3100B Clinical Training Program

3100B HFOV
VIASYS Healthcare
HFOV at Alveolar Level

- Nieman, G, SUNY 1999
Who DO We Treat?

- Only Pathology studied to date has been ARDS
- Questions about management of adults with massive airleak and BP fistula?
- Questions about management of Respiratory Failure based on any other disease process
HFOV: One More Tool in the Management of ARDS

How does it work?

- Reduces the risk of further lung destruction.
- Keeps lung open alveoli at constant pressure.
- Ventilates very rapidly at very small volumes.
- Early intervention is key to success.
Theory of Operation and Controls
3100 A

Limit Adjust Button

Piston centering adjustable

3100 B

No Limit Adjust Button

Piston centering connected to I/E Ratio
Decoupling of Ventilation and Oxygenation

- Controls for Oxygenation
  - Paw
  - FiO2
  - Alveolar recruitment maneuver

- Controls for Ventilation- takes time!
  - Amplitude
  - Hertz
  - % I time
  - Cuff Deflation
  - Permissive Hypercapnea
Oxygenation

- Oxygenation is primarily controlled by the Mean Airway Pressure (Paw) and the FiO2.

- Mean Airway Pressure is a constant pressure used to inflate the lung and hold the alveoli open.

- Since the Paw is constant, it reduces the injury that results from cycling the lung open for each breath.
Oxygenation Strategies

- Initial Paw 5 cms > CMV Paw
- ↑ Paw until you are able to ↓ FiO2 to 60% with a SaO2 of 90% or >
- Avoid hyperinflation - CXR
- Optimize preload, myocardial function
- Mean Arterial Pressure > than 75 mmHg
Ventilation

• Controlled by the movement of the pump/piston mechanism
• Alveolar ventilation during CMV is defined as: $f \times Vt$
• Alveolar ventilation during HFV is defined as $f \times Vt^2$
• Therefore changes in volume delivery (as a function of Delta-P, Frequency or % Insp. Time) have the most significant affect on ventilation.
Regulation of stroke volume

The stroke volume will increase if

- The amplitude increases (higher delta P)
- The frequency decreases (longer cycle time)
- There is an increase in Inspiratory Time % (time in forward motion)
Amplitude is a *measurement* created by the *force* that the piston moves which is based on the *POWER setting*, resulting in a volume displacement and a *visual CHEST WIGGLE*.

It is represented by a peak-to-trough pressure swing across the mean airway pressure.
Secondary control of PaCO$_2$ is the Frequency set.
The % Inspiratory Time also controls the time for movement of the piston, and therefore can assist with CO₂ elimination.

Increasing % Inspiratory Time will also affect lung recruitment by increasing delivered Paw.
Clinical Tips

- With cuffed ET tubes, minimally deflating the cuff may allow airway wall CO$_2$ to exit the circuit at the tip of the tube.
Key to Success for ANY Patient considered for HFV

- Choosing the RIGHT patient. HFV is NOT for every patient.
- When to Start?
  - Early application provides protection and reduces incidence of further lung damage
  - Rescue may or may not improve mortality chances. The later HFV is started the less chance of survival
- Gathering the right information before you start in order to make an informed and appropriate decision.
- Monitoring the patient is MANDATORY
- Assessment skills are necessary by everyone at the bedside.
  - Rule #1 Patient tells ALL!
When Do We Think about HFOV for the ARDS Patient?

- When to consider HFOV use?
  - As with all candidates, the earlier the better
  - \( \text{FiO}_2 > 60 \), \( \text{PEEP} \geq 10 \) with P/F ratio < 200
  - > than 30 Plateau Pressure
  - OI > than 24
    - OI = \((\text{FiO}_2 \times 100) \times \text{MAP} / \text{PaO}_2\)
  - ARDS Net Protocol Failing
  - Refer to “outcome assessment” form
Initial Settings and Suggestions for Larger Patient Use On 3100 B

- Patients with ARDS >35 Kg
- Set Paw 5 cmH20 above CV Paw
- FiO2 100%
- Set Hertz at 5-6
- Power 4.0, adjust for good chest wiggle
- I time % at 33%
- Set Bias Flow at >25 lpm, may need to go higher
Ventilator Strategies - Goals

- Normalize lung volume
- Minimize pressure change at alveolar level
- Wean FiO₂ to a safe level first
  - Physiological targets include:
    - Oxygen saturation > 88% < 93%
    - Delay weaning Paw until FiO₂ < 0.50
    - pH > 7.20
    - PaCO₂ in the range of 40 - 70 mmHg
Ventilation Strategies

- **CWF-** adjust Amplitude to target PaCO2 to between 45-70
  - *Remember it is not uncommon to see an increase in PaCO2 when first transitioned*
  
  - ↓ frequency by 1Hz increments if unable to improve ventilation or if Power Setting is maximized
  
  - Allow permissive hypercarbia if indicated, keeping pH>7.25. If necessary, consider buffering pH for the transition phase.
HFOV: Adjusting the settings

- **Hypercapnia**
  - $\uparrow$ delta P
  - $\downarrow$ frequency
  - $\uparrow$ I time
  - (deflate cuff)
HFOV: Adjusting the settings

- **Hypocapnia**
  - ↑ frequency
  - ↓ delta P
HFOV Management

- **Weaning** -
  - Wean FiO2 for arterial saturation > 90%
  - Once FiO2 is 60% or less, re-check chest x-ray and if appropriate inflation, begin decreasing the Paw in 2 - 3 cmH2O increments
  - Wean Delta-P in 5 cmH2O increments for PaCO2
  - Once the optimal frequency is found, leave it alone
Clinical Tips

- Failure Criteria
  - Inability to decrease FiO2 by 10% within the first 24 hrs.
  - Inability to improve ventilation or maintain ventilation (after optimizing both frequency and amplitude) with PaCO2 < 80 with pH > 7.25. A transcutaneous CO2 monitor or ABG’s are imperative for monitoring CO2 in larger patients.
Transition to conventional ventilation

- Mean airway pressure stable
- Tolerating position and nursing care
  - No substantial physiologic changes
- Stable blood gases
- Resolution of original lung pathology
- Switch to PCV (TV 6 ml/kg, 1:1 with PEEP 10)
Monitoring and Assessment

- SPO2
- CXR
- ABG - ½ follow Spo2
- HR and B.P.
- TCCo2 very effective
- Auscultation
- Wiggle

- Settings – measured
- Compliance changes
- This darn thing will enhance my assessment skills!
Clinical Assessment

- Chest Wiggle factor (CWF) must be evaluated upon initiation and followed closely after that.
  - CWF absent or becomes diminished is a clinical sign that the airway or ET tube is obstructed.
  - CWF present on one side only is an indication that the ET tube has slipped down a primary bronchus or a pneumothorax has occurred. Check the position of the ET tube or obtain a CXR.
  - Reassess CWF following any position change.
Clinical Assessment

- **Chest X-rays**
  - Obtain the first x-ray at 1 hour preferably, but no greater than 4 hour mark to determine the lung volume at that time. Paw may need to be re-adjusted accordingly.
  - Always obtain a CXR, if unsure as to whether the patient is hyper-inflated or has de-recruited the lung.
Clinical Assessment

- Chest X-rays
  - Stopping the piston, or re-positioning the head to shoot an appropriate film is not necessary.
  - Do not remove the patient from HFOV and manually ventilate to shoot the film. The purpose of the x-ray is to verify the lung volume that the HFOV is producing.
  - A physician, nurse, or therapist should be at bedside to assure the patency of the airway and the patient’s position.
When Good Compliance Turns Bad

- Monitor B.P. and HR
- Wean Paws on low FiO2
- Signs of hyperinflation or increased alveolar dead space
- Obtain frequent CXRs- 1 hour and Q6
- Pay close attention to CWF and Transcutaneous CO2
Clinical Assessment

- Auscultation
  - Heart Sounds - stop the piston, (the patient is now on CPAP); listen to the heart sounds quickly, and start the piston back up. Removing the patient from the ventilator may result in loss of lung volume.
Auscultation

- Breath sounds - identifying the normal “breath sounds is difficult, since HFOV is not ventilation with a bulk flow of gas through the airway.
  - Listen to the “intensity or sound” that the piston makes, it should be equal throughout.
  - If not the same sound, re-assess the patient to determine if a chest x-ray is necessary at this time.
Suctioning

- Indicated by decreased or absence CWF, decrease in O2 saturation, or an increase in TcCO2.
- Remember that each time the patient is disconnected from HFOV, they will potentially de-recruit lung volume.
- Closed suction catheters may mitigate de-recruitment, and you may have to adjust the delta P to compensate for the attenuation of the delta P due to the right angle adapter.
- It may be necessary to temporarily ↑ Paw
Patient Care

- **Bronchodilator Therapy** -
  - Patients who are actively wheezing or have RAD
  - administration via bagging - try to coordinate with suctioning
  - IV terbutaline for patients who do not tolerate disconnects
Patient Care

- Humidification of bias flow accomplished with a traditional heated humidifier
- Longer, flexible circuit allows patient positioning to prevent skin breakdown
Patient Care

- Sedation or Paralysis
  - Patients may require paralysis for initial transition and then may be sedated to be maintained on the 3100B. Limitation of flow on the 3100B to meet inspiratory demand of an ARDS patient is the reason.
Patient Care: Positioning

- Every position possible including PRONING
- At least 1 therapist and 1 nurse (risk of disconnection)
- After change of position, observation of chest wiggle, SpO2 and tcPCO2
- Re-adjustment of ventilator parameters if needed
- Check ET tube position
Potential Complications

- Hypotension - may occur
  - Administer serial boluses of fluid until CVP or PCWP has increased by 5 - 10 mmHg
  - Vasopressors - may be necessary if hypotension persists following fluid boluses
Potential Complications

- **Pneumothorax may occur during HFOV**
  - Patient may exhibit with progressive hypotension and desaturation
  - CWF may be affected on the pneumothorax side, visual decrease
  - Auscultation may be affected on the pneumothorax side. Distant and dampened sound of piston in comparison to opposite side
Potential Complications

- **Endotracheal Tube Obstruction**
  - An abrupt rise in PaCO2 during HFOV in an otherwise stable patient may be the result of airway obstruction
  - Suction catheter should be passed immediately to ensure patency of ET tube
  - May consider bronchoscopy