**OVERVIEW**

High Frequency Oscillation Ventilation (HFOV) is an unconventional form of mechanical ventilation that maintains lung recruitment, avoids overdistention, and does not rely on bulk flow for oxygenation and ventilation

**DESCRIPTION**

small tidal volumes (1-4mL/kg)
delivered at high frequencies (3-15 Hz) with an oscillatory pump
maintains constant lung recruitment
targets a mean airway pressure and then maintains it with very little change
aims to prevent lung injury from overdistention and loss of recruitment (atelectrauma)

**MECHANISM OF GAS EXCHANGE**

Tidal volume is less than dead space so normal bulk flow inadequate. But gas delivery into the system still undergoes gas exchange by a number of proposed mechanisms:

Pendelluft mixing = mixing of gas between lung units due to impedance differences
Augmented diffusion = gas mixing within the alveolar units
Taylor dispersion = dispersion of molecules beyond the bulk flow front
Coaxial flow patterns = net flow through the center of the airway on way down, then on outside of airway on way up
Cardiogenic mixing = agitation of surrounding lung tissue with molecular diffusion

**INDICATIONS AND CONTRA-INDICATIONS**

**Indications**

-oxygenation failure: requiring an $FiO_2 > 0.7$ and PEEP >14 cmH20. ARDS/ALI in primary treatment or rescue in failed oxygenation with conventional ventilation
Multiple studies show it isn't beneficial (see below)
-ventilation failure: pH < 7.25 with VT 6mL/kg and plateau pressure > 30cmH20
This is where it still has benefit

**Contraindications**

-alternative means of treating respiratory failure available and preferred (e.g. ECMO)
-severe airflow obstruction
-intracranial hypertension

**VENTILATION PRINCIPLES**

**Targets**

pH > 7.25
Utilize highest possible frequency to minimize tidal volume (only decrease for $CO_2$ control if amplitude of oscillations maximal)
$SpO_2$ > 88% or $PaO_2$ 55mmHg (decreases oxygen toxicity)

**Factors determining $PaO_2$**

mean airway pressure
$FiO_2$

**Factors determining $PaCO_2$**

amplitude of oscillations (delta P) ("power")
frequency of oscillations (Hz)
inspiratory time
cuff leak

These factors can be independently adjusted

**Typical Initial settings in adults**

- Bias flow 40 L/min
- Inspiratory time 33%
- mPaw 34 cm H2O
- FIO2 1.0
- Amplitude (delta P) 90 cm H2O.

Initial frequency based on most recent arterial blood gas:

pH <7.10 = 4 Hz
pH 7.10–7.19 = 5 Hz
pH 7.20–7.35 = 6 Hz
pH >7.35 = 7 Hz

After initial HFOV settings are established, perform an initial recruitment maneuver and oxygen/mPaw adjustment as per protocol (see Fessler et al, 2007)

**<u>PROS AND CONS OF HFOV</u>**

Advantages

- decreases ventilator induced lung injury
    - although when they get a pneumothorax it is usually rapid and spectacular
- dissociation between oxygenation and carbon dioxide clearance
- mobilization of secretions

Disadvantages

- derecruitment once ceased
- requirement for heavy sedation and paralysis
- higher risk of hemodynamic instability due to high mean airway pressure
- requires active humidification
- no evidence of benefit, and higher mortality in adult ARDS in one important RCT (OSCILLATE)

**EVIDENCE**

Evidence summary

- HFOV found to cause harm or have no benefit in the 2 best RCTs in adult ARDS patients
- previous studies compared HFOV to outdated ventilation strategies
- Unclear if lack of benefit is due HFOV per se or the protocols used, patient selection or need for increased sedation and paralysis
- As ARDS is a heterogeneous lung disease from differing causes, there may be some patient subgroups that might be helped (e.g. patients with homogeneous, recruitable lung) while others are harmed — but we don't know if this is true!
- HFOV should not be a routine part of the management of ARDS patients, but is still an option for refractory ARDS patients (in the absence of ECMO)

Cochrane Systematic Review (published prior to OSCAR and OSCILLATE)

- meta-analysis in ALI and ARDS patients
- 8 RCTs, n= 419 patients
- reviewed HFOV vs conventional MV as initial strategy rather than as a rescue treatment for refractory hypoxaemia
- in HFOV group
  -> PF ratios higher at 24 hour intervals through improving mean airway pressure
  -> mortality significantly reduced at 30 days
  -> less likely to fail
  -> no effect on duration of MV
  -> not associated with an increase in adverse events
- Commentary and criticisms:
  — results of OSCAR and OSCILLATE were not included
  — based on only a small number of patients

OSCAR trial 2013

- non-blinded intention-to-treat MC RCT
- 795 patients
- HFOV versus usual care control group
- outcomes:
  -> all cause mortality at 28 days was 41.7% vs 41.1% (P=0.85 chi-square test)
- Commentary and criticisms:
  — less hemodynamic compromise, lower airway pressures than OSCILLATE and more protocol variation, possibly due to physician judgement limiting the harm from HFOV settings
  — HFOV groups received more sedatives and muscle relaxants
- Conclusion: no mortality difference at 1 month

OSCILLATE trial 2013

- non-blinded intention-to-treat MCRCT
- 548 new-onset, moderate-to-severe ARDS patients
- HFOV vs low TV high PEEP controlled ventilation strategy
- outcomes:
  -> 47% vs 35% in-hospital mortality (RR 1.33, 95% CI 1.09 to 1.64)
  -> were given more midazolam, more NMBs, more vasopressors
- Commentary and criticisms:
  — stopped early due to harm from HFOV
  — HFOV strategy had high mean airway pressures – would a lower mean airway pressure strategy make a difference?
  — groups similar at baseline, both had baseline recruitment manoeuvre to improve lung homogeneity
- Conclusion: Increased mortality in ARDS patients treated with HFOV