### Volume-Targeted Ventilation

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| Site  | BCH Only |
| Setting/Population | 7 North |
| Clinician | RRT, MD, NP, RN |

#### Policy

* Volume-Targeted Ventilation (VTV) is a mode of ventilation characterized by time-cycled pressure-limited breaths. Tidal volume (VT) is set and monitored Peak Inspiratory Pressure (PIP) is variable. The ventilator adjusts PIP on a breath-by-breath basis in pressure increments up to 3 cm H2O until targeted VT is achieved or pressure is regulated (5 cm H2O below set High PIP alarm). Several randomized control trials have compared VTV with pressure-limited ventilation (PLV) have found important safety benefits with VTV in ELBW infants. VTV has been associated with a reduction in hypocapnia, risk of neurologic sequelae (e.g. periventricular leukomalacia or grade 3-4 IVH), bronchopulmonary dysplasia, pneumothorax and shorter duration of mechanical ventilation.
* The major goals of this strategy are: 1) to prevent alveolar over-distension (volutrauma) by controlling tidal volume and limiting inspiratory pressure; 2) to reduce the repetitive closing and reopening of alveolar lung units (atelectrauma) by recruiting and maintaining adequate lung volume (FRC); 3) to provide more consistent VT delivery, thereby limiting swings in PCO2 and pH.

##### Purpose

* This guideline outlines a strategy for minimizing the risk of ventilator induced lung injury in premature infants (≤35 weeks gestation) with respiratory distress syndrome (RDS) undergoing conventional mechanical ventilation.

#### Procedure

##### Inclusion Criteria

* Premature infants ≤35 weeks gestation requiring invasive mechanical ventilation
* For ELBW infants (e.g.< 1000 grams) the proximal Y-sensor is recommended
* Larger infants may benefit from VTV; however, the Y-sensor should not be used as resistance increases in proportion with higher inspiratory flow rates (Y-sensor is not recommended for VT > 10 mL)

##### Exclusion Criteria

* Endotracheal tube leak > 50%

##### Planning

* The Servo-U ventilator should be used for VTV in conjunction with a proximal flow sensor (hot-wire anemometer).
* The Servo-U includes leak compensation and targets VT based upon corrected exhaled volumes. Additionally, this device uses two separate VT delivery algorithms based upon how the breath is initiated (e.g. patient assisted or unassisted). Therefore, PIP is adjusted according to exhaled VT and PIP based on the preceding breath of the same type.
* PIP is incrementally adjusted by a maximum of 3 cm H2O on a breath-by-breath basis to achieve the set VT unless the high-inspiratory pressure alarm threshold has been breached; in which case pressure is regulated.

##### Implementation

1. Discuss patient eligibility with the care team and ensure order is written.
2. Ensure the patient profile is configured to “Neonatal”
3. Configure and calibrate the proximal Y-sensor as described in the Servo-u reference tool. This procedure involves connecting the pressure line to the wye and should be completed before connecting the patient to ventilator to prevent tension on or migration of the endotracheal tube.

##### Initial Settings

* **PRVC mode:**
* **VT** :4-6 mL/kg
* **PEEP**: 5-7 cm H2O
* **Frequency**: 20-40 breath/min. It is important that infants trigger the majority of breaths as inspiratory efforts contribute to VT and therefore require a lower PIP.
* **Inspiratory time** (Ti): 0.3-0.4 seconds for ELBW; larger infants may require longer Ti. The appropriateness of Ti can be assessed by observing the flow waveform. Ti is adjusted to ensure the pressure plateau is reached prior to exhalation but not held too long (e.g. flow has returned to baseline with no further increase in VT).
* **FIO2 :** titrate to maintain SpO2 88-94%

##### Management

* Permissive hypercapnia (PCO2 50-60 mm Hg) is recommended to limit ventilator induced lung injury while concomitantly maintaining pH ≥ 7.28.
* Utilize transcutaneous CO2 monitoring when necessary for trending and/or stabilization of ventilator settings, particularly for patients requiring a proximal flow sensor.
* **Hypercarbia**: (e.g. PCO2 > 60 mm Hg)
	+ Increase set VT in increments of 0.5 mL
	+ For paralyzed infants, or those with limited respiratory drive (e.g. not breathing over set frequency); breathing frequency may be incrementally increased (max: 50 breaths/min).
* **Hypocarbia**: (e.g. PCO2 <40 mm Hg)
	+ Decrease set VT in increments of 0.5 mL ensuring minimum VT ≥4 mL/kg.
	+ Weaning frequency on control modes will not necessarily reduce PCO2 elimination; however, frequency can be reduced to ensure patient is initiating the majority of breaths.

##### Special considerations/Troubleshooting

* Persistent tachypnea, retractions, low PIP and measured VT ≥ set VT are indicative of inadequate support. If set VT is too low and the patients spontaneous efforts are able to generate VT > set VT; the ventilators algorithm will continue to lower the PIP, potentially under supporting the patient. This scenario leads to loss of lung recruitment and increased work of breathing as PIP falls closer to the lower limit (5 cm H2O above set PEEP level).
* Smaller infants (e.g. ≤ 500 grams) may require a larger set VT to compensate for increased endotracheal tube and flow sensor dead space. In this population the initial VT will be set for 6 ml/kg and incrementally adjusted to a maximum of 8 ml/kg.
* For patients requiring prolonged mechanical ventilation, it is important to adjust set VT for weight gain. Additionally, over time the immature tissues of the trachea and larynx stretch due to positive pressure; leading to increased leak-related underestimation of VT by the flow sensor.
* If monitored PIP is continuously high (e.g. pressure-regulating) and set VT is not consistently achieved; potential causes include: need for suctioning, increased ETT leak, abdominal splinting, unassisted breaths, worsening lung mechanics, tension pneumothorax, migration of the ETT into right mainstem or ETT kinking.
* Consider transitioning to PCSIMV when experiencing large leaks or persistent pressure regulation. Refer to <http://chbshare.chboston.org/TS/ptsvc/nicu/NICU/ref_nicu_premature_infant_vent_guideline.doc> for guidance on PC settings.
* Consider High-frequency ventilation if monitored PIP is consistently ≥ 25 cm H2O, or it is not possible to maintain SpO2 > 90% with optimized PEEP and FIO2 ≥ .6

##### Weaning

* As respiratory system compliance improves the PIP required to achieve VT will automatically be reduced by the ventilator.
* Extubation may be considered when the infant is occasionally generating monitored VT ≥ set VT and monitored PIPs are consistently <18 cm H2O without retractions, tachypnea or increased FIO2 requirement.

##### Alarms

* Set High PIP alarm 10 cm H2O above the average monitored PIP. The Servo-u regulates pressure at 5 cm H2O below the High PIP alarm threshold (e.g. A High PIP alarm of 30 cm H2O, will limit pressure at 25 cm H2O.)
* Other alarms will be set in accordance with the Respiratory Care Equipment Alarms Management document.

#### Documentation

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| Patient Care Flowsheet/ Electronic Documentation |  |

#### Related Content

Extubation Readiness Assessment and Testing: Clinical Practice Guideline [NICU]

Respiratory Care Equipment Alarms Management

#### References

Keszler M. Volume-targeted ventilation: one size does not fit all. Evidence-based recommendations for successful use. Archives of disease in childhood Fetal and neonatal edition 2019; 104(1):F108-F112.

Klingenberg C, Wheeler KI, McCallion N, Morley CJ, Davis PG. Volume-targeted versus pressure-limited ventilation in neonates. The Cochrane database of systematic reviews 2017; 10:CD003666.

Klingenberg C, Wheeler KI, Davis PG, Morley CJ. A practical guide to neonatal volume guarantee ventilation. Journal of perinatology: official journal of the California Perinatal Association 2011; 31(9):575-585.

#### Document Attributes

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