High Frequency OSCillation in ARDS

Dr Elena Lambert
Clinical Fellow for the OSCAR Trial

Introduction

- What is HFOV
- About the OSCAR Trial
- The Vision Alpha ventilator
- Day to day use of the ventilator
- Protocols
- Support
- Summary and Questions

Agenda

- Theory
  - This morning
- Practical
  - This afternoon
  - Setting up the ventilator
  - SimMan demonstration
- Q&A
- Feedback

What is HFOV?

- 'CPAP with a wiggle'
- High frequency ventilation
- Tidal volumes approach or are less than anatomical dead space
- Lungs kept 'open' with a constant airway pressure
- Allows clinician to deal with oxygenation and ventilation separately

History of HFOV

- Initial concept, 1915, smoke blown down a tube travels in a very thin column, could you ventilate with only a small volume?
- Trialled in animals from 1975 but results not replicated in human model
- Used successfully in neonates and then Paediatrics since 1983
- Several small trials in adults since 1999
- Used in several units in UK but often 'when all else fails'

Theory behind HFOV

*Weavind and Wenker 2000

- Bulk flow can still provide conventional gas delivery to proximal alveoli with low regional dead space volumes.
- Coaxial flow. Gas in the centre flows inward, while gas on the periphery flows outward. This can develop because of the asymmetric low profile of high velocity gases.

Theory behind HFOV (2)

*Weavind and Wenker 2000

- Pendelluft can mix gases between lung regions having different impedances.
- Taylor dispersion can produce a mixing of fresh and residual gas along the front of a flow of gas through a tube.

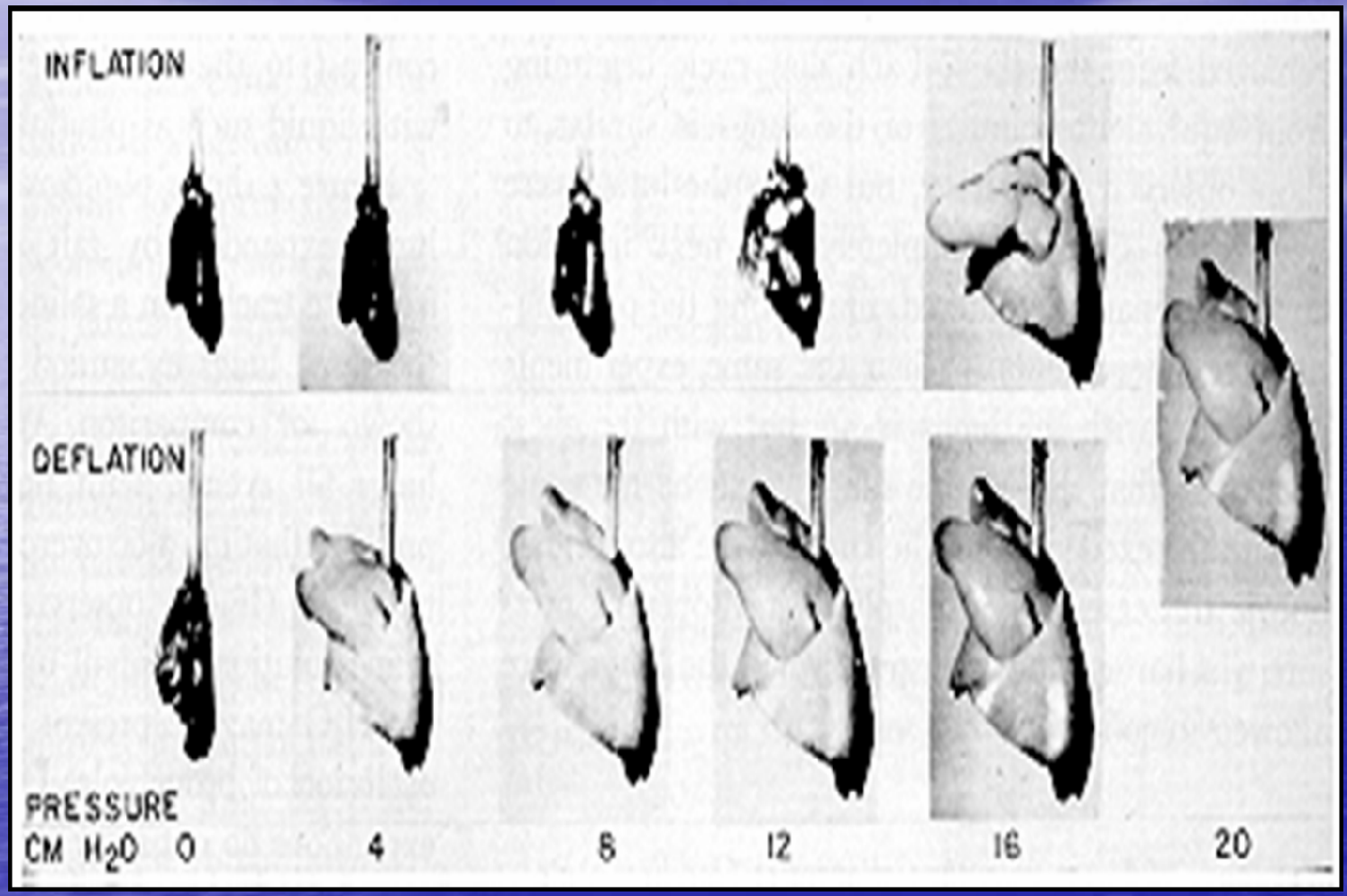
Theory behind HFOV (3)

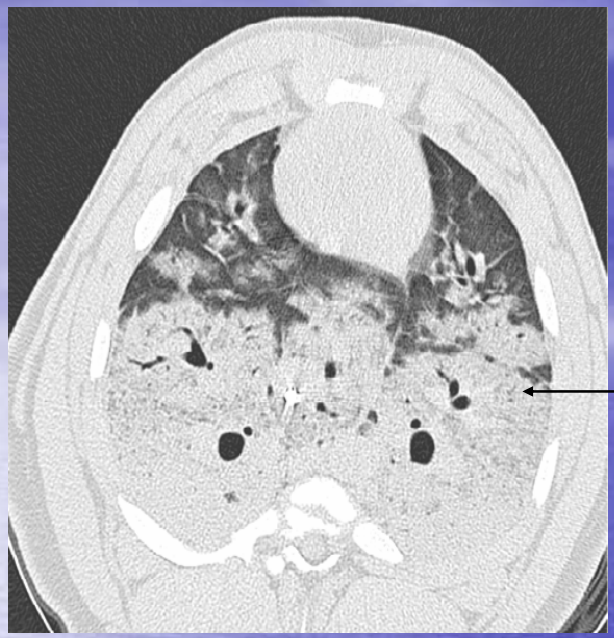
*Weavind and Wenker 2000

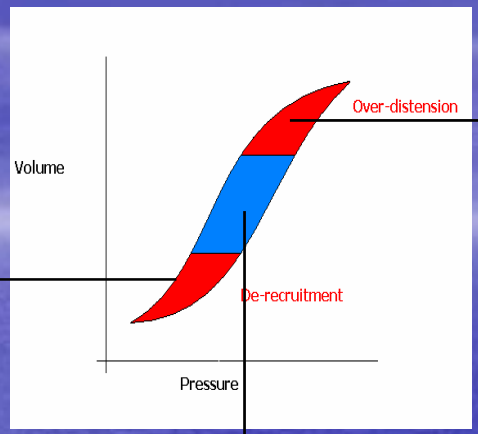
- Augmented molecular diffusion can occur at the alveolar level secondary to the added kinetic energy from the oscillations.

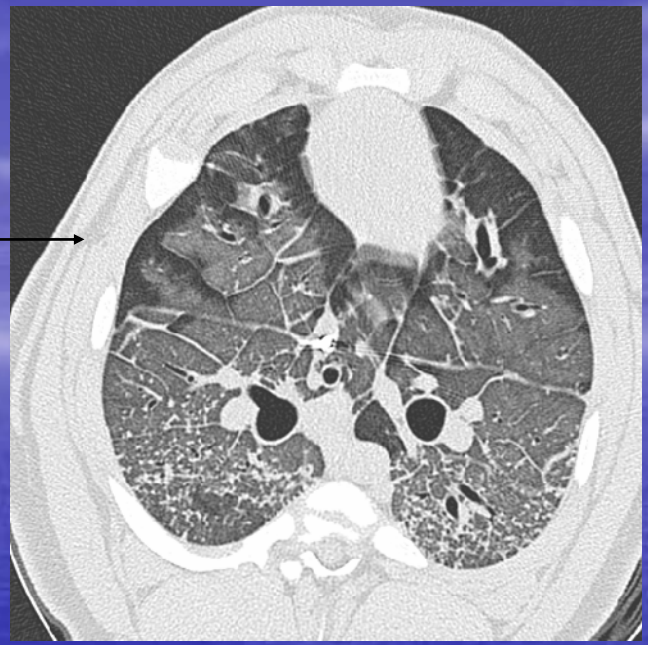
Why HFOV?

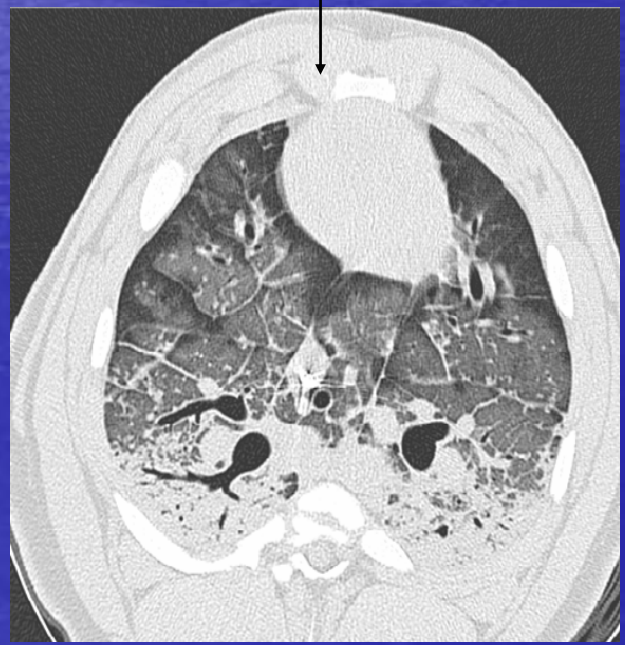
- We know that 'conventional ventilation' can be harmful
- ARDS has high morbidity and mortality rates
- Lung protective ventilation
- Theorised to reduce biotrauma


INFLATION
DEFLATION
PRESSURE
CM H2O 0
4
8
12
16
20




Over-distension
Volume
De-recruitment
Pressure





The OSCAR Trial

- High frequency OSCillation in ARDS
- Several small studies comparing CV and HFOV – but not enough evidence
- Need to know if it is better
- 10 centre, open, randomised control trial
- Early ARDS rather than as a rescue therapy
- Start recruiting 1/11/07, for 3 years
- Target = 2 patients per month per unit

Other Trials

- Two other current trials
- USA and Canada
- Similar criteria to ours
- Small
- Canada has view to extend if preliminary results are good
- Using Sensormedics ventilator

Inclusion Criteria

- ≥16 years
- ≥35 kg
- ARDS
  - PaO_2/FiO_2 ratio≤26.7kPa, with a PEEP≥5cmH_2O on 2 ABG's, 12 hours apart
  - Bilateral infiltrates on CXR
  - 1 or more RF for ARDS
- Receiving artificial ventilation
- Likely to require ≥48 hours of ventilation
- 'Substantially uncertain' as to the utility of HFOV for this patient
- Ventilated for <7 consecutive days (168 hours)

Exclusion Criteria

- LA hypertension
- Moderate - severe airway disease causing airflow limitation
- Lung biopsy or resection (this admission)
- Patient refuses
- Patient unable to consent (language)
- If active treatment is/to be withdrawn
- In another trial (30 days prior to randomisation)
- Previously enrolled in the OSCAR trial
- Any other condition likely to make HFOV hazardous

Vision Alpha Ventilator

- Both HFOV and CV
- New to this country
- Made in Japan
- Currently used in Germany
- CE marked
- Motorbike muffler to reduce noise

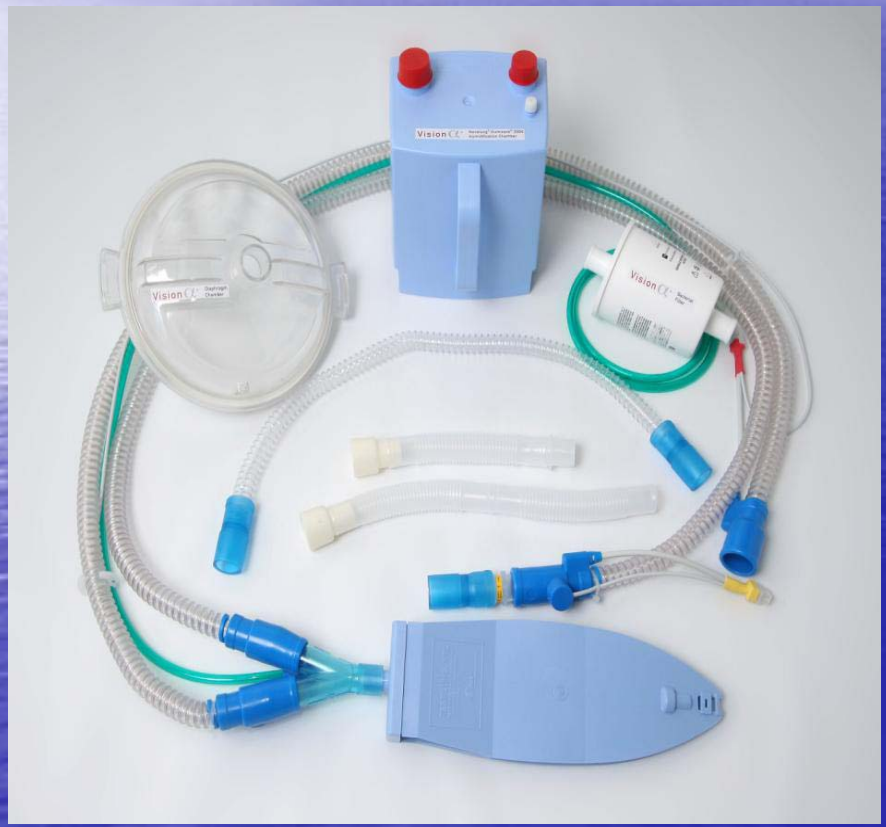
Front view

- Divided into main (upper) and blower (bottom) units
- Operation panel
- Respiratory circuit connector sections
- HFOV drive section
- Dedicated humidifier bracket

Rear View

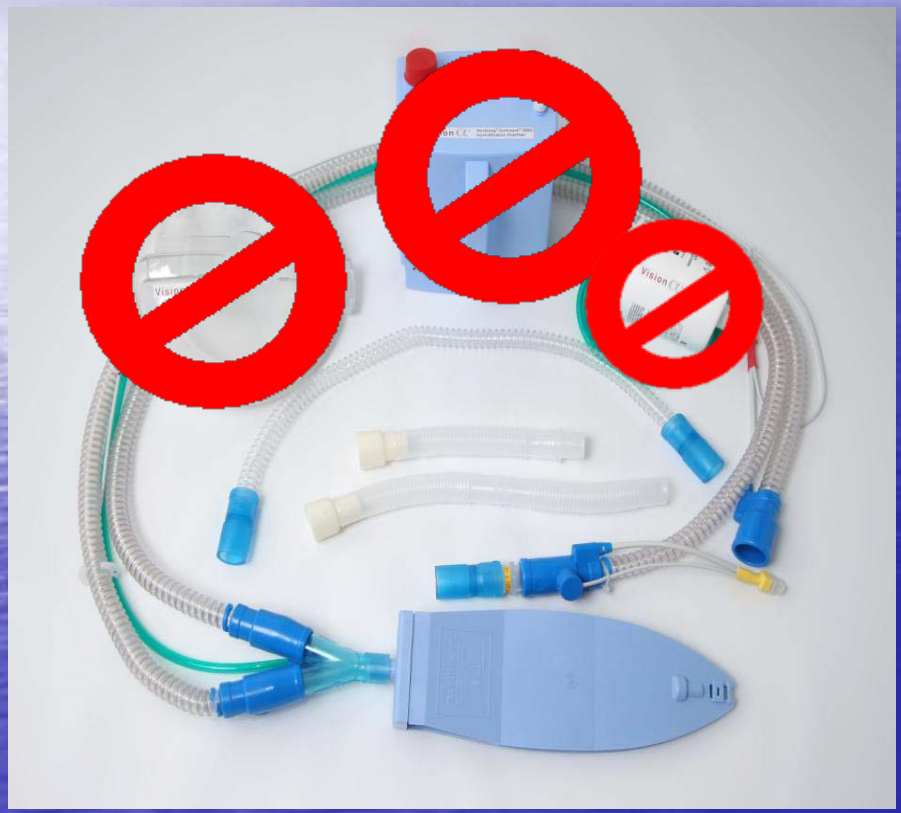
- Interface block, currently only used for service
- Gas connector section
- Breaker section
- Filter section
- Auxiliary breaker section
- No battery

Patient set



- Humidifier
- Expiratory filter
- Circuit
- Oscillator diaphragm
- Disposable

Circuit

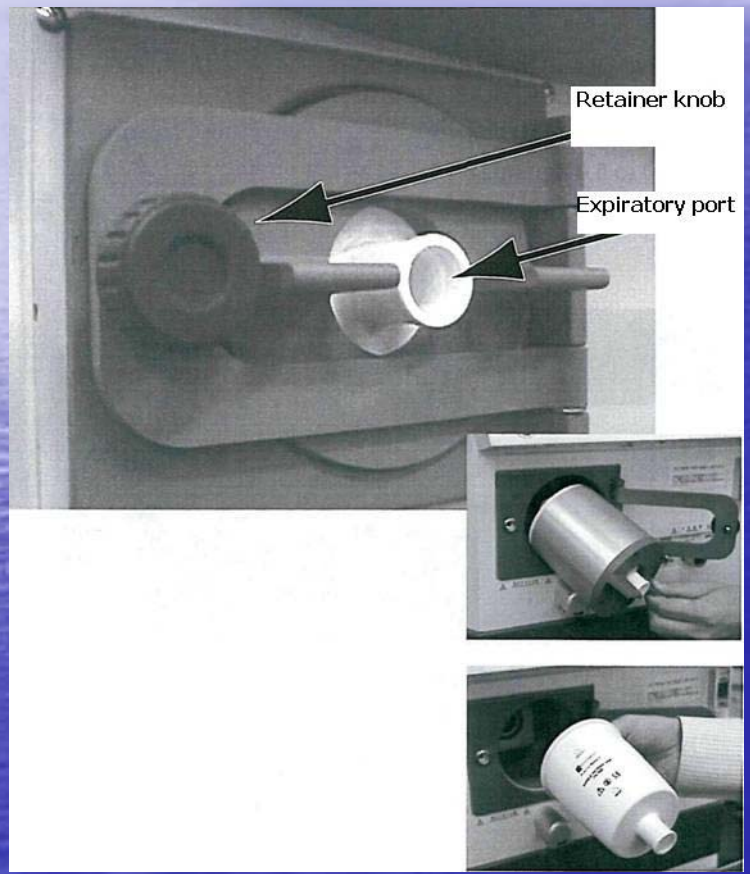


- No rain out
- Narrower tubing
- Heated from the outside
- Disposable

Impedance valve

- Expensive!
- Requires EOG sterilisation between patients

Expiratory Filter

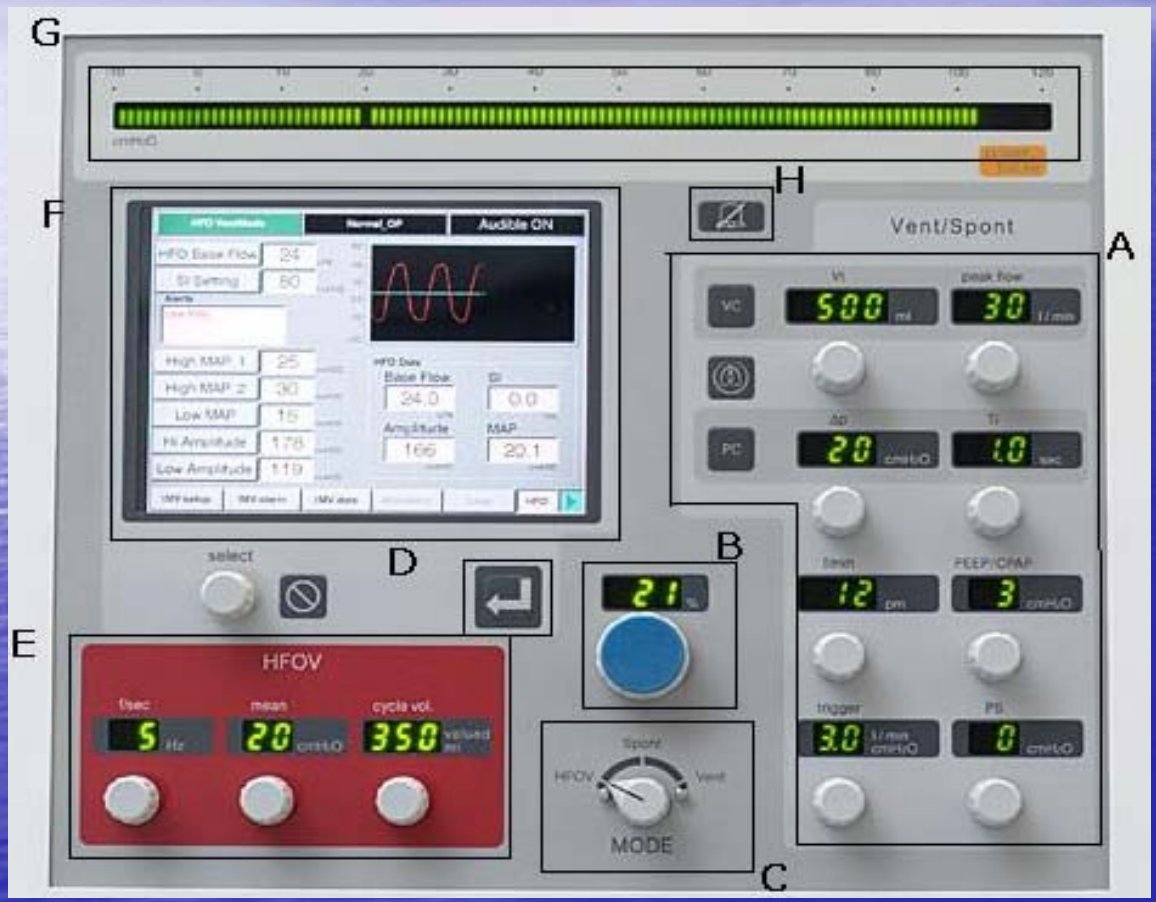


- Heated so does not require changing as frequently
- Easy to change

Humidifier

- Opaque
- Large membrane
- Auto fills
- 30 day life

Control Panel



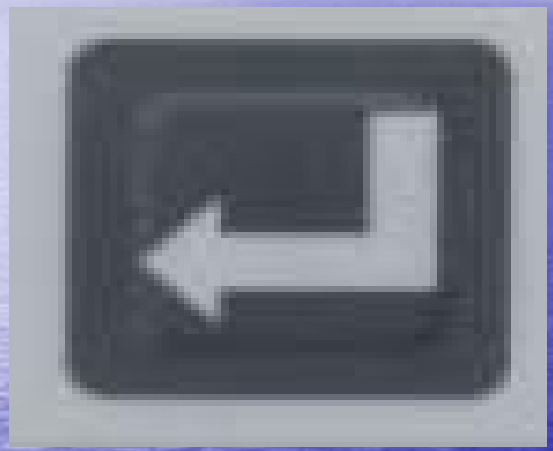
- A: CV controls
- B: FiO_2 control
- C: Mode adjustment
- D: Accept button
- E: HFO controls
- F: Screen
- G: LED bar graft
- H: Silence alarm

HFOV Controls

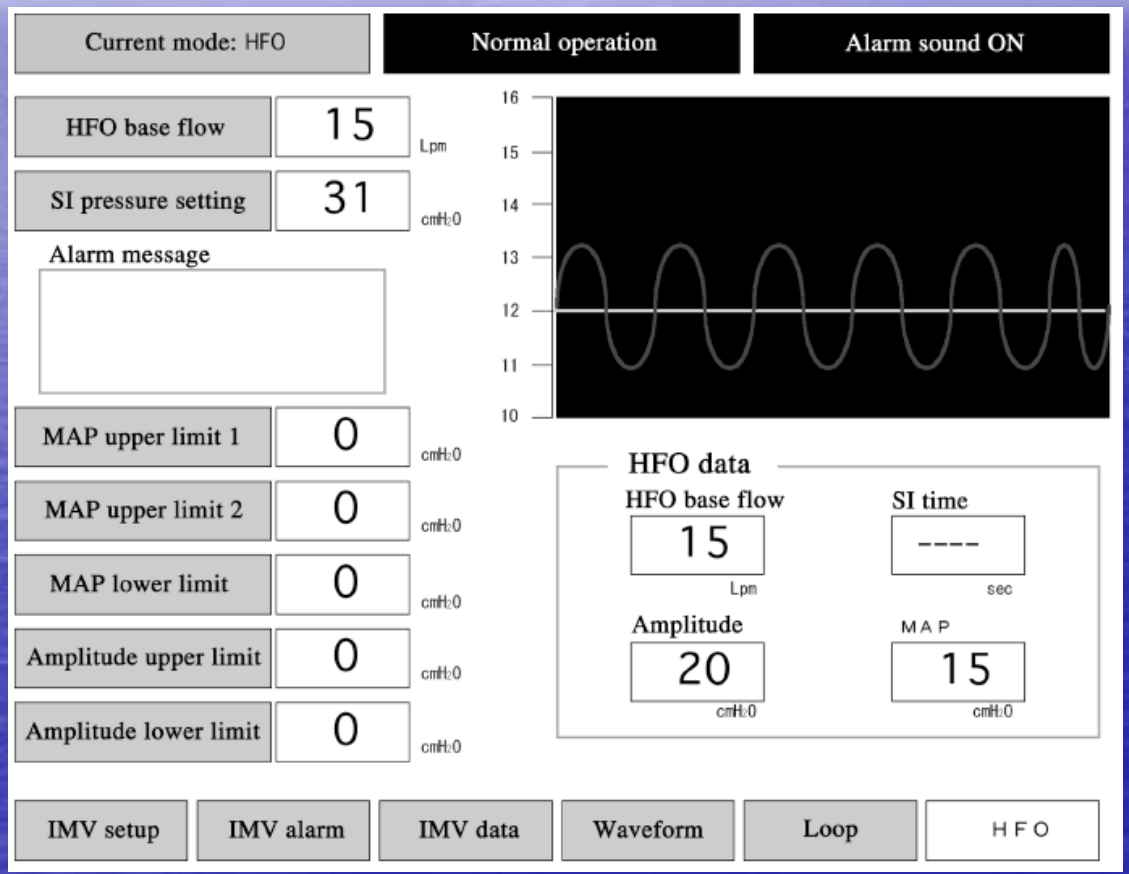
Conventional Ventilation Controls

FiO_2 and Mode Controls

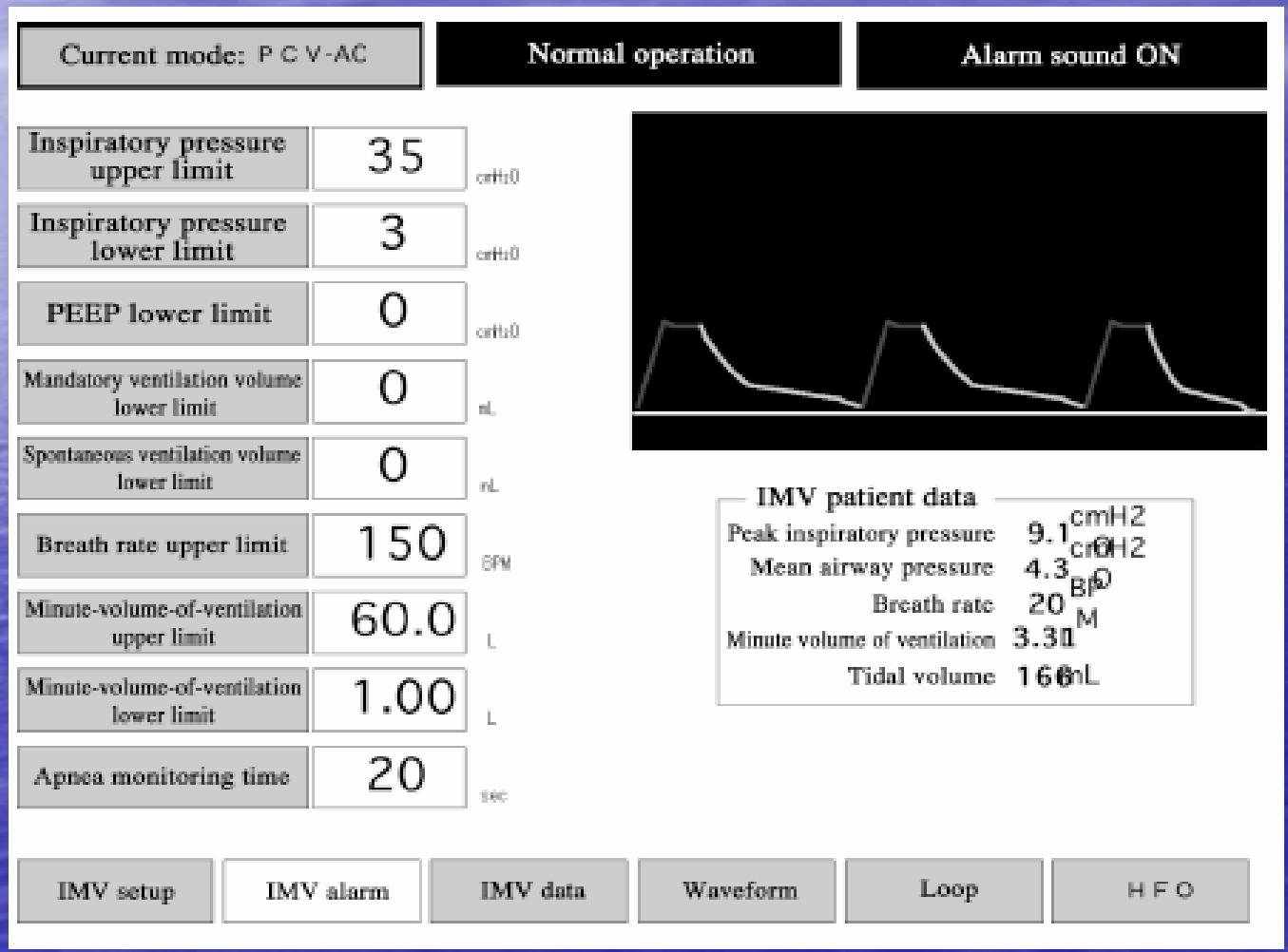
Accept, Silence and LED Bar



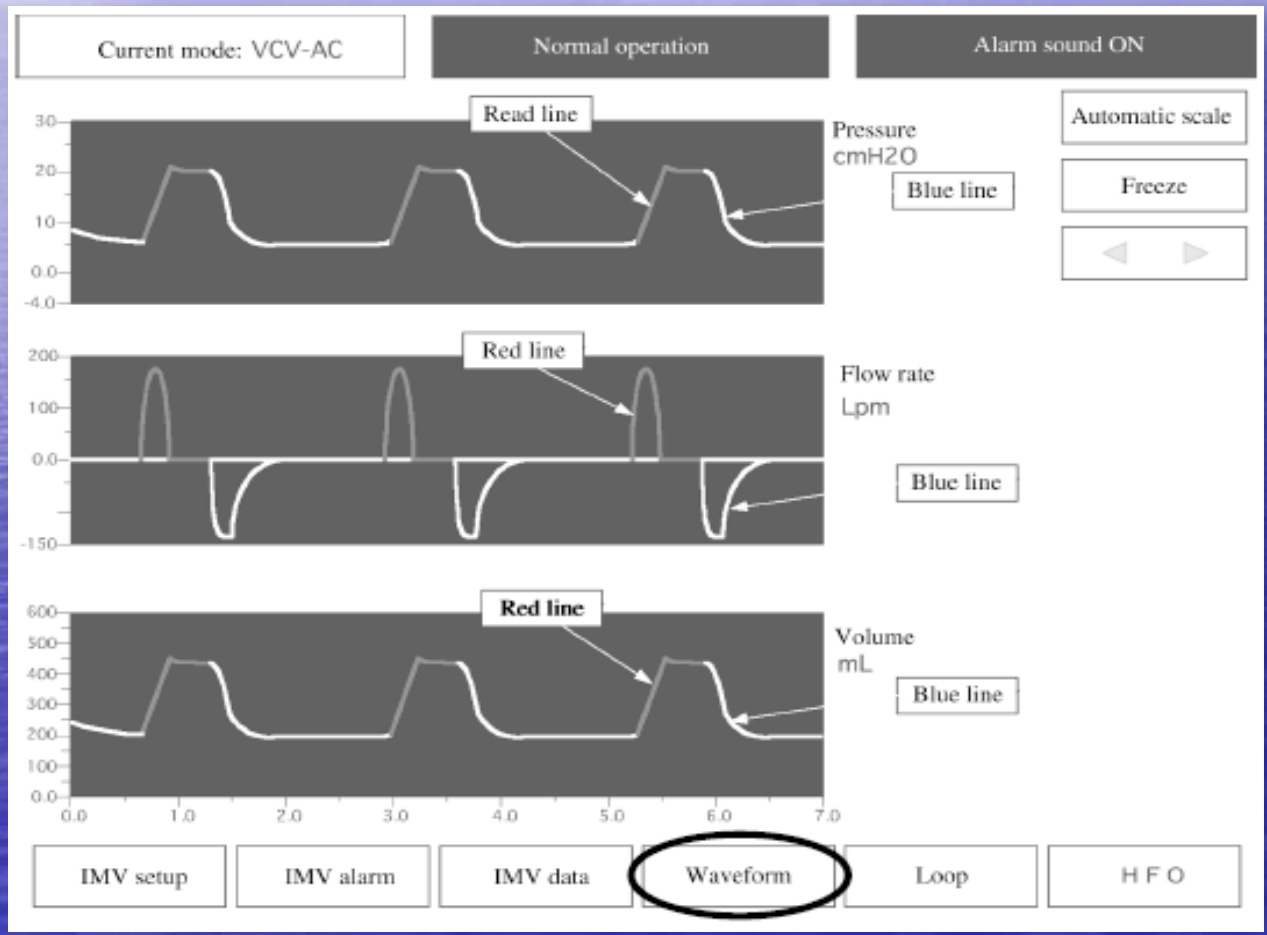
HFO Screen


Current mode: HFO
Normal operation
Alarm sound ON
HFO base flow
15
Lpm
SI pressure setting
31
cmH:0
Alarm message
16
15
14
13
12
11
10
MAP upper limit 1
0
cmH:0
MAP upper limit 2
0
cmH:0
MAP lower limit
0
cmH:0
Amplitude upper limit
0
cmH:0
Amplitude lower limit
0
cmH:0
HFO data
HFO base flow
15
Lpm
SI time
----
sec
Amplitude
20
cmH:0
MAP
15
cmH:0
IMV setup
IMV alarm
IMV data
Waveform
Loop
HFO

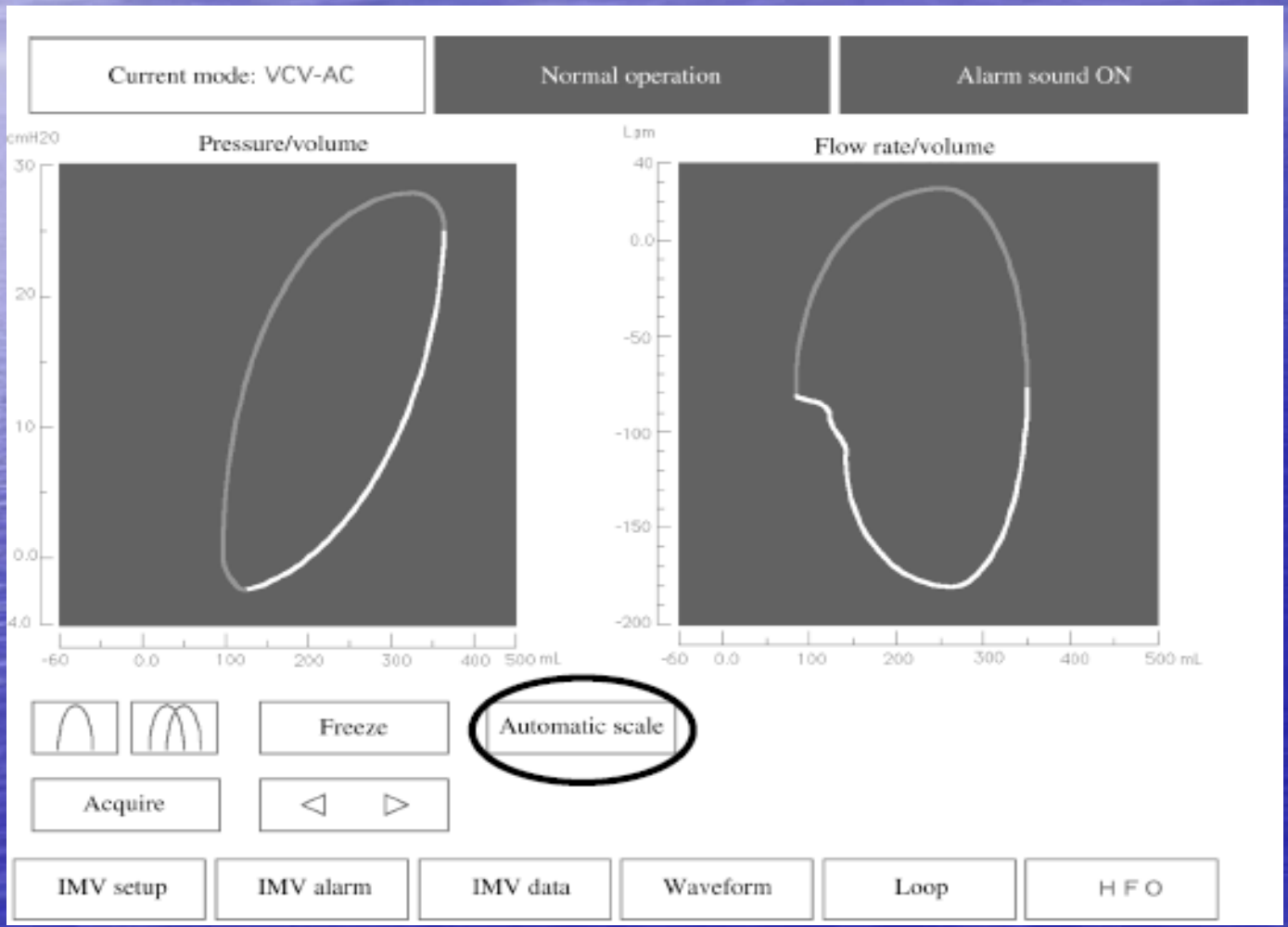
CV screen


Current mode: P C V-AC
Normal operation
Alarm sound ON
Inspiratory pressure upper limit
35
cmH2O
Inspiratory pressure lower limit
3
cmH2O
PEEP lower limit
0
cmH2O
Mandatory ventilation volume lower limit
0
mL
Spontaneous ventilation volume lower limit
0
mL
Breath rate upper limit
150
BPM
Minute-volume-of-ventilation upper limit
60.0
L
Minute-volume-of-ventilation lower limit
1.00
L
Apnea monitoring time
20
sec
IMV patient data
Peak inspiratory pressure
9.1 cmH2O
Mean airway pressure
4.3 cmH2O
Breath rate
20 BPM
Minute volume of ventilation
3.31 L
Tidal volume
166 mL
IMV setup
IMV alarm
IMV data
Waveform
Loop
H F O

Waveform screen



Loop screen


Current mode: VCV-AC
Normal operation
Alarm sound ON
cmH2O
Pressure/volume
30
20
10
0.0
-4.0
-60
0.0
100
200
300
400
500 mL
L/m
Flow rate/volume
40
0.0
-50
-100
-150
-200
-60
0.0
100
200
300
400
500 mL
Freeze
Automatic scale
Acquire
IMV setup
IMV alarm
IMV data
Waveform
Loop
H F O

Differences between CV and HFOV

- Tidal volumes ≤ dead space
- Decreasing the frequency (i.e. RR) helps remove CO_2
- Different values to observe and record
- Auscultation of little value
- No rain-out in tubing owing to new humidifier

Family

- Possibility of more concerns as patient looks less ‘alive’ on HFOV compared to CV
- Or may think that this is a ‘miracle machine’ that will save patient
- Family need to be informed and not given unrealistic hope

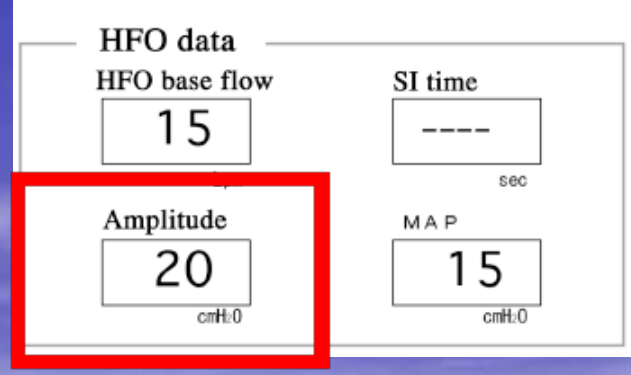
Daily data collection

- Mean Airway Pressure
  - A control of oxygenation
  - Start at value according to protocol
  - Increase to promote recruitment and oxygenation
  - Can be decreased when happy with oxygenation to a more constant level
  - Value on screen will fluctuate slightly

Daily data collection

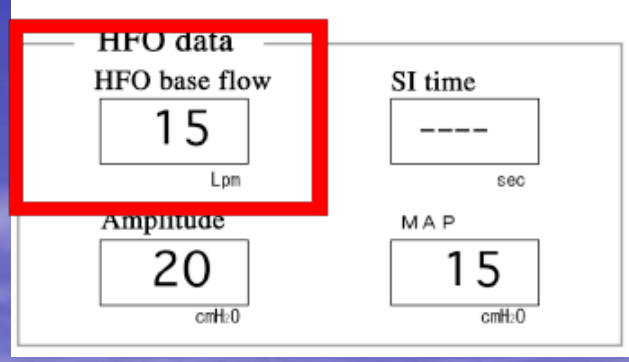
- Frequency (H_z)
  - A control of ventilation
  - Start at value according to protocol
  - Decrease this to remove CO_2
- Cycle volume (ml)
  - A control of ventilation
  - Start at value according to protocol
  - This will change with a change in frequency
  - Increase this to remove CO_2
  - Affects the Amplitude

Daily data collection



- Measured Amplitude (cmH_20)
  - Reflects the compliance of the circuit/lungs
  - Changes can be subtle but can be effective warning system
  - Will change if the frequency is altered
  - Unexplained rise: Secretions/Obstruction
  - Unexplained fall: Pneumothorax

Daily Data Collection



- Base (Bias) Flow
  - Usually stable
  - Set at level according to protocol
  - May need to be increased e.g. if patient has lighter sedation

Suctioning

- Always suction patient before going on to HFOV
- Suctioning possible with closed system device
- Need to be aware that this can cause de-recruitment
- Low pressure alarm may sound, PaO_2 may drop
- May need to re-recruit lungs after as algorithm
- Physio: possible as normal

Problems at initiation

- Coughing
- MAP swings
- Alarms
- Hypotension – most common cause at this stage is hypovolaemia

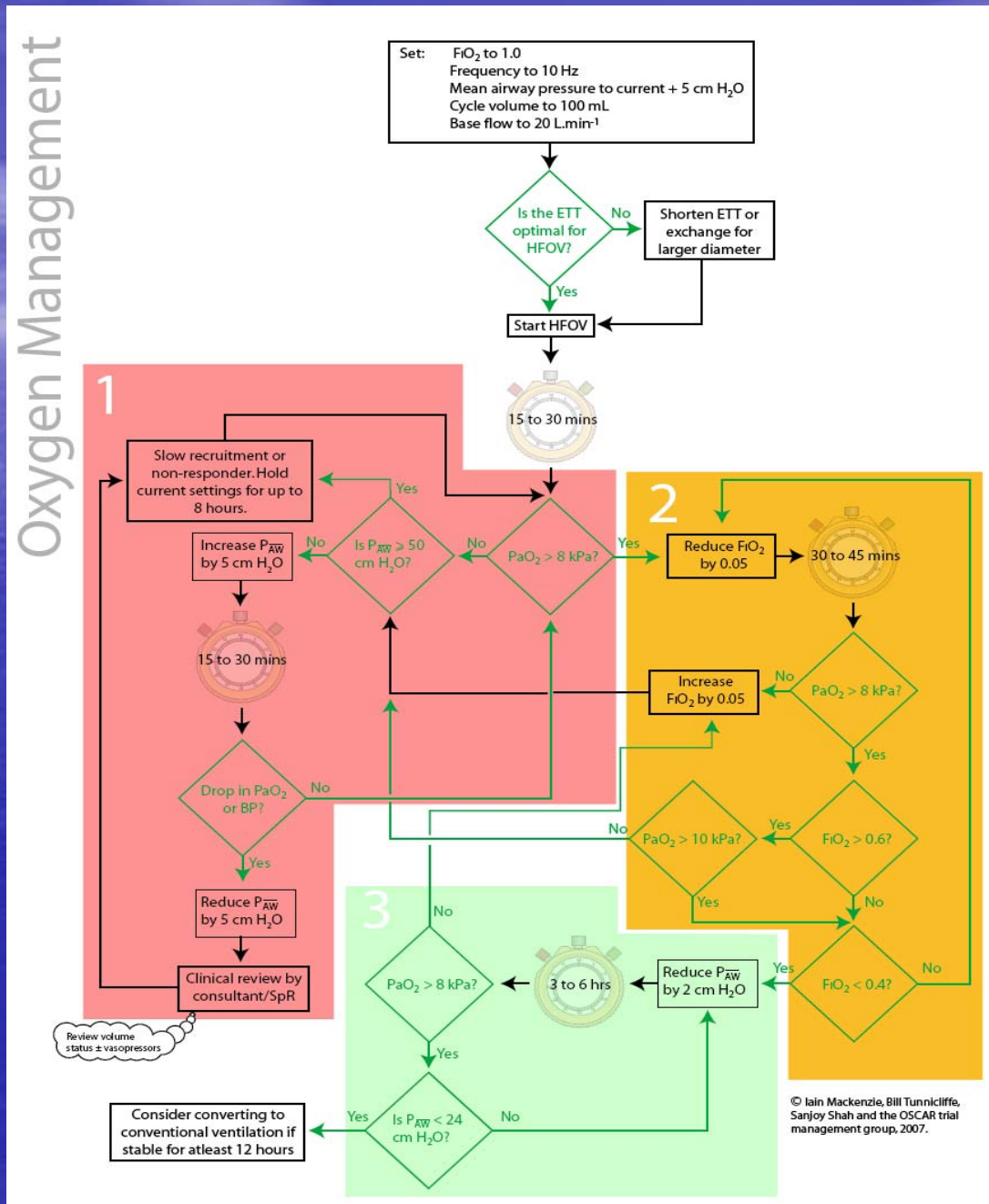
Problems once established

- Pneumothorax
  - Hypotension (acute), fall in PaO_2, asymmetric chest wall movement
- Air trapping
  - Hypotension (gradual), fall in PaO_2, rise in CVP
- Blocked ET Tube
  - Fall in PaO_2, rise in $PaCO_2$, increase in Amplitude

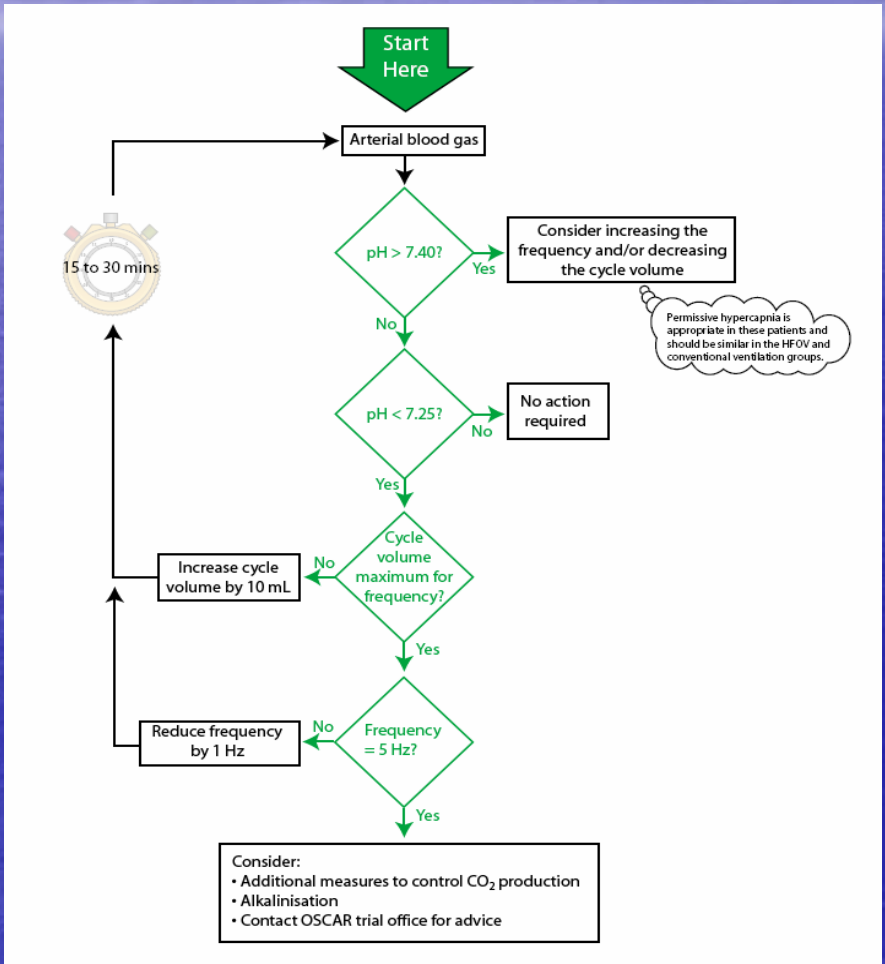
HFOV Protocol

Control of Oxygenation

- Step 1 = Recruitment
- Step 2 = FiO_2 delivery
- Step 3 = Reducing P_{AW}



HFOV Protocol
Management of Ventilation



CV Protocol

- As ARDS 'best practice'
- Patients ventilated using tidal volumes of 6-8ml kg^{-1} body weight
- Plateau pressure of no greater than 30cmH_2O.
- The ventilation target = normal arterial pH
- Permissive hypercapnia to avoid plateau pressures above 30cmH_2O.
- Oxygenation target = PaO_2 of 7.5-11.5kPa or an SpO_2 of 88–95%.

CV Protocol

- The recommended combinations of FiO_2 and PEEP are:

FiO2	PEEP
0.3	5
0.4	5
0.4	8
0.5	8
0.5	10
0.6	10
0.7	10-14
0.8	12-14
0.9	12-16
1.0	12-18

Support

- Me
- Management Group
- Inspiration Healthcare/Novalung
- Website
- Abbreviated manual attached to ventilator

Summary

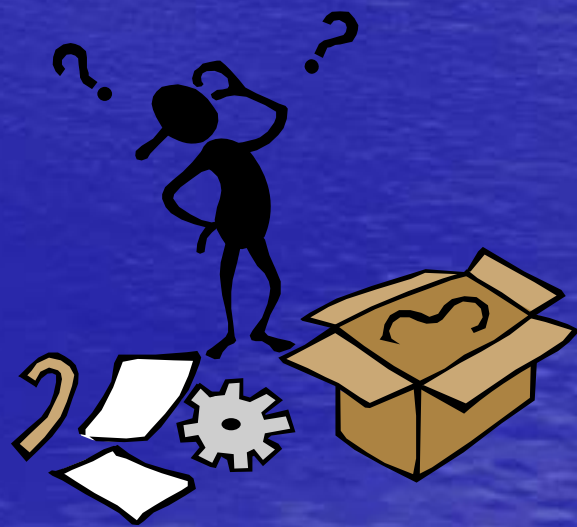
- HFOV – frequency 5-15Hz, tidal volumes ≤dead space, lungs kept 'open'
- Separates oxygenation and ventilation
- Protocols guide management of patient
- Several of sources of support
- Recruiting from 1st November 2007
- 2 patients per centre per month (min)

Practical

- How to assemble
- SimMan Demonstration

Any Questions?

(Feedback Forms)



My Contact Details

Dr Elena Lambert

Clinical Fellow OSCAR Trial
ICS Trials Group
Kadoorie Centre
John Radcliffe Hospital
Oxford. OX3 9DU

- Tel: 01865 221755
- Fax: 01865 857611
- Work Mobile: 07825733953
- Bleep: 1114 (via John Radcliffe switchboard)
- Email: OSCAR.Trial@nda.ox.ac.uk