High Frequency Oscillatory Ventilation (HFOV)

HFOV is a technique that aims to reduce lung injury from ventilation by avoiding both over-inflation and recurrent collapse and re-expansion. Very small tidal volumes are delivered at high frequency (most commonly 10 Hz – 600/minute) on top of a background mean airway pressure (MAP) that maintains full alveolar recruitment. Because most infants have received antenatal steroids and propylactic surfactant, there is probably no great advantage or disadvantage to the routine initial choice to use HFOV or conventional ventilation. If there is severe initial lung disease or interstitial emphysema there is some evidence to suggest that HFOV may be a more successful strategy than conventional ventilation.

The way HFOV works is best understood if oxygenation and CO_2 elimination are considered separately.

Oxygenation on HFOV

- As in conventional ventilation oxygenation is determined by the mean airway pressure (MAP)
- HFOV can be considered as a special kind of CPAP. The MAP (CPAP) is set at a level that results in good alveolar inflation which is usually higher then can be weaned once lung is better recruited.
- Aim to achieve a low FiO_2 by using an adequate MAP (high volume strategy)
- If MAP is appropriate the FiO_2 should be low
- If MAP is too low atelectasis will cause increased oxygen requirements
- If MAP is too high, reduced pulmonary blood flow can increase oxygen requirements
- Check for overinflation with regular chest x-rays
- Once FiO_2 is low start turning the MAP down
- Do not tolerate a high FIO_2 in the interests of having a low MAP
- Ensure that the blood pressure and blood volume are satisfactory as compromised pulmonary blood flow will limit the efficacy of HFOV
- **FIO_2 greater than 30% it may mean that you are doing it wrong and need to discuss things with someone more senior**

Sometimes when the MAP is decreased e.g. with suction, or weaning that is too rapid, the alveoli collapse down and the FiO_2 goes up. Under these circumstances the alveoli have to be re-inflated. This will only happen gradually if nothing active is done.

- If the FiO_2 stays low the lungs are adequately recruited and no action is required
- If the FiO_2 goes up, increase the MAP in increments until the FiO_2 comes back down again and then reduce the MAP until you are back where you were before
- **In our experience, loss of lung recruitment is rarely a problem and we seldom need to use recruitment strategies**

CO_2 Elimination on HFOV

- CO_2 elimination on HFOV is achieved by the tidal volume of the oscillations
- The amount of gas that goes in and out of the baby with each oscillation (VTHF) is usually around **2ml per kg**
- **Some of our newer ventilators allow you to target tidal volumes**
- **CO_2 elimination is altered by adjusting the size (amplitude) of the oscillations**
- Increasing the amplitude will blow off more CO_2 and decreasing it will blow off less
- CO_2 elimination is proportional to tidal volume squared
- **Adjusting the rate (frequency) is not often necessary**
- The best CO_2 elimination generally occurs at 10 Hz (600 per min)
- Increasing the frequency may paradoxically worsen the CO_2 exchange by allowing less time for the oscillations to be transmitted
- Exceptionally, the frequency may be lowered if CO_2 exchange is poor because the VTHF is inadequate on maximum power

- **HFOV often lowers PCO_2 very rapidly**. Very frequent blood gases are required to avoid low PCO_2 during stabilisation

On the **SLE2000HFO** the amplitude is the delta-P (d -P) in cmH_2O measured in the ventilator circuit. Increases in d -P are linear.

Clinical approach to HFOV

There are only 3 things to adjust on HFOV:

- MAP to optimise lung inflation, eliminate atelectasis and minimise FiO_2
- Amplitude to determine CO_2 elimination
- FiO_2 to fine tune oxygenation

There is no need for routine paralysis, nor is there any increased need for sedation in comparison to conventional ventilation.

Infants less than 29 weeks gestation

- Before the birth of these infants, the consultant on-call should be notified of their anticipated delivery
- The Consultant will aim to attend the delivery and supervise the resuscitation and prophylactic surfactant administration with you
- Soon after admission of the infant to the neonatal unit the consultant will decide which ventilation strategy should be used after assessment of the clinical situation

Initial HFOV settings

- Frequency 10 Hz
- Amplitude SLE2000HFO d -p which gives visible chest oscillation
- MAP 8-10cmH_2O (higher if the infant required high pressures during transition)
- Tidal Volume 2-3 ml/kg (try lower end, may be lower in CDH/Pulmonary hypoplasia)

Adjustment

- The chest should be visibly oscillating
- Adjust the amplitude according to the TV achieved/$PaCO_2$
- Get another x-ray after several hours on the oscillator to assess the lung inflation
- Good inflation is assessed as 8 ribs visible above the diaphragm posteriorly
- Avoid over-inflation.
- If FIO_2 is < 30% wean the MAP in increments of 1cmH_2O
- Stop weaning if this is associated with increasing FIO_2

Rescue treatment of infants with severe lung disease

- If there is already established lung injury when HFOV is commenced or if it develops on HFOV aim to reduce the mean airway pressure a little and tolerate a higher FIO_2 (up to 60%)
- This is referred to as a low volume strategy

HFOV with Pulmonary hypoplasia/diaphragmatic hernia

- HFOV has been used with some promise in this situation
- The lungs are usually small but not immature
- High MAP's tend to make things worse
- The associated PPHN means that you should be happy with FiO_2 of around 60% rather than trying to get it down to less than 30%

- High MAP will worsen the pulmonary vascular resistance
- Good blood pressure is important
- Lung inflation is hard to assess radiologically
- Check to see that the lungs are not bulging at the intercostal spaces as the number of posterior ribs visible will be less than normal

Weaning HFOV

- Decrease MAP to 6-8 cm H_2O
- Decrease amplitude as long as this is tolerated
- Consider extubation direct from HFOV
- If early extubation is not possible, HFOV often becomes problematic after a week or two as secretions begin to increase
- Consider switching to gentle SIMV then wean as usual

Endotracheal suction on HFOV

- In the early stages of RDS there are very few secretions so routine suction is seldom required to begin with
- If secretions are building up they cause decreased tidal volume and increased PCO_2 so this may guide when suction is needed
- If FiO_2 goes up after suction you may have to re-open the alveoli with more MAP or a few manual inflations