PROCEDURE FOR: **Volume Guarantee (VG) in the Draeger Ventilator**

POLICY: This mode is defined as pressure-limited, time-cycled ventilation with tidal volume guidance. It is available with all triggered modes of ventilation (A/C, SIMV, PSV) and is dependent upon a functioning flow sensor. The ventilator software uses continuously measured data from the flow sensor to compare delivered expiratory tidal volume with set tidal volume. The ventilator uses a variable peak inspiratory pressure, between set Pinsp-max and PEEP to deliver the set tidal volume. In effect, it uses the lowest possible peak inspiratory pressure (Ppeak) needed to achieve the target tidal volume. The maximum peak pressure (Pinsp-max) set 20% higher than Ppeak, alerts the clinician of worsening compliances and limits excessively large tidal volumes. The neonate's respiratory rate, I time and Ppeak are allowed to vary.

INDICATIONS:

1. Infants requiring mechanical ventilation whose lung mechanics are changing rapidly.
2. Infants that have variable respiratory efforts.
3. Infants without significant parenchymal disease (e.g. post surgical patient).

ADVANTAGES:

1. VG automatically compensates for changes in compliance, resistance and spontaneous respiratory effort.
2. Infants who are on low maintenance respiratory support with periodic breathing/apnea are assured of set tidal volume.
3. VG leads to a more stable tidal volume and avoidance of volutrauma.
4. Ppeak is automatically regulated based on 6-10 breaths to reach the set tidal volume at the lowest lung compliance. Last three breaths are most heavily weighed (accurate).
5. As lung compliance deteriorates the Pinsp-max will alarm and alert for possible underinflation.
6. VG reduces tidal volume variability and therefore CO2 variability.

LIMITATIONS:

1. When the endotracheal tube is too small producing a leak greater than 35%, accurate determination of tidal volumes is compromised. The measured expiratory tidal volume may be erroneously less than actual tidal volume delivered to the lungs.
2. Infants with vigorous spontaneous efforts can result in set tidal volume being less than spontaneous tidal volume. Indications that the set tidal volume may be too low are when there is labored breathing, gasping and an elevated PCO2. The set tidal volume needs to be increased.
3. Very small tidal volumes < 3-4 cc per breath is difficult to target.

INITIATION:

1. Volume guarantee can be implemented upon initiation of mechanical ventilation.
2. The target tidal volume is 4-7cc/kg for neonates. Variation of measured tidal volume is greater in lower birth weight infants.

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3. Example:
   Set tidal volume parameter.
   Engage volume guarantee.
   Observe pressure required to achieve tidal volume for six consecutive breaths.
   Set Pinsp-max 20% greater than observed pressure.
   Document Ppeak, Pinsp-max, Vt, rate, I-time, and FiO_2.
   Reassess measured tidal volume after 5-10 minutes of initiation.

4. Larger target tidal volumes may be needed for older infants with chronic lung disease due to increased dead space.

5. Pinsp-max is set at upper desired pressure limit. The Pinsp-max should be set 20% higher than the Ppeak needed to deliver the target tidal volume. The Pinsp-max needs to be adjusted in response to changing lung mechanics. When the flow sensor is removed the ventilator will default to the Pinsp-max pressure limit possibly leading to overdistension. Therefore when flow sensor is removed remember to decrease Pinsp-max and when reinserting flow sensor readjust Pinsp-max.

6. When changing the PEEP, the ventilator will compensate to deliver the target tidal volume. Therefore the Pinsp-max may need to be adjusted accordingly.

7. If the infant is persistently tachypneic and the $PaCO_2$ and pH are normal, review spontaneous tidal volumes and consider increasing the target tidal volume.

8. If the pressure limit has to be increased substantially and/or repeatedly verify that the tidal volume measurement is accurate (calibrate the sensor) and assess the patient for compliance changes.

9. If the low tidal volume alarm sounds repeatedly, check three ventilator parameters and assess the infant for changes in lung mechanics. The most common reason is the inspiratory pressure.

Not sure what to call this

1. INSPIRATORY PRESSURE:

   - If the measured Ppeak is close to or the same as the Pinsp-max, then the Pinsp-max is too low for the target tidal volume to be delivered. First check for poor compliance due to worsening disease process. Rule out a plugged ETT or a misplaced ETT. Increase the Pinsp-max if the infant's assessment is unchanged.

2. INSPIRATORY FLOW:

   - **"Measured Ppeak is not close to or equal to Pinsp-max"**. Flow rate is too low if the slope of the rise of pressure (pressure waveform) is very shallow without a pressure plateau and the flow waveform shows flow still going in at the end of Ti. (Refer to diagram B and C on last page)

3. INSPIRATORY TIME:

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- **"Measured Ppeak is not close to or equal to Pinsp-max".** The Ti is too short if the flow on the flow waveform does not return to baseline by the end of Ti and the rise slope in the pressure waveform is normal. (Refer to diagram A and C on last page)

WEANING:

1. The preset ventilatory rate may be decreased, allowing the neonate to do more breathing.

2. When the target tidal volume is set at the low end of the normal range and the $PaCO_2$ is allowed to rise to the low to mid 40"s mm HG, weaning occurs automatically as Ppeak is lowered in response to improving compliance and increasing spontaneous effort.

3. If the tidal volume is set too high and/or the $PaCO_2$ is too low, the baby will not have a respiratory drive and will not self-wean. He will become dependent on the ventilator due to lack of respiratory muscle training. The tidal volume should be set lower to encourage the respiratory drive.

4. If infant is not weaning as expected despite improving lung disease, try lowering the tidal volume to 4cc/kg. Verify normal blood gases and minimal work of breathing.

5. PEEP may need to be increased to provide adequate oxygenation as Ppeak is automatically lowered.

6. Extubation can occur when the tidal volume can be consistently maintained at or above target value with a delivered PIP < 10-12cm H_2O (12-15 cmH2O in infants> 1kg) with FiO_2 < .35 and good respiratory effort.

CLINICAL MANAGEMENT:

1. The target tidal volume should be ordered by physicians and advanced practitioners as _____cc/kg to deliver a tidal volume of ____cc_. An example is as follows: A 1.5 kg infant using a tidal volume range of 4-7cc/kg will require a set tidal volume range between 6 – 10.5 cc. This order is to be initialed by the respiratory therapist and nurse and documented on the respective flow sheet. The very small baby < 700g will require a slightly larger tidal volume. To compensate for the dead space of the sensor, the upper range of the cc/kg number should be used to ensure adequate volume delivered to the baby.

2. The Pinsp-max should be set 20% greater than the measured Ppeak.

3. As the compliance improves the Pinsp-max should be adjusted to maintain a 20% difference between Pinsp-max and measured Ppeak and documented by Respiratory and Nursing. The respiratory therapist will make the adjustment.

4. The percent leak will be documented on respiratory and nursing flow sheets. The respiratory therapist or nurse will notify the advanced nurse practitioner or physician when the leak is greater than 35%. Either the baby will be reintubated to decrease the size of the leak or volume guarantee will be removed as an adjunct to the SIMV/PSV mode.

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5. Prior to removal of the flow sensor (eg. Nebulization) the nurse will contact the respiratory therapist who will turn off the volume guarantee and set the Pinsp-max to the pressure generated by the infant to receive the ordered tidal volume. When the sensor is ready to be placed back in line the respiratory therapist will calibrate the sensor, place the sensor in line and turn on the volume guarantee to deliver the target tidal volume order and reset the Pinsp-max.

TROUBLE-SHOOTING:

1. Alarms: Visual display: “Vt low Check settings”; Lights flashing above flow knob, Pinsp knob and Ti knob.

2. Check % leak --- verify leak less than 35%

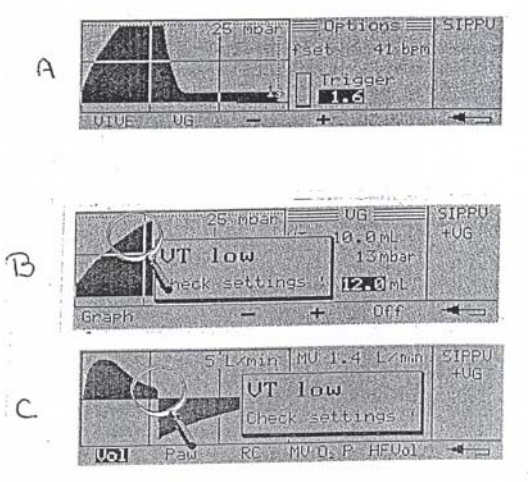
3. Check peak pressure on the **measure 1** screen and the Pinsp-max on the **list screen** to see if the Pinsp-max set by the clinician is too close to the Ppeak. Check on the VG screen and compare set Vt to measured Vt to view disparity. If these exist assess the patient for changes in compliance and possible worsening of disease.

4. Verify placement of ETT and possible obstruction. If the infants’ status is unchanged two other possibilities exist.

5. If the measured Ppeak is not close to or equal to the Pinsp-max and there is no pressure plateau on the pressure waveform then the flow rate may be too low or the Ti is too short to reach the set Pinsp-max.

   - The set flow rate may be too low if the **flow** waveform shows flow still going in at the end Ti and the **rise slope** of pressure in the pressure waveform is very shallow with no pressure plateau. (Refer to diagram B and C)

   - The Ti may be too short if there is significant flow, (flow does not return to baseline) and the rise slope in the pressure waveform is not shallow. (Refer to diagram A and C)



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APPROVAL:

EFFECTIVE DATE:

REVISION DATES: