

Ventilation modes in paediatric respiratory failure



May 2017

Outline

- Goals of ventilation
- Modes
 - NIV, IPPV, HFOV
- Lung protective strategies
- Common conditions

Goals of Intubation & Ventilation

- Oxygenate and ventilate
- Reduce respiratory work
- Protect airway in comatose patient
- Overcome airway obstruction
- Reduce oxygen consumption in shocked patients and limit acidosis
- Allow airway toilet

- **Primum non nocere!**

Modes of Ventilation:

- **Non-invasive:**
 - High flow O₂
 - CPAP
 - BiPAP
- **Invasive:**
 - IMV: Pressure vs Volume control
 - HFOV: High frequency oscillation
 - ECMO: extracorporeal membrane oxygenation

Hi flow



Nasal High flow Oxygen

- Benefits:
 - Delivery of prescribed F_iO_2 , less air entrainment and dilution.
 - nasal interfaces better tolerated
 - humidification
 - low level positive airway pressure.
- Use if $> 5\text{kg}$: flow at $2\text{L}/\text{kg}/\text{min}$. ($<5\text{kg}$, use CPAP)
- If $> 20\text{kg}$, flow rates up to $45\text{-}50\text{ L}/\text{min}$
- Keep fixed flow & adjust F_iO_2 to $SpO_2 >92\%$
- Wean F_iO_2 , then try low flow, do not wean flow.

Bubble CPAP



CPAP/PEEP

- Pulmonary Effects

- Increases alveolar volumes

- Redistributes lung water

- Recruits alveoli

- Prevents cyclical alveolar collapse/re-expansion thereby limiting VALI

Invasive Ventilation



New type of chest respirator- a Polio victim in the University of Michigan Hospital wearing a chest respirator devised by a children's doctor and an engineer. The new machine, 400 times lighter than the cumbersome iron lung, permits the use of muscles not paralysed by the disease.

Auckland Star, Monday August 16, 1948



Positive Pressure Ventilation

Adult/Pediatric/Neonate

Airway press. cm H₂O

- Upper press. limit: 27
- Mean: 18
- Pause: 21
- End. Exp: 5

Pressure Control/Support

- Level above PEEP: 20
- Level above PEEP: 20
- PEEP: 5
- Trig. sensitivity Level below PEEP: -10

Volume Support

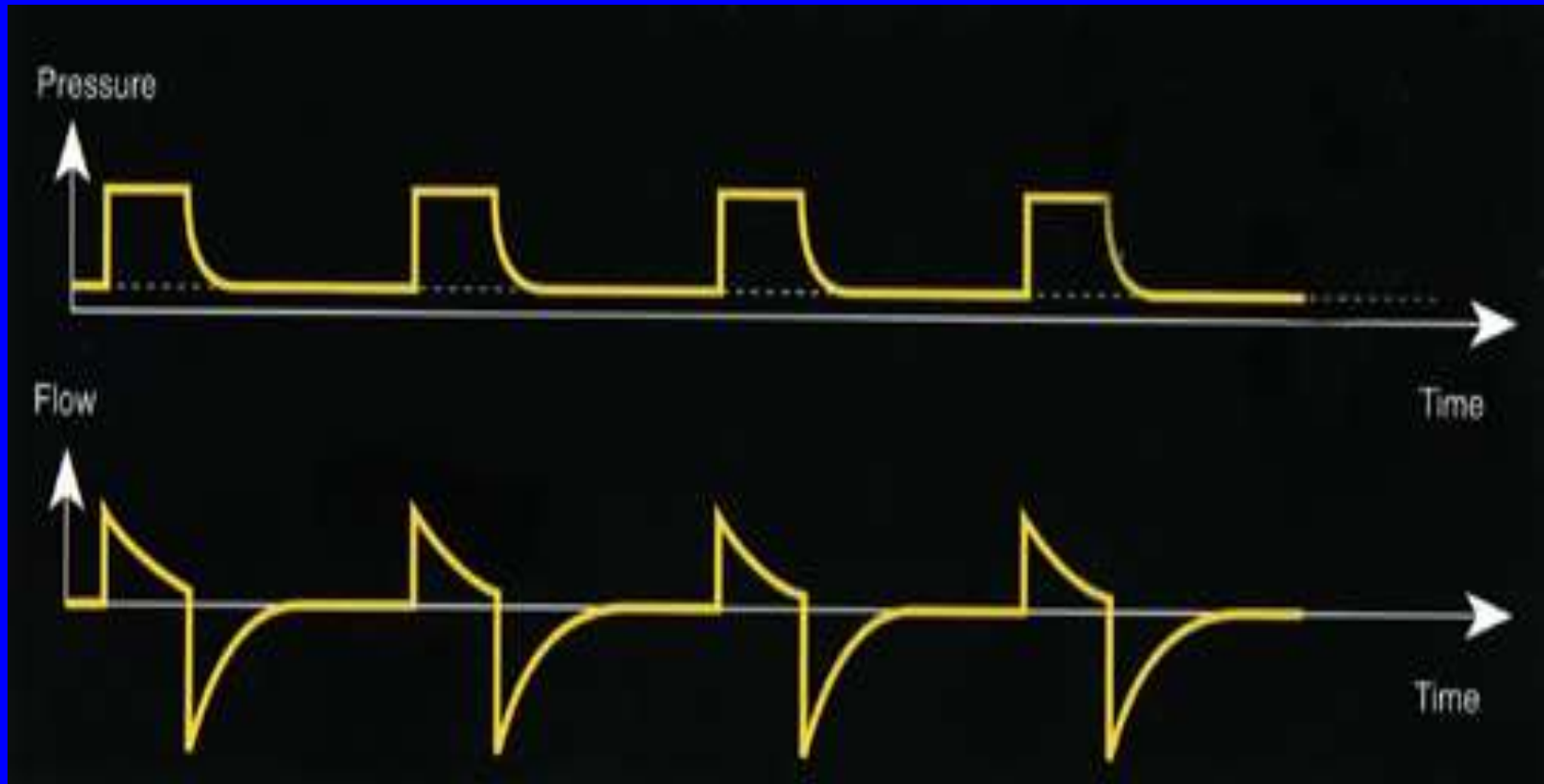
- Volume: 500
- Minute vol. l/min: 10.0
- Insp. tidal vol. ml: 499
- Exp. tidal vol. ml: 498
- Exp. minute vol. l/min: 9.9

Alarms and messages

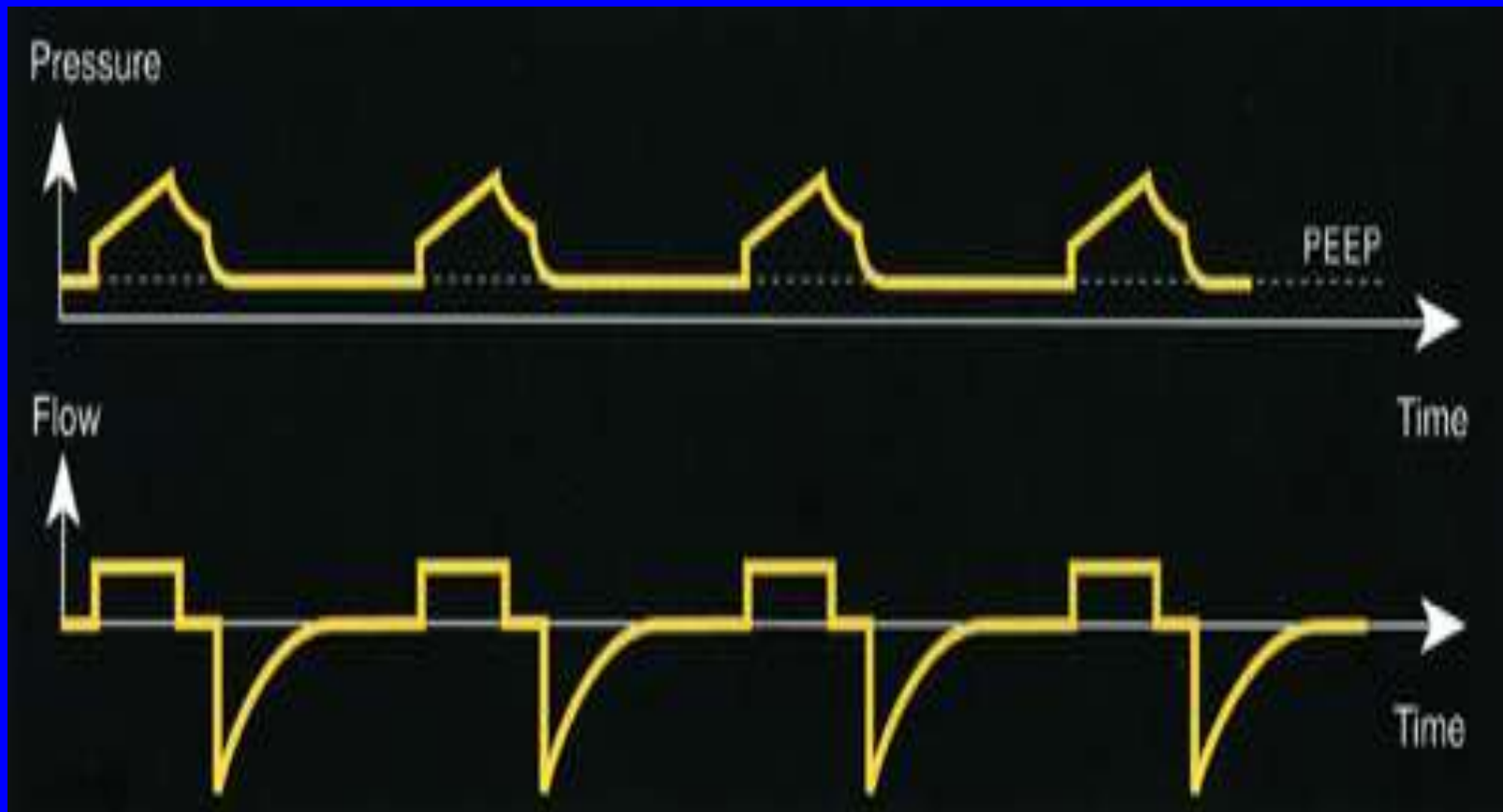
- Tidal vol. 02 40 %
- Airway Pressure
- O₂ concentration
- Exp. inhaled volume
- Apnoea
- Gas supply
- Battery
- Technical
- Reset
- 2 min
- Alarm limits
- Neonate 1/10
- Pause hold
- Insp.
- Exp.

SIEMENS Servo Ventilator 300A

Pressure Control Ventilation



Volume Control Ventilation



Which mode?

- Historically PC used in children ? better for bad lungs & old ventilators,
- Modern ventilators allow for a decelerating flow with volume control
- 6 different ventilation modes in 421 children:
 - HFOV, PC, PS, VS, volume diffusive respirator (VDR) and biphasic positive airway pressure.
 - no significant differences in LOV and mortality or survival rate
 - Weaning time did not differ between groups.

Crit Care. 2011;15(1):R24. doi: 10.1186/cc9969. Epub 2011 Jan 17.

Invasive ventilation modes in children: a systematic review and meta-analysis

What do we use?

- Volume Control/ SIMV:
 - Cardiac patients, head injury
- Pressure Control:
 - Respiratory disease/ stiff lungs, minimise PIP
 - Often when paralysed
 - Overcomes presence of leak
- Assist Control/ Pressure support:
 - respiratory illness/ pneumonias
 - Spontaneously breathing unparalysed.

Inspiratory Time

- Prolonging the IT improves oxygenation by
 - Increasing PEEP (auto PEEP)
 - Improving distribution of Tidal volume
- Beware excess auto PEEP

Lung Protective Strategy

- use of high TV (12ml/kg) with $P > 30-35$ may increase barotrauma and mortality
- reducing TV to $< 6\text{ml/kg}$ & $P_{\text{plat}} < 30\text{cmH}_2\text{O}$ may improve outcome
- increase in PEEP, titrated to PV curve, may be protective against VALI

Lung Protective Strategy

- does it work?
- mortality from ARDS has fallen
 - 30-50% to 20-30%
- LPS more commonly used
- permissive hypercapnia
- recruitment manoeuvres

Permissive Hypercapnia

- Limiting V_t may cause $PaCO_2$ to rise
- High pCO_2 may benefit damaged lung
- Acceptable pH uncertain -7.2 ($?>7.0$)

Hickling KG et al Int Care Med 16:373-377 1990

High Frequency Oscillation



HFO improves oxygenation and limits VILI...

BUT in recent studies HFOV associated with:

- higher risk for mortality.
- greater neuromuscular blockade & opioids
- Higher risk cognitive/functional impairment.
- longer ventilatory duration

High Frequency Oscillatory Ventilation (HFOV)

- little evidence for HFO as initial therapy in pediatric ARDS.
- routine early use of HFO in children with respiratory failure should be discouraged
- possibility of HFO as rescue therapy

Am J Respir Crit Care Med Vol 193, Iss 5, pp 471–485, Mar 1, 2016

HFOV Settings

- Frequency (cycles/sec): 8-12 HZ
 - Increase frequency to increase pCO₂
- Amplitude: 30-60
 - Increase to increase oxygenation
- Paw: (MAP) 15-30
 - Increase to increase oxygenation
- FiO₂: increases O₂

What to check on oscillation

- Ventilation parameters
- Wiggle
- CXR
 - ETT position: ensure does not migrate
 - Expansion: - 6.5 anterior, 9 posterior ribs
 - Watch for silent air leaks
- Wean to prevent overdistension as recruits

Other strategies:

- Diuretics
- Prone positioning
- Nitric oxide/ sildenafil
- Steroids
- Surfactant

ECMO



Conclusions

- Adapt the mode of ventilation to match the patients disease state
- Try least invasive first
- Use lung protective strategies

Questions?

