary.
- Consider increasing the rates or set tidal volume.
- If gases are good and ventilation settings are appropriate, then consider resetting the minute volume limits but do not exceed 50% of the desired range (eg minimum 0.1 L/kg/min and max 0.45 L/kg/min).

High minute volume alarm

- Set V_T may be too low so that you are not providing adequate alveolar volume and the infant has to breathe very quickly. – adjust V_T up.

- There may be water in the line causing the ventilator to trigger at times when the infant is not taking a breath. This situation can lead to gas trapping. Clear the water from the circuit and observe.
- If excess triggering is not due to either of the above, discuss a small increase (0.3) in the trigger sensitivity with your consultant (do not exceed a trigger sensitivity of 1.3).

Low tidal volume

- Look for obstruction.
- See if there is air leak more than 60 percent. If so, review tube position & orientation , discuss about changing the Tube to a bigger one or consider taking baby off volume guarantee.
- Check that appropriate amount of flow is delivered to ensure that pressure achieves plateau within first 33-50% of inspiratory period. Increase flow if necessary to achieve this goal.
- Check that inspiratory time is not set to an inappropriate low value (review duration of inspiration on flow vs. time graph).
- Limitations at very low volumes - The ventilator cannot accurately deliver volumes of less than 2 mL.

VIVE

- **Inspiratory flow (VI)** is effective during ventilation strokes, while the **expiratory flow (VE)** is effective during spontaneous breathing phases.
- Continuous expiratory flow can be adjusted independently of the continuous inspiratory flow.
- Potential advantages of higher expiratory flow.
  Provides the patient with a higher flow for spontaneous breathing than that used for the ventilation strokes.
  Promotes flushing of the dead space volume in the Y-piece by means of increasing turbulence in the hose system.
  Permits adjustment of the pattern of manually initiated ventilation strokes in CPAP mode.
- Reduced expiratory flow reduces gas (oxygen and medical air) utilisation and may decrease expiratory work of breathing.