Oxygen Delivery Systems

Calvary Hospital EMET

Foundations of Respiratory Management

Lecture 1

Learning Outcomes

1. To list different oxygen delivery methods – advantages and disadvantages

2. To define/ describe NIV

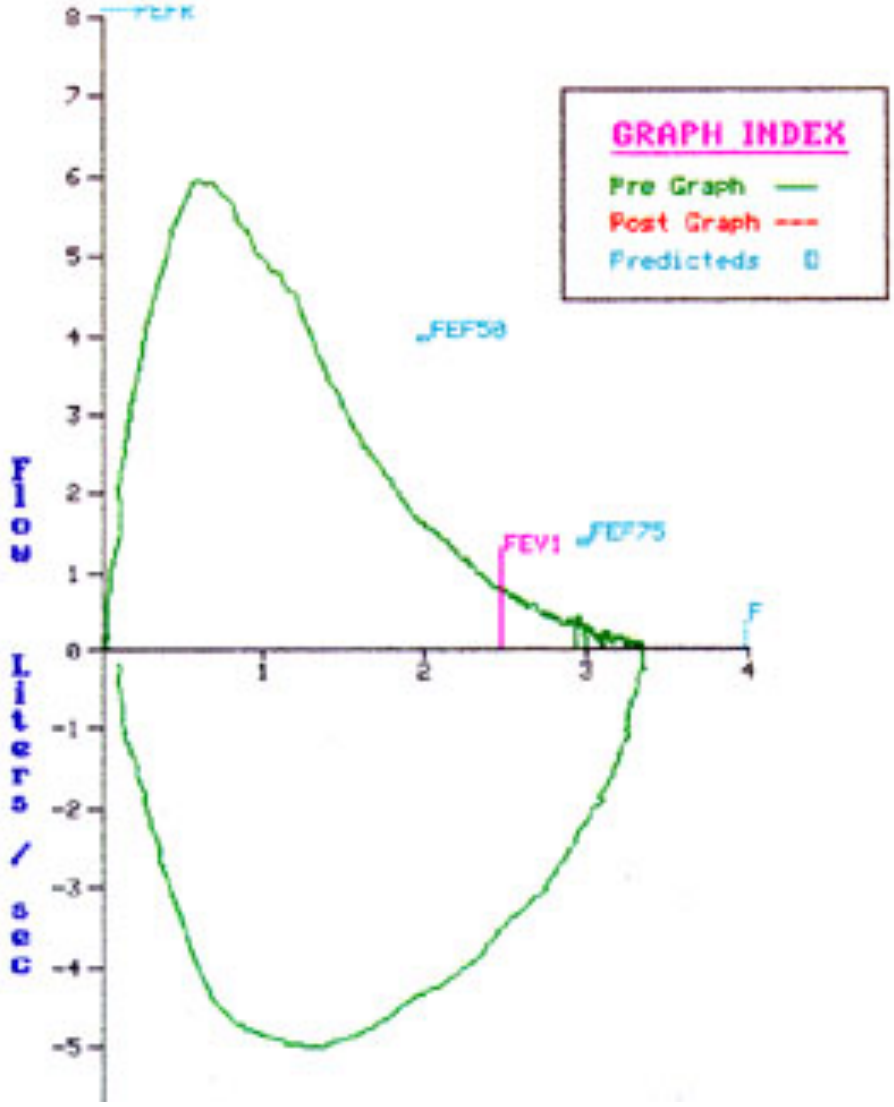
3. To understand the indications for NIV in the emergency department

4. To nominate some initial settings for NIV

5. To list some contraindications for starting NIV and some indications where it is not appropriate to be used

- Variable-Performance Systems
  - Deliver variable FiO2 depending on other variables including the patients inspiratoy flow rate, minute volume, characteristics of the delivery system
  - E.g. Nasal prongs, hudson mask
- Fixed-performance systems
  - Delivers a specified FiO2 to the patient that is not altered by other variables
  - E.g. Venturi Mask, oxygen blenders
- One hundred percent oxygen systems
  - A sub-group of fixed performance systems where 100% O2 is delivered to the patient
  - E.g. Non-rebreathing circuits, Closed circuits systems

FLOW VOLUME LOOP




CALL
NITROUS OXIDE
NITROUS OXIDE
OXYGEN
200
WIPES

- Wall oxygen port – 15/l min
- A quietly breathing adult has a **peak** inspiratory flow rate of 30-40L/min
- Thus a free flowing system such as nasal prongs or a hudson mask must entrain air into the system in order to match the patients PIFR and this subsequently reduces the FIO2 down to a maximum of 0.6

- Multiple wall oxygen ports using a Y connector or T piece may increase flow rate to 30l/min, 45l/min or 60l/min thus achieving an FIO2 of nearly 1.0 (100%)

Appatatus	Oxygen Flow (l/min(	Oxygen concentration (%)
Nasal prongs	1-4	24-40
Hudson Mask	6-15	35-60
Hudson Mask (>1 O2 port)	15-30	Up to 80
Mask + Reservoir	12-15	60-90

Nasal prongs

- Creates an oxygen reservoir in the nasopharynx
- Influenced by pattern of breathing (nose or mouth breather)
- More effective in children (nose breathers)
- Ideal for home oxygen use – can eat and talk, economy of oxygen
- Role in intubation to increase safe apnoea time
- *(Ideal for actors in movies.....)*

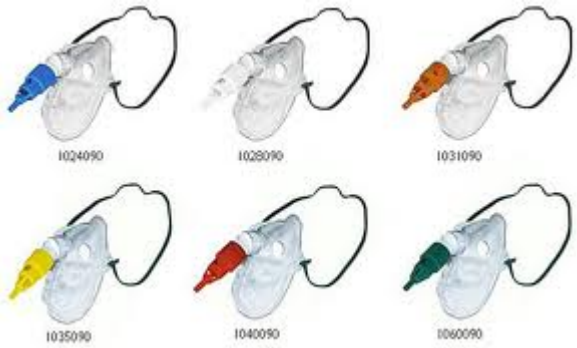
Hudson mask

- Variable performance system
- Standard oxygen mask used in the ED
- Maximum FIO2 0.6 (with one O2 port)



Venturi Mask

- Fixed performance system
- Venturi system results in air entrapment resulting in a fixed concentration of O2 to a patient
  - 0.24, 0.28,0.35,.040,0.50,0.60
  - Different coloured masks and different flow rates to achieve these targets
  - As the patients PIFR increases, system becomes more variable





Non-Re-breather

- i.e. a face mask with a reservoir
- Can achieve FiO2 close to 1.0 (100%)



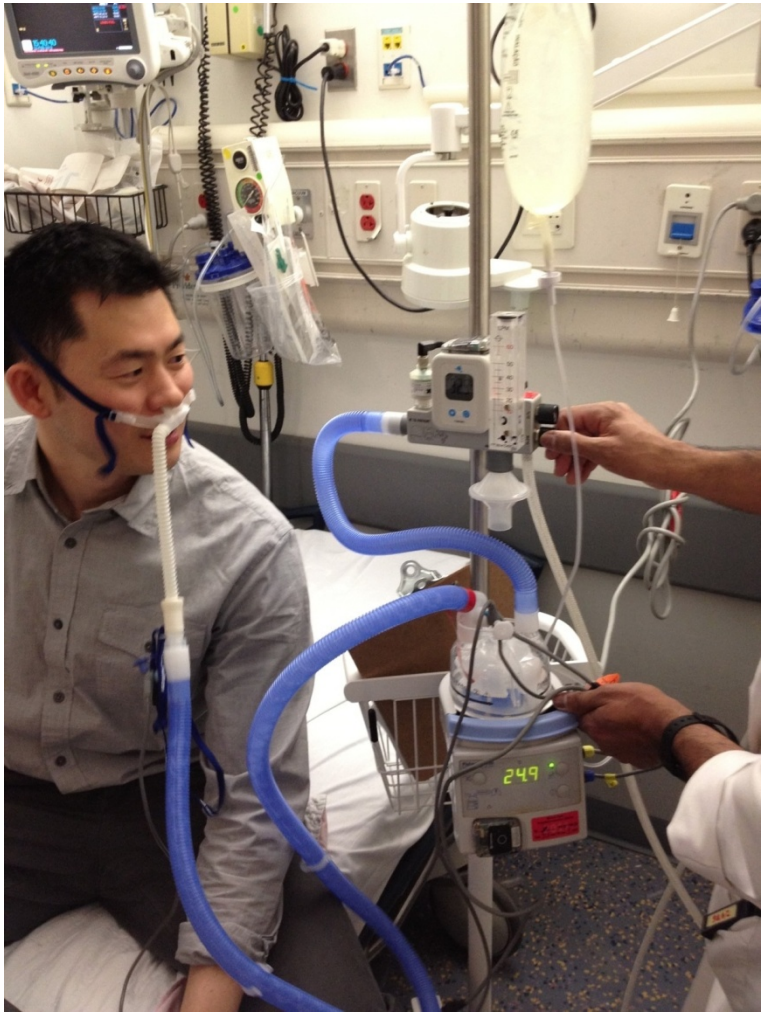
Bag/Valve/Mask

- Provides ventilation
- Not as effective as a non-re-breather in oxygenating a spontaneously breathing patient



High Flow Nasal Prongs

- Can deliver FiO2 of 1.0 and flow rates of 60l/min
- Provides some positive pressure thus helping with oxygenation
  - (peep of up to 7.4cmh2o with snug fitting prongs at high flow rates)
- May prevent requirement for aggressive strategies
- May help weening from e.g. NIV
- Can be very effective in infants (e.g. Bronchiolitis)
- Increases “safe apnoea time”



Non-Invasive Ventilation



History of NIV

- The concept of mechanical ventilation first evolved with negative-pressure ventilation. In 1876, Woillez first developed a workable iron lung. In 1889, Alexander Graham Bell designed and built a prototype of iron lung for use with a newborn infant. In the late 1920s, Drinker introduced negative-pressure ventilation and popularized the iron lung. He maintained an 8-year-old girl with acute poliomyelitis on artificial respiration continuously for 122 hours. The polio epidemics of the 1930s, 1940s, and 1950s led to the development of pulmonary medicine as a specialty and the iron lung as a workhorse.
- Ventilators delivering negative-pressure ventilation fell out of favour as the use of invasive positive-pressure ventilation (PPV) increased during the 1960s. However, over the past decade, a striking resurgence has been observed in the use of non-invasive ventilation, fuelled by the development of PPV delivered through a nasal or face mask.



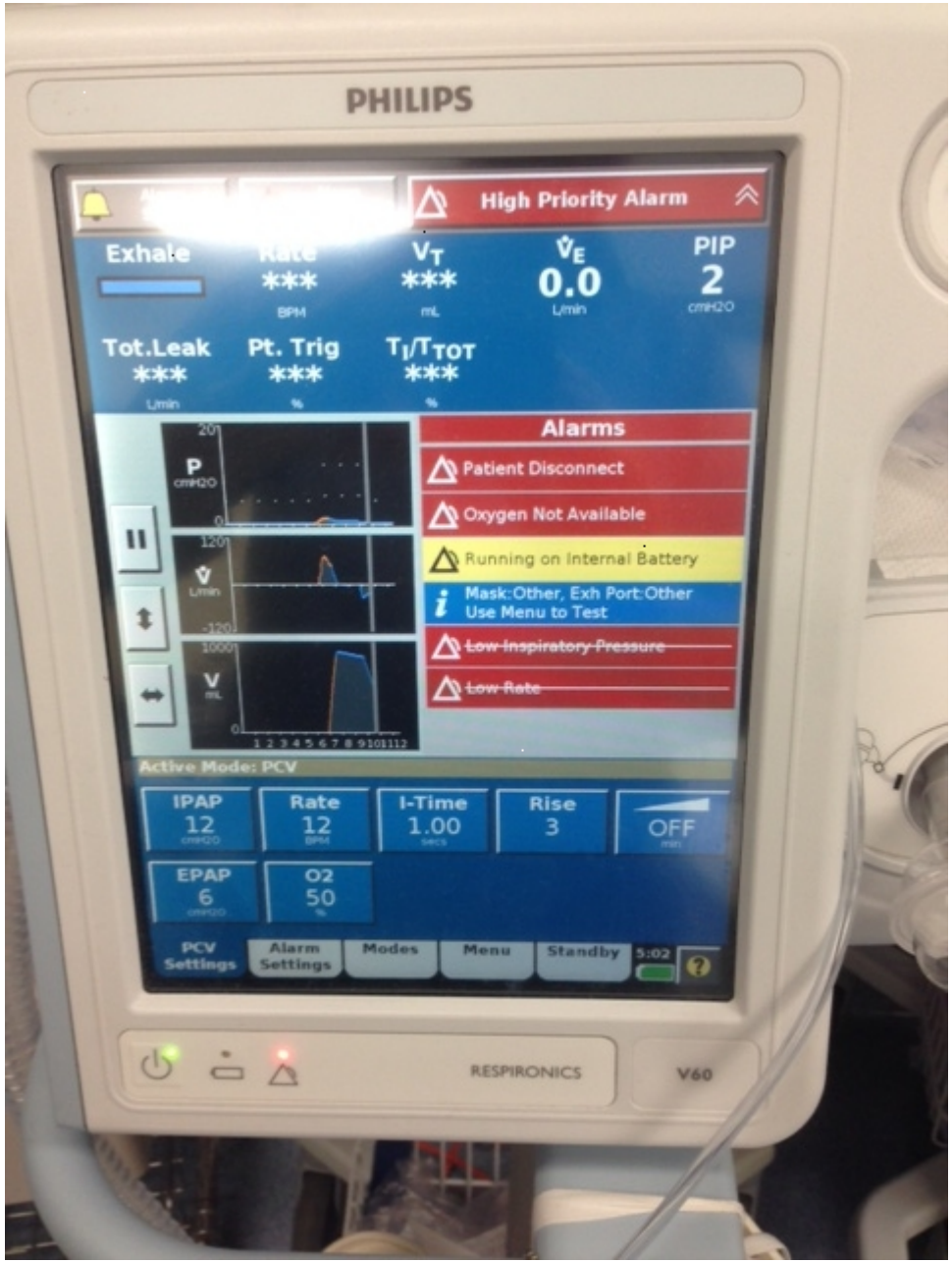
Modes of NIV

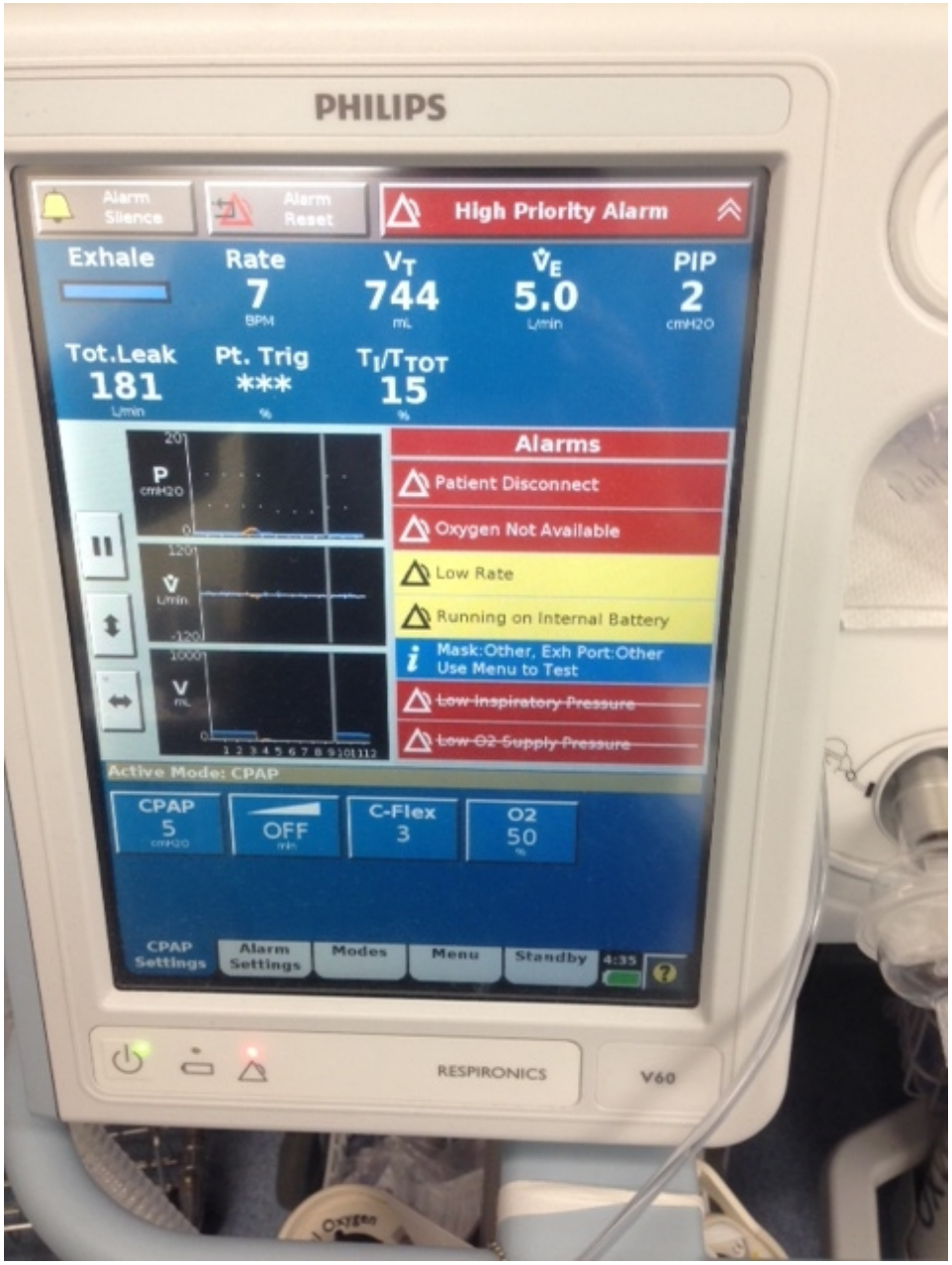
- **CPAP "continuous positive airway pressure"**
  - a "pneumatic splint" which holds the airways open
  - provides positive airway pressure throughout all phases of spontaneous ventilation
  - CPAP increases the FRC and opens collapsed alveoli
  - CPAP reduces left ventricular transmural pressure and therefore increases cardiac output. Hence it is a very effective for treatment of pulmonary oedema.
  - Pressures are usually limited to 5-12 cm of H_2O, since higher pressure tends to result in gastric distention
- **BIPAP / Bi Level "bi-level positive airway pressure"**
  - provides two levels of **positive** pressure. During exhalation, pressure is variably positive. Airflow in the circuit is sensed by a transducer and augmented to a preset level of ventilation. Cycling between inspiratory and expiratory modes may either be triggered by the patient's breaths or preset.


REMINGTON
OFF

Settings

- CPAP
  - **Oxygenation**
  - E.g. Acute pulmonary oedema
  - Set “ipap” and FIO2
  - E.g. 5cm H2O at 100%
- BiPAP
  - **Work of breathing**
  - E.g. Exacerbation of COPD
  - Set “ipap” and “epap” and FI02
  - E.g. 12cm and 6cm H2O at 50%


PHILIPS
High Priority Alarm
Exhale
Rate
***
BPM
VT
***
mL
V̇E
0.0
L/min
PIP
2
cmH2O
Tot.Leak
***
L/min
Pt. Trig
***
%
TI/TTOT
***
%
Alarms
Patient Disconnect
Oxygen Not Available
Running on Internal Battery
Mask:Other, Exh Port:Other
Use Menu to Test
Low Inspiratory Pressure
Low Rate
Active Mode: PCV
IPAP
12
Rate
12
I-Time
1.00
Rise
3
OFF
EPAP
6
O2
50
PCV Settings
Alarm Settings
Modes
Menu
Standby
5:02
RESPIRONICS
V60


PHILIPS
Alarm Silence
Alarm Reset
High Priority Alarm
Exhale
Rate
7
BPM
VT
744
mL
V̇E
5.0
L/min
PIP
2
cmH2O
Tot.Leak
181
L/min
Pt. Trig
***
%
TI/TTOT
15
%
Alarms
Patient Disconnect
Oxygen Not Available
Low Rate
Running on Internal Battery
Mask:Other, Exh Port:Other
Use Menu to Test
Low Inspiratory Pressure
Low O2 Supply Pressure
Active Mode: CPAP
CPAP
5
OFF
C-Flex
3
O2
50
CPAP Settings
Alarm Settings
Modes
Menu
Standby
4:35
RESPIRONICS
V60

Indications for NIV

- **Acute respiratory failure**
- **Hypercapnic acute respiratory failure**
- **Acute exacerbation of COPD**
- Post extubation difficulty
- Weaning difficulties
- Post surgical respiratory failure
- Thoracic wall deformities
- Cystic fibrosis
- Status asthmaticus
- “Delayed Sequence induction”

Requirements for Successful NIV

- A co-operative patient who can control their airway and secretions with an adequate cough reflex. The patient should be able to co-ordinate breathing with the ventilator and breathe unaided for several minutes.
- Haemodynamically stable and normal GI function

- The patient should ideally show improvement in gas exchange, heart rate and respiratory rate within first two hours

Contraindications

- Respiratory arrest/unstable cardiorespiratory status
- Uncooperative patients
- Unable to protect airway- impaired swallowing and cough
- Facial/oesophageal or gastric surgery
- Craniofacial trauma/burns
- Anatomic lesions of upper airway
- *relative:*
  - Extreme anxiety
  - Morbid obesity

Advantages of NIV

- Preservation of airway defence mechanism
- Early ventilatory support
- Intermittent ventilation
- Patient can eat, drink and communicate
- Ease of application and removal
- Patient can cooperate with physiotherapy
- Improved patient comfort
- Reduced / No sedation requirements
- Avoidance of complications of intubation
  - (upper airway trauma, sinusitis, otitis, nosocomial pneumonia)
- Ventilation outside hospital setting possible

Disadvantages of NIV

- Mask is uncomfortable
- Facial pressure sores
- Time consuming for medical and nursing staff
- Airway is not protected
- No direct access to bronchial tree for suction



Complications and Side Effects

- Air leak
- Skin necrosis (bridge of nose)
- Failure to ventilate
- Gastric Distention
- Sleep Fragmentation
- Retention of Secretions
  - Airway obstruction secondary to secretions
  - patient developed life threatening airway obstruction caused by large desiccated concretion of mucous and blood lodged in posterior oral pharynx after NIV for 6 days

- Proven to be effective in the treatment of acute pulmonary oedema and exacerbation of COPD.
- Used in the treatment of pneumonia
- Asthma?

Invasive Ventilation

- Indications for Endotracheal Intubation:
  - To create an airway
  - To maintain an airway
  - To protect an airway
  - To provide mechanical ventilation

  Endotracheal intubation provides secure, definitive airway management and allows assisted mechanical ventilation. Patients who are ineligible for NIV or fail NIV should be intubated.

Contraindications to Intubation

- Mostly relative
  - Not appropriate
  - Facial trauma or congenital abnormality or spondoylisis of Cspine
  - lack of resources (including airway competence)



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Mode of Ventilation

- Pressure Control Ventilation (PC SIMV+)
  - i.e. Set pressure / Monitor Volumes
- Volume Control Ventilation (SIMV)
  - i.e. Set Volume / Monitor Pressures

Adjustables on the Ventilator

- Mode - usually SIMV / sometimes PCV
- Tidal Volume (VT) (only in volume control)
- Respiratory (RR)
- FiO2
- PEEP
- P insp (only in pressure control mode)
- Pmax
- Slope/inspiratory flow rate –*Patient Comfort*

Ventilation Strategies

- Lung Protection Strategy
  - i.e. all patients that are not obstructive
- Obstructive Strategy
  - asthmatics

Lung Protection Strategy

- Mode - Usually SIMV
- VT – *6-8 ml/kg*
- RR – *16-18*
- Pmax (< or =40)
- FiO2 and PEEP – *use peep table for stats 88-95%*
- Pinsp (pressure control mode only start at 20)
- I:E Ratio - *1:1.5 (default)*
- Slope/inspiratory flow rate –*default*

Keep Saturations 88-95% using the PEEP Table

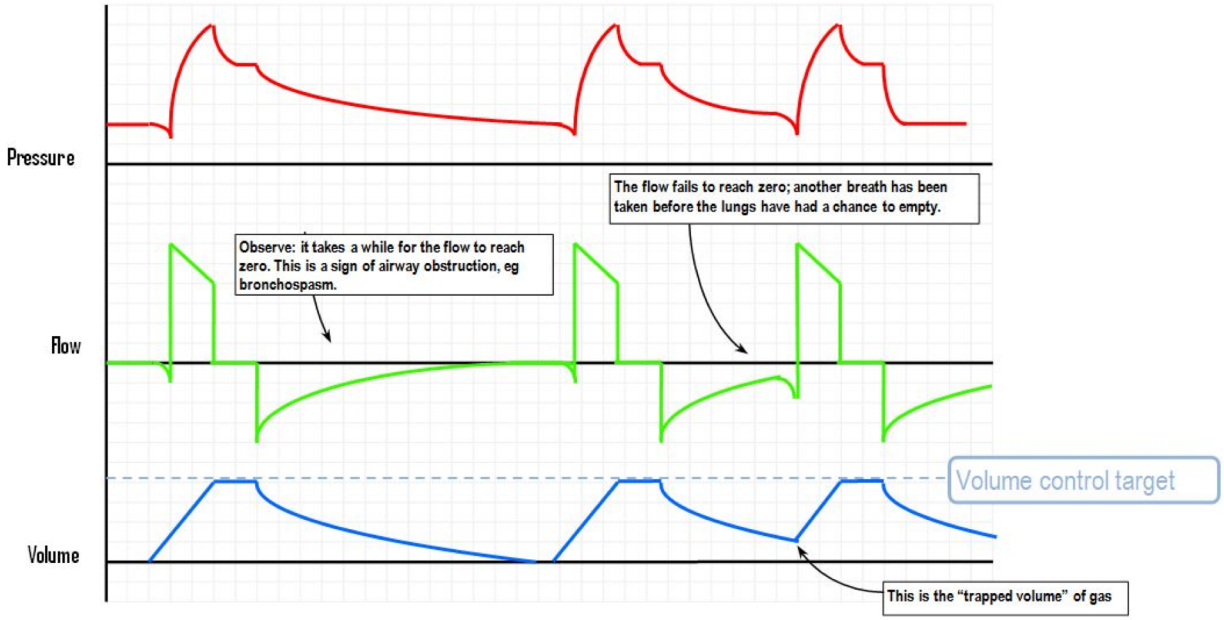
FiO2	.4	.4	.5	.5	.6	.7	.7	.7	.8	.9
PEEP	5	8	8	10	10	10	12	14	14	14

“the strategy helps keeps the alveoli just at the point where recruitment is maintained and avoids barotrauma”

Obstructive Strategy

- Mode - Usually SIMV
- VT – *6-8 ml/kg*
- RR – *6 - 10*
- Pmax (< or =40)
- FiO2 *to maintain sats of 88-95%*
- *Zero PEEP ("ZEEP")*
- Pinsp (pressure control mode only start at 20)
- I:E Ratio – *1:4 or 1:5*
- Slope/inspiratory flow rate – *fast*

- Look for gas trapping / auto peep / breath stacking
  - Watch flow waves
  - Check plateau pressure (if <30 not likely)



- IF PATIENT IS CRASHING……
  - TAKE OFF THE VENTILATOR AND HAND BAG
  - CHECK TUBE
  - CHECK PATIENT

…….then check ventilator