VENTILATING CHILDREN- a quick recap

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OVERVIEW

- Introduction
- Six “Tricks”
- Case Scenarios
- Goals of ventilation
- Modes of ventilation
- Different diseases
- Conclusion

INTRODUCTION

- Children are not small adults
- Also not big neonates

INTRODUCTION

- Respiratory disorders→ main cause of respiratory failure
- Average PICU has about 30% (range 20%–64%) of its patients mechanically ventilated for a mean of 5–6 days

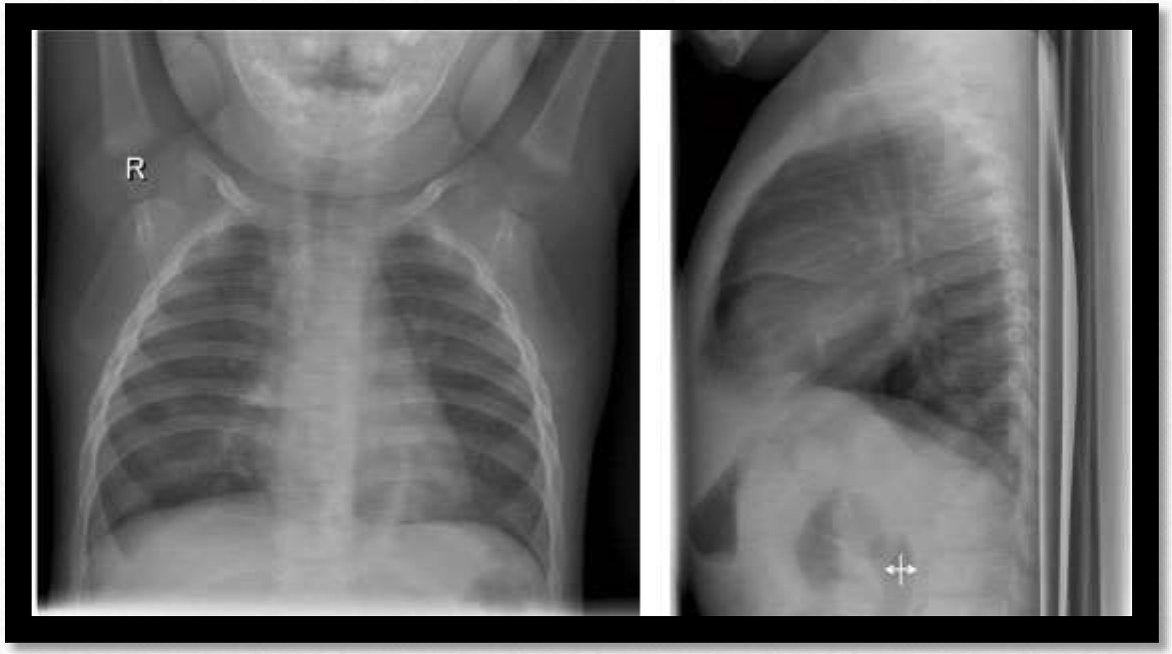
CASE 1

- Baby Porky
- 10-month-old female infant
- 7-day history of cough, mild pyrexia, wheeze
- PMH: multiple episodes of cough and wheeze, some of which required admission to hospital (treated with inhaled bronchodilators and steroids)
- Birth history: Prem @ 28 weeks' gestation, BW 1050 grams. Required nCPAP and suppl oxygen

CASE 1

- Temperature 37.8 ºC
- Respiratory rate 48 breaths.min−1
- Saturations 88%–92% R/A, 96% in 2 litres of oxygen
- Chest: Moderate subcostal/intercostal recession widespread expiratory wheeze and fine crackles
- Nasopharyngeal aspirate: Negative for respiratory viruses

CASE 1



Hyperexpanded with areas of atelectasis in both lung fields

CASE 1

- Treatment: oxygen, a trial of salbutamol & ipratropium bromide inhalers as metered dose inhalers using a spacer device
- Next 24 hours→ episodes of increased respiratory distress & rising oxygen requirements
- Oral clarithromycin
- Feeds were given by nasogastric tube
- Blood gas: pH = 7.39, pCO_2 = 47 mHg, BE =3.1
- Nasal Continuous Positive Airway Pressure (nCPAP)

TRICK #1

- Know which kids are "sick" and need ventilation
- Goals of ventilation

“SICK” KIDS

- Hypoxia
- Hypercarbia
- Airway protection
- (Decrease demand in cases of poor cardiac output)

“SICK KIDS”

- SIGNS OF DETERIORATION
  - Increasing recession
  - Increasing respiratory rate
  - Increasing pulse rate
  - Fatigue
  - Altered mental status
  - Cyanosis

CASE 1

- Few hours later: deteriorated with a respiratory rate above 60 breaths min^{-1}
- Head-bobbing and severe recession
- Pale, sweaty, lethargic
- Blood gas: pH = 7.17 pCO_2 = 72 mmHg, BE = −3.4
- No longer able to cope→ intubated

TRICK #2

- Know your ventilator
- Terminology
- Different modes
- Ventilator settings

OXYGEN

- Alveolar gas equation
- $PAO2 = FiO2\ (PATM - PH2o) - PaCO2$
- Nasal Prongs 24%-30 %
- Face mask 28%-80 %
- NOT "Double oxygen"

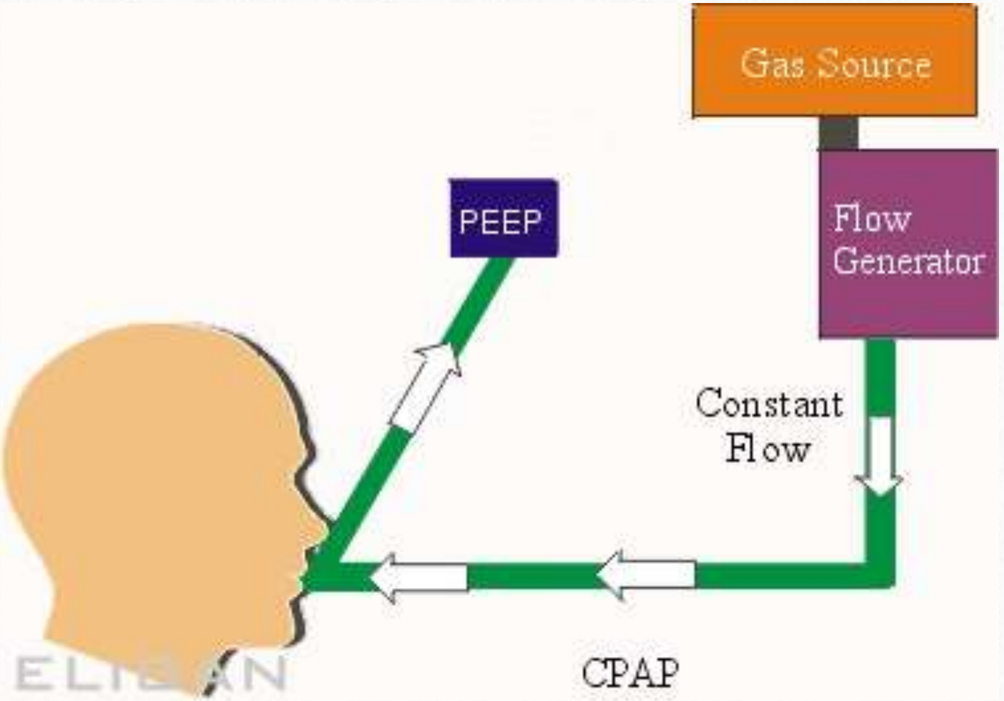
CPAP and NIV

- 2 main effects
- Increase pressure in posterior pharynx => increase ΔP across conducting airways => improves airflow
- Increases PEEP, thus FRC > Closing capacity
- Nasal CPAP increasingly NB in neonates – reduces need for ventilation in pre-term infants
- Also useful in small infants
- After infancy, before childhood – difficult to achieve
- > 6-8years face mask

NIV

- Key Features of Airvo Humidifier:
- Humidifier with integrated flow generator
  Oxygen delivery without a blender
  Variety of interfaces
  Easy to set up and use
  Validated high-level disinfection process

VENTILATORS-schematic



VENTILATORS-terminology

- TIME
    - I - Time: amount of time spent in inspiration
    - E - Time: amount of time spent in expiration
- Volume
    - Amount of tidal volume that a patient receives
- Pressure
    - Measure of impedance to gas flow rate
- Flow
    - Measure of rate at which gas is delivered

VENTILATORS-terminology

- PEEP = positive end expiratory pressure
    - Pressure maintained in the airways at the end of exhalation
    - Keeps Alveoli from collapsing

- PIP = peak inspiratory pressure
    - Point of maximal airway pressure

- Delta P = the difference between PIP – PEEP

- MAP = mean airway pressure

MODES OF VENTILATION

- Controlled Mechanical Ventilation (CMV)
- Assist Control (AC)
- Continuous Positive Airway Pressure (CPAP)
- Intermittent Mandatory Ventilation (IMV)
- Synchronized Intermittent Mandatory Ventilation (SIMV)
- Pressure Support
- Volume Support
- Pressure Regulated Volume Control (PRVC)

VOLUME VENTILATION

- Preset
  - Volume
  - PEEP
  - Rate
  - I-time
  - FiO2
- Ventilator Determines
  - Pressure required
- Advantages
  - Guaranteed minute ventilation
  - More comfortable for patient
- Draw-backs
  - Large ETT leak
  - Not optimal for poorly compliant lungs

PRESSURE VENTILATION

- Preset
  - PIP
  - PEEP
  - Rate
  - I-time
  - FiO2
- Vent determines
  - Tidal volume given
- Advantages
  - Provides more support at lower PIP for poorly compliant lungs
- Draw back
  - Minute ventilation not guaranteed

MODES OF VENTILATION

- **<u>Control Modes</u>:**
  - every breath is fully supported by ventilator
  - in classic control modes, patients *unable* to breathe except at the controlled set rate
  - in newer control modes, machines may act in assist-control, with a minimum set rate and all triggered breaths above that rate also fully supported.

- **<u>IMV Modes</u>:** intermittent mandatory ventilation modes - breaths "above" set rate not supported
- **<u>SIMV</u>:** vent synchronizes IMV "breath" with patient's effort

MODES OF VENTILATION

- **Assist/Control Mode Ventilation**
  - Combined mode of ventilation
  - Ventilator delivers positive pressure breath of predetermined TV in response to each inspiratory effort (*assisted ventilation)*
  - If pt fails to initiate breath within a specific time period, ventilator automatically delivers a mechanical breath to maintain minimum or "backup" respiratory rate (*controlled ventilation)*
  - To trigger assisted breath must lower airway pressure by preset amount- the *trigger sensitivity.*

MODES OF VENTILATION

- *Advantages*: Ensures the security of controlled ventilation and allows synchronization of the breathing rhythm of patient and ventilator. Ensures ventilatory support during every breath.
- *Disadvantages*: Excessive patient work may occur if inadequate peak flow or sensitivity setting, especially for pts with increased ventilatory drive
- May be poorly tolerated in awake, non-sedated subjects and can require sedation to ensure synchrony;
- May be associated with respiratory alkalosis due to excessive triggering of ventilator by anxious patient
- May potentially worsen air trapping

MODES OF VENTILATION

- **Synchronized Intermittent Mandatory Ventilation**
  - Mandatory number of positive pressure breaths per minute, each synchronized to patient effort. Ventilator detects initiation of spontaneous breath and does not deliver machine breath during a spontaneous breath.
  - Between mechanical breaths may breathe an indefinite number of times from reservoir
  - Spontaneous breaths produce no response from the ventilator.

MODES OF VENTILATION

- *Advantages:* Pt able to perform variable amount of respiratory work with security of preset mandatory level of ventilation;
- Allows for variation in support-full support to spontaneous breathing
- Useful weaning mode.
- *Disadvantages:* Dysynchrony between pt effort and machine-delivered volume can occur especially with inadequate flow rates;
- Hyperventilation and respiratory alkalosis possible, similar to A/C;
- Excessive work of breathing during spontaneous breaths can occur due to presence of poorly responsive demand valve or inappropriate flow delivery;
- May potentially worsen air trapping with asthma.

MODES OF VENTILATION

- **<u>Pressure-Support Ventilation</u>**
  - When inspiratory flow rate falls below preset threshold, flow of gas terminates.
  - Patient controls respiratory rate and inspiratory time and flow.
  - TV + minute ventilation partly determined by patient + partly by ventilator.
  - *<u>Advantages</u>:* Most spontaneously breathing pts comfortable with little dys-synchrony.
  - Useful as weaning tool
  - *<u>Disadvantages</u>*: Tidal volume dependent on respiratory mechanics, cycling frequency, and patient-ventilator synchrony. Need careful monitoring for unstable patients and back-up minute ventilation needed for safety.

MODES OF VENTILATION

- **Pressure Control Ventilation (PCV)**
  - Minimises static airway pressures in ARDS patients.
  - Involves setting target airway pressure on ventilator which then delivers rapid flow to that set pressure with a square pressure wave form.
  - *Advantages:* Airway pressures uniformly controlled by set pressure limit thus minimizing overdistension
  - Decelerating flow curve ? allows improved oxygenation by optimizing alveolar recruitment
  - *Disadvantages:* Can be an uncomfortable mode of ventilation and thus require significant sedation
  - TV varies with compliance → close monitoring avoid excessive/inadequate ventilation

MODES OF VENTILATION

- **Pressure regulated volume control (PRVC)**
  - Good alternative to PCV if rapidly changing compliance -Remains a pressure regulated approach but pressure varies to maintain given tidal volume.
  - Tidal volume, PEEP, rate, inspiratory time is set
  - Advantage of having a guaranteed tidal volume with a flow pattern that doesn't harm the lungs
  - Agitated patients may hyperventilate

MODES OF VENTILATION

- **Airway Pressure Release Ventilation (APRV)**
  - Spontaneous breathing with CPAP interrupted by short (1-1.5s) releases of pressure to augment expiration.
  - Moderately high airway pressure (20-30 cm H_2O) most of the time, thereby keeping alveoli open.
  - Unique in that ventilation is enhanced by reduction rather than increase in lung volume. During short expiratory release PEEP remains present to keep alveoli with slow time constants open as well

MODES OF VENTILATION

- *Advantages*: Preservation of spontaneous breathing -may improve comfort + decrease sedation need
- CPAP useful in keeping alveoli open
- A short expiratory time which favours ventilation of fast compartments
- Reduced barotrauma risk
- Relatively low airway pressures - ↓ volutrauma, improve pulmonary circulation + O2 delivery

MODES OF VENTILATION

- *Disadvantages*: Very short expiration times can lead to incomplete exhalation of slow compartments of the lung which can lead to the development of auto-PEEP secondary to breath stacking
- Requires spontaneous respiratory drive ? associated with ↑ work of breathing
- Dead space ventilation may be relatively increased due to lower tidal volumes
- Potential for de-recruitment and atelectrauma during intermittent pressure releases

Conventional (Positive Pressure) Ventilation

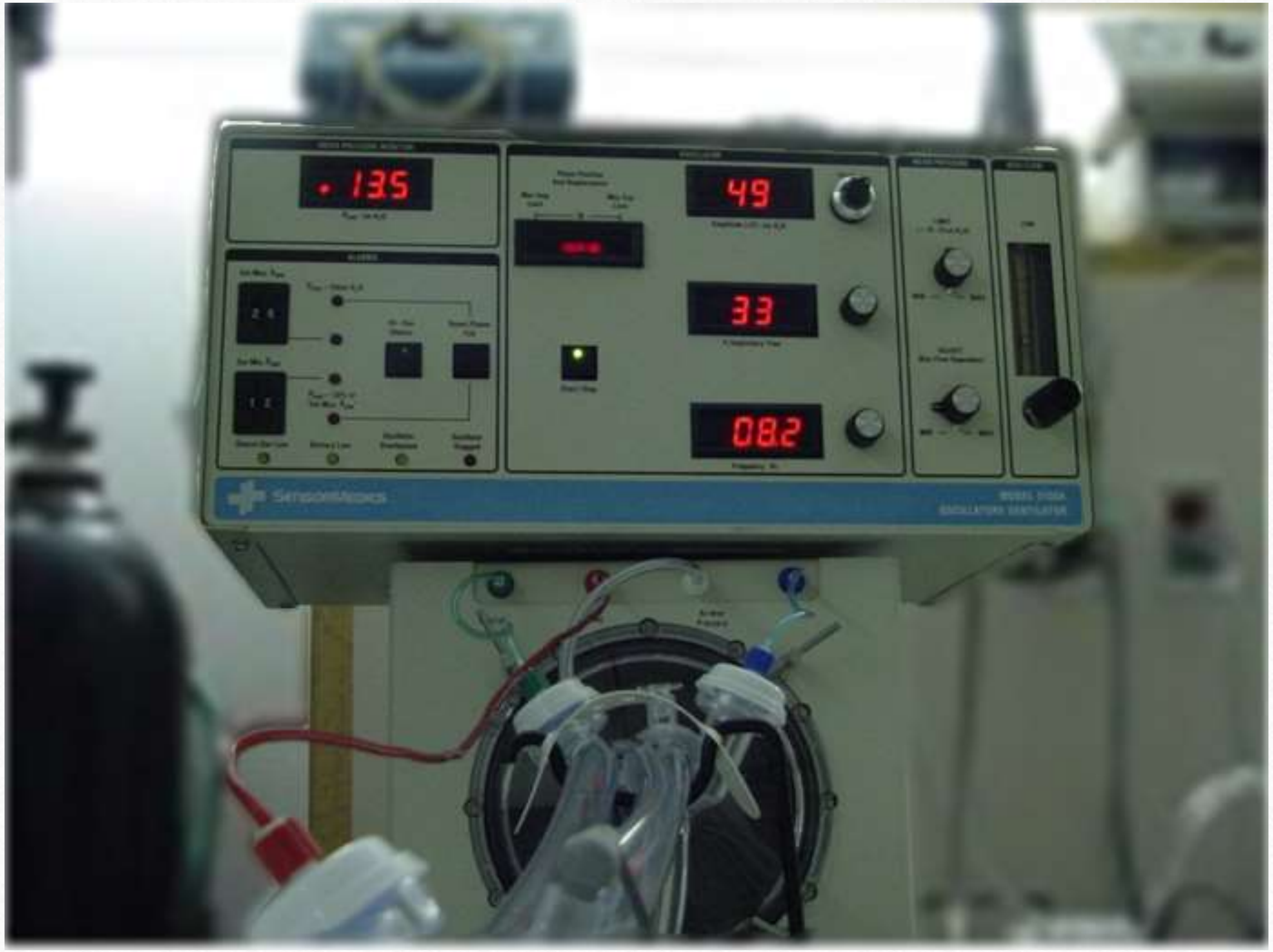
	Trigger	Limits	Cycle
Controlled	Ventilator	Ventilator	Ventilator (time)
Assisted	Patient	Ventilator	Ventilator (time)
Supported	Patient	Ventilator	Patient (flow)

CASE 1

- SIMV
- 27 cmH_2O PIP and 6 cmH_2O PEEP, to generate a tidal volume of 6–7ml kg^{-1}
- Central venous and arterial access
- Nebulized salbutamol was administered. Intravenous cefotaxime was added to her antibiotic regime

CASE 1

- Deteriorated: HFOV
- Oxygenation index was 19.0
- Alveolar Arterial Difference in Oxygen (AaDO2) 520 mmHg.
- Prone position
- Therapeutic options reconsidered →nitric oxide, steroids, surfactant, and ECMO discussed


13.5
49
33
08.2
SensorMedics

HFOV

- Adjustable Parameters
  - Mean Airway Pressure: usually set 2-4 higher than MAP on conventional ventilator
  - Amplitude: monitor chest rise
  - Hertz: number of cycles per second
  - FiO2
  - I-time: usually set at 33%

HFOV

- Advantages:
  - Decreased barotrauma / volutrauma: reduced swings in pressure and volume
  - Improve V/Q matching: secondary to different flow delivery characteristics
- Disadvantages:
  - Greater potential of air trapping
  - Hemodynamic compromise
  - Physical airway damage: necrotizing tracheobronchitis
  - Difficult to suction
  - Often require sedation

SETTING THE VENTILATOR

Ventilator Settings- FiO_2

- Dangerous drug
- Lowest setting to keep Sats >88-92 %
- "Closed loop" Auto-weaning
- Trigger ∝"Patient comfort"
- Flow vs Pressure
- Beware "Auto-triggering"
- Beware increased work of breathing
- New – Neurally Adjusted Ventilatory Assist

Ventilator Settings- PEEP

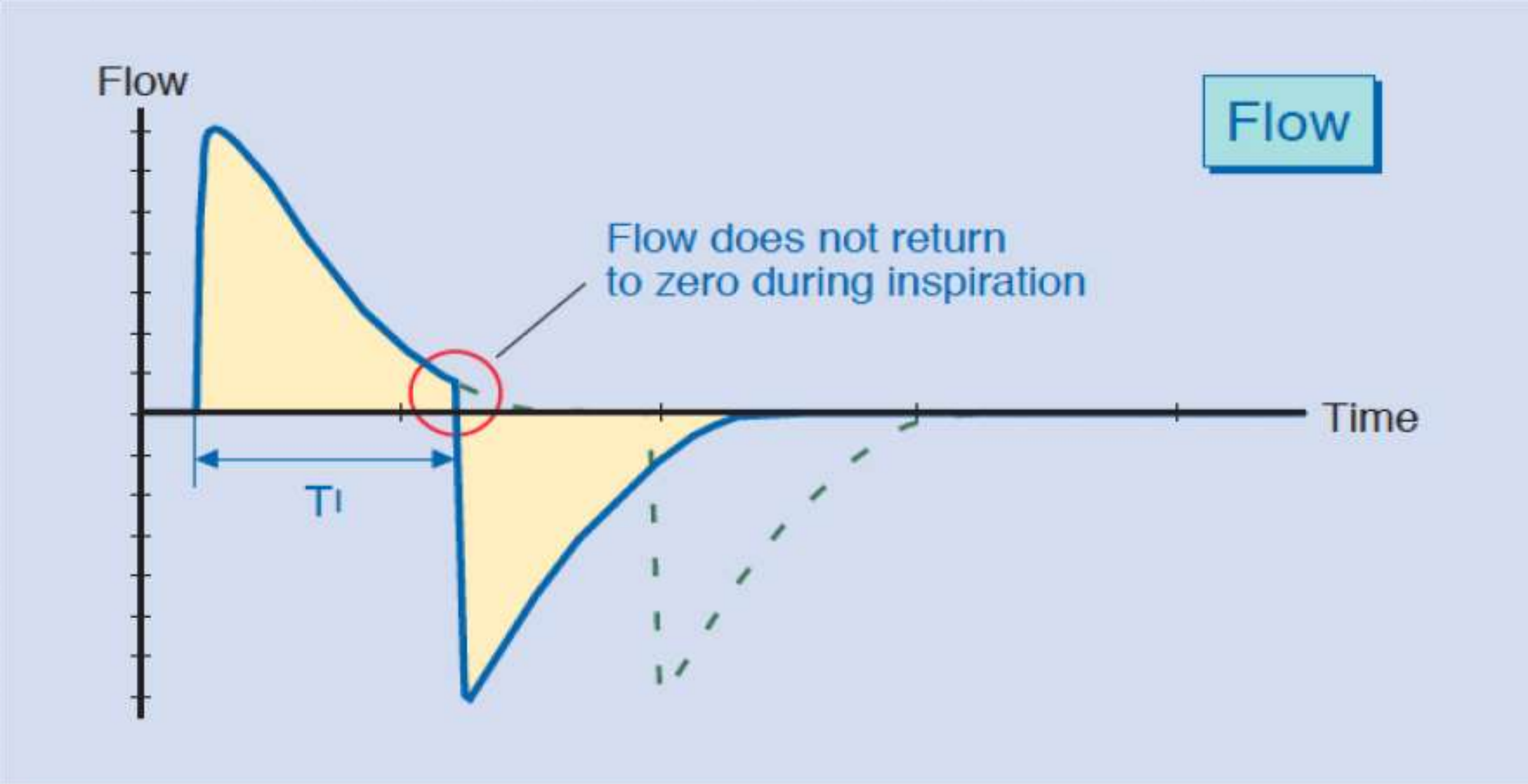
- Role in Paediatrics?
- Improve FRC > Closing capacity
- Normal healthy lung has PEEP +/- 3-5 cmH_2O
- Intubation removes natural PEEP augmentation – bypassing post pharynx
- Generally 8-10 cmH_2O
- Higher for recruitment
- Contra-indications
  - Isolated head injury
  - Asthma

Ventilator settings- Driving Pressure

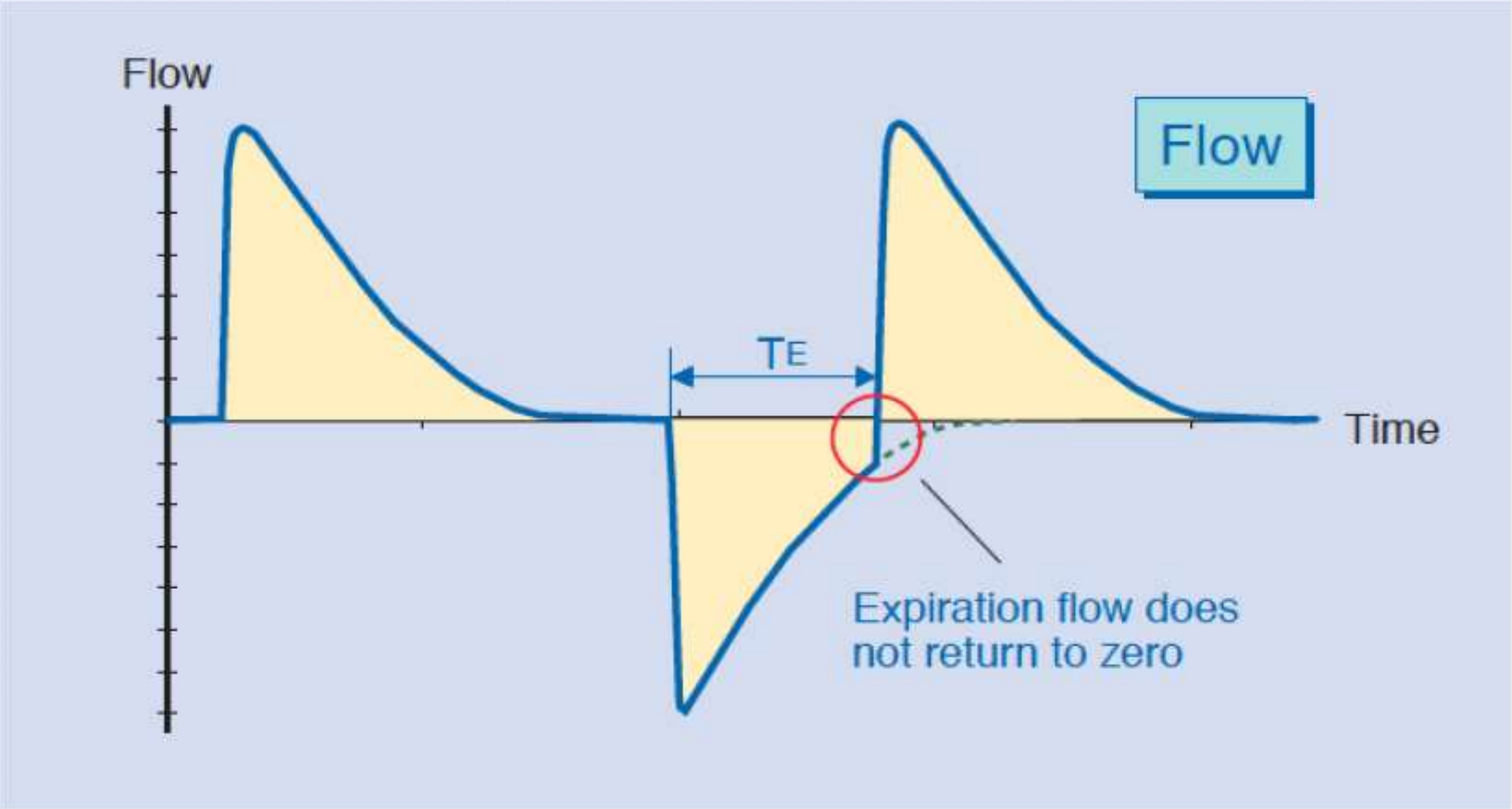
- PIP vs ΔP
- Generates MAP – oxygenation
- Generates TV – Alveolar ventilation
- Should not exceed 30 cm H_2O

Ventilator settings I:E

- I-time / I:E ratios
- Dependent on age of patient
- Dependent on time constant – relationship to compliance and resistance of the lung
- Neonate 0.4sec,
- Child 0.6-0.8sec,
- "Big Child" 1 sec
- Guided by Flow-time curve



The flow curve in the case of insufficient inspiration time



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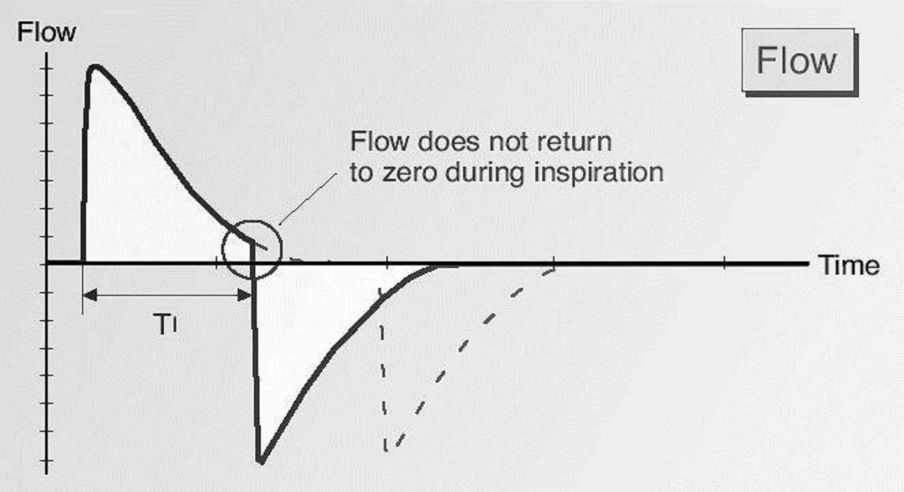
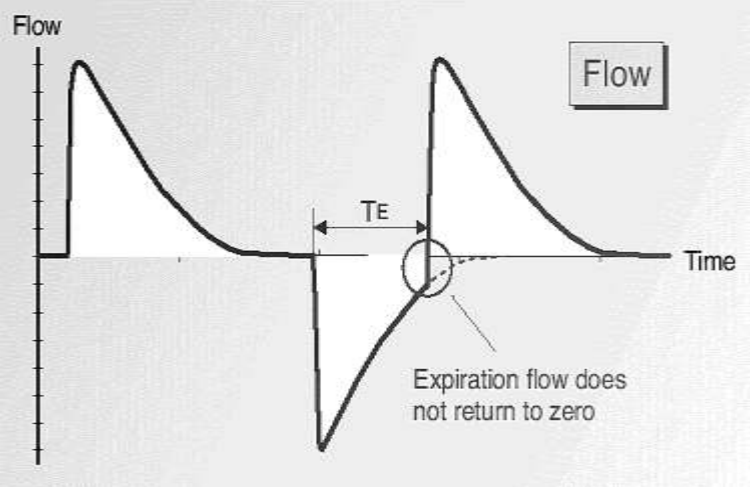




Too short Ti will reduce delivered Vt

→ unneccessary high PIP will be applied
→ unnecessary high intrathoracic pressures

Too short Te will not allow to deliver max. possible Vt at given P

→ will induce PEEPi
→ increases the risk for hemodynamic instability

The patient respiratory mechanics dictate the maximal respiratory frequency

Ventilator Settings- Rate

- In Assist control – back-up rate
- Set to allow spontaneous breaths
- Air drawn to lower regions
- Avoid high rates to “blow off CO_2”
- Can cause drop in TV; dead space ventilation
- Be guided by flow-time curve

TRICK #3

- Know how to manage different diseases
- Know the pathophysiology
- "Lung protective strategies"

HYPOXIA

- Hypoventilation: decreased alveolar ventilation, i.e. CNS depression
- Diffusion impairment: abnormality at pulmonary capillary bed
- Shunt: blood flow without gas exchange
  - Intra-pulmonary
  - Intra-cardiac
- Ventilation-perfusion mismatch: Both dead space and shunt abnormalities

TREATING HYPOXIA

- Increase FiO_2: >60% toxic to lung parenchyma
- Increase mean airway pressure
  - PEEP : not too much, not too little
  - PIP
  - I-time

HYPERCARBIA

- Decreased minute ventilation
  - Respiratory rate
  - Tidal volume
- Treatment:
  - Increase respiratory rate: assure I-time not too short as rate increased
  - Increase tidal volume
  - Allow permissive hypercarbia

LUNG PROTECTIVE STRATEGIES

- High PEEP
- Pressure limiting PIP: <30 cmH2O
- Low tidal volume: 4-6 ml/kg
- FiO2 <60%
- Permissive hypercarbia
- Permissive hypoxia

ALI/ARDS

- Disorders marked by a significant inflammatory response to a local (pulmonary) or remote (systemic) insult resulting in injury to alveolar epithelial and endothelial barriers of the lung, acute inflammation and protein rich pulmonary oedema.
- ARDS is the more severe form of ALI.

TABLE 1. 1994 Consensus Conference Definitions of ALI and ARDS[3]

Onset	:	Acute and persistent
Oxygenation criteria	:	$PaO_2/FiO_2 \leq 300$ for ALI; ≤ 200 for ARDS
Radiographic criteria	:	Bilateral infiltrates
Exclusion criteria	:	Pulmonary artery occlusion pressures ≥ 18 mmHg Clinical evidence of left atrial hypertension

Table 5. Therapeutic Strategies in ARDS[38]

Control of causative factors (sepsis, shock, etc)
Mechanical ventilation
- Controlled oxygen exposure (FiO_2)
- Avoidance of volutrauma (low V_T)
- Avoidance of atelectrauma (appropriate PEEP)

Non-conventional ventilation
- High frequency ventilation
- Liquid ventilation

Careful fluid administration
Drug-based therapies
- Nitric oxide
- Surfactant
- Corticosteroids and other anti-inflammatory agents

Positioning (Prone ventilation)
Supportive therapy
- Analgesia and sedation
- Nutrition/Immunonutrition
- Psychosocial support

ARDS Management

- **Mechanisms implicated in VILI**
  - Oxygen toxicity from use of high FiO_2
  - Over distension of alveoli leading to volutrauma and barotrauma
  - Repetitive opening and closing of alveoli causing shear stress and triggering further inflammation (atelectrauma)

ARDS Management

- **Key features of "lung protective" ventilation**
- Controlled oxygen exposure
- Permissive hypercapnia
- Low tidal volumes 4-6 ml/kg
- Adequate PEEP
- Peak pressure < 30 cm H_2O

ARDS Management- PEEP

- PEEP improves oxygenation by providing movement of fluid from the alveolar to interstitial space, recruitment of small airways and collapsed alveoli and an increase in functional residual capacity.
- PEEP is adjusted between 8 cm H_2O and 20 cm H_2O; PEEP is progressively increased by 2-3 cm H_2O increments to maintain saturation between 90 and 95% with $FiO_2 < 0.5$.
- The child should be monitored for any evidence of cardiovascular compromise and hyperinflation

ARDS- HFOV

- The advantages of HFOV are
  - use of low VT and avoidance of barotrauma
  - maintenance of near normal $PaCO_2$ with improved minute ventilation.
  - Some studies in paediatric population have shown that early initiation of HFOV is associated with better oxygenation but none have demonstrated clearly improved outcome.

ARDS- NITRIC OXIDE (NO)

- Causes pulmonary vasodilation and decrease in pulmonary hypertension. Maximal improvement in oxygenation is usually achieved with <10 ppm in most patients. The effect can be frequently seen in less than ten minutes or may take several hours.
- Paediatric studies suggest that iNO improves short-term oxygenation in children with ARDS but little change is seen in long-term oxygenation indices.

ARDS- SURFACTANT THERAPY

- Metanalysis (Crit Care 2007) & systemic review of surfactant use in critically ill children with acute respiratory failure → significant reduction in mortality, as well as a significant reduction of ventilator days and less need for rescue therapy (nitric oxide, High frequency ventilation and ECMO) in these patients
- Dose: 2ml/kg (50mg/kg/dose)

- Acute hypoxaemic respiratory failure with no improvement within 48 hrs of starting ventilation using a lung protective strategy.(Wilson, 2005)
    - With OI >7 (Wilson 2005, Wilson 1999)
    - With PF<150 (Luchetti 1998, 2002)
    - Diffuse bilateral infiltrates on CXR (Wilson 1999, 2005, Moller 2003)

- Aspiration of hydrocarbons. (Horoz OO 2010, Mastropietro 2011)

- Bronchiolitis
    - Ventilated >24 hrs without improvement (Luchetti 1998)
    - PF <160 (Luchetti 2002, 1998)
    - CXR showing air trapping (Luchetti 2002)

ARDS- CORTICOSTEROIDS

- Prospective, randomized controlled trial→ prolonged administration of methylprednisolone in adult patients with unresolving ARDS (ARDS>7 days) → improvement in lung injury and MODS scores and reduced mortality.
- Larger more recent RCTs→ have shown improved ventilatory parameters but increased late mortality in the group given steroids

PRONE POSITIONING

- Changes in regional lung perfusion, regional pleural pressures & recruitment of dorsal lung → improve oxygenation during prone positioning
- Few risks & costs involved

CASE 2

- Child Amy
- 13-year-old girl
- History of recurrent exacerbations of asthma
- Now sudden onset of severe respiratory distress 2 hours earlier.
- She had not improved, despite repeated doses of aerosolised salbutamol

CASE 2

- Conscious patient, agitated
- Increasing respiratory effort, RR 55
- Intercostal and suprasternal retraction and nasal flaring.
- Wheezing, poor air entry and poor chest movement, the heart rate had increased 165 min^{-1}, whilst her skin was still warm and well perfused.

CASE 2

- Deteriorated →inability to speak, a decrease in chest movement, air entry, sats 85%
- Non-invasive assisted ventilation using triggered full-face mask biphasic positive airway pressure (BiPAP) at 5 and 20 cmH20
- ABG: pH of 7.1, pCO_2 65mmHg, pO_2 75mmHg, BE –8, lactate 8mmol l^{-1}, and a potassium of 2.3mmol l^{-1}.
- Over the next hour, fluctuating conscious state and markedly decreased peripheral perfusion.
- INTUBATED

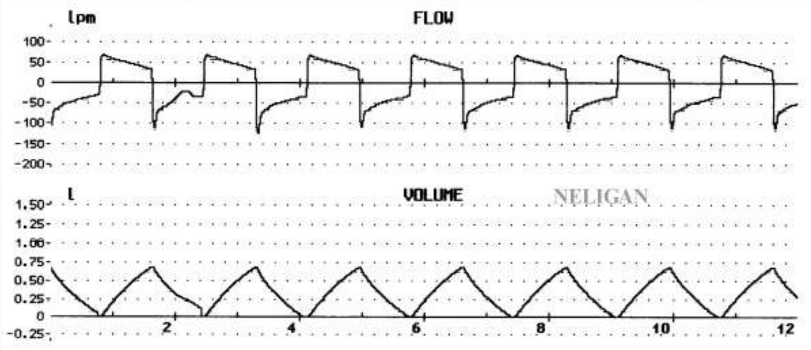
PULMONARY DISEASE- RESTRICTIVE

- Compromised lung volume:
  - Intrinsic lung disease
  - External compression of lung
- Recruit alveoli, optimize V/Q matching
- Lung protective strategies

PULMONARY DISEASE- OBSTRUCTIVE

Airway obstruction causing increase resistance to airflow: e.g. asthma

- Optimize expiratory time by minimizing minute ventilation
- Bag slowly after intubation
- Don't increase ventilator rate for increased CO_2



ASTHMA

- Pressure controlled ventilation (keep PIP <30) or volume controlled ventilation (Tv 5-8 ml/kg) may be used
- A long expiratory time (with a optimum inspiratory time) with an I/E ratio of >1:2 and a slow rate allow emptying of the lungs and avoid ‘air trapping’ and progressive hyperinflation
- Manual decompression of chest → may help to deflate overinflated lungs and improves ventilation.

ASTHMA

- Sedation → important to avoid the complications of air-leak
- Preferred drugs for these patients are ketamine (has a bronchodilator effect) & fentanyl (as morphine causes histamine release which might aggravate bronchospasm).
- ? Suction and physiotherapy → clear mucus plugging and prevent atelectasis
- Specific treatments for asthma→ nebulised and intravenous salbutamol, intravenous aminophylline, systemic steroids and magnesium sulphate

CASE 2

- Initially, the ventilator was set at a rate of 30 min^{-1}, I:E ratio 1:4, PIP 40 cmH_2O, and PEEP 0cmH_2O.
- Considering a rise in arterial pCO_2 from 110 to 130mmHg, the PEEP was increased to 8 cmH_2O.
- Infusions of ketamine, midazolam, and paralysis with a vecuronium infusion
- Magnesium sulphate at a dose of 30 mg kg^{-1}per h was added to the continuous intravenous treatment with salbutamol and aminophylline.

BRONCHIOLITIS

- Apnoeas (relatively normal lungs) – Minimise VILI with low Tv
- Air trapping – Manage like asthma
- ARDS – Manage like ARDS (including HFOV, iNO, ECMO)

PNEUMONIA/LUNG COLLAPSE

- Minimise oxygen toxicity (FiO2 <0.60)
- Minimise atelectrauma (adequate PEEP)
- Minimise volutrauma (low Tv 4-6 ml/kg)
- Permissive hypercapnia

PULMONARY OEDEMA/HAEMORRHAGE

- Cardiogenic
- Negative pressure (post-obstructive)
- Neurogenic
- Non-cardiogenic

PULMONARY OEDEMA/HAEMORRHAGE

- Conventional ventilation
  - Minimise oxygen toxicity (FiO_2 <0.60)
  - Minimise atelectrauma (adequate PEEP)
  - Minimise volutrauma (low Tv 4-6 ml/kg)
  - Permissive hypercapnia
- High frequency ventilation
  - Constant MAP
  - Recruitment of lung

TRICK #4

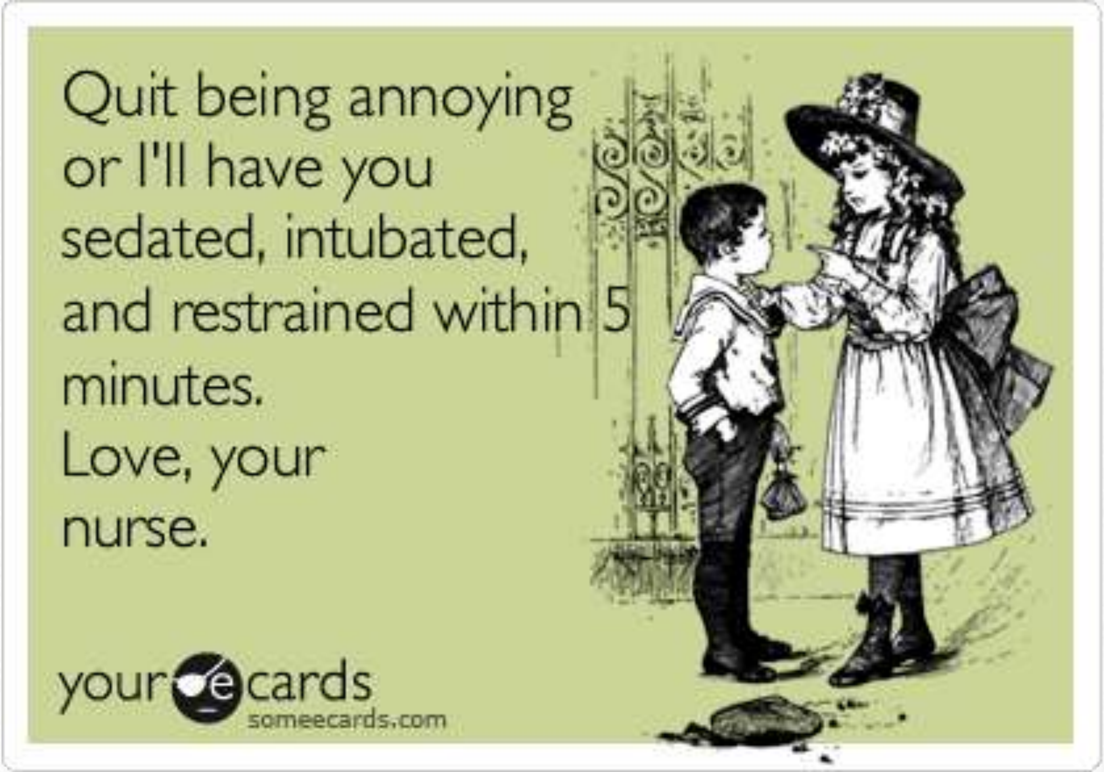
- Be safe
- Safety bundle

VENTILATOR-ASSOCIATED PNEUMONIA (VAP)BUNDLE:

- DVT prophylaxis
- GI prophylaxis
- Head of bed (HOB) elevated to 30-45°
- Daily Sedation Vacation
- Daily Spontaneous Breathing Trial

TRICK #5

- Daily assessment trial of readiness to extubate
- Adjuncts to extubation eg decr airway oedema in UAO (steroids >6 hrs)
- Sedation holiday
- Conservative fluid regime


Quit being annoying
or I'll have you
sedated, intubated,
and restrained within 5
minutes.
Love, your
nurse.
your ecards
someecards.com

Daily sedation vacation/ Spontaneous Breathing Trials

- Implement a protocol to lighten sedation daily at an appropriate time to assess for neurological readiness to extubate.
  - Include precautions to prevent self-extubation such as increased monitoring and vigilance during the trial.

- Include a sedation vacation strategy in your overall plan to wean the patient from the ventilator
  - if you have a weaning protocol, add "sedation vacation" to that strategy.

VENTILATOR MODES IN WEANING

Mode	Weaning Description	Notes
Reducing mechanical support		
Assist control	Reduce set rate on ventilator.	Patient-triggered breaths are of uniform set volume.
Synchronized intermittent mandatory ventilation	Reduce set rate on ventilator.	Patient-triggered tidal volume is determined by patient effort and ability only.
Pressure support	Reduce maximum pressure assisting each inspiration.	Patient triggers each breath; tidal volume is determined by patient effort and ability and level of pressure support.
Volume support	Reduce guaranteed minimal tidal volume.	Patient triggers each breath; pressure support level will vary according to patient effort and ability and set tidal volume.
Intermittent T-piece weans	Endotracheal tube is disconnected from ventilator circuit. Increase frequency and/or duration of periods of disconnect.	Patient triggers each breath; patient effort and ability determine each inspired volume.
Unassisted breathing trials		
T-piece	Endotracheal tube is disconnected from ventilator circuit.	Patient triggers each breath; patient effort and ability determine each inspired volume.
Pressure support	Ventilator augments each inspiration with minimal support only (5–8 cm H_2O).	Sufficient pressure support to overcome resistance of ventilator circuit.
Continuous positive airway pressure	Ventilator maintains minimal airway pressure throughout respiratory cycle (3–5 cm H_2O).	Sufficient pressure to replace loss of “physiologic” airway pressure that occurs with glottic closure.

CRITERIA FOR EXTUBATION READINESS TEST FAILURE

Proposed criteria for failure during 2 hrs on
Continuous positive airway pressure ≤5 cm H_2O or T-piece (zero end-expiratory pressure)

- Clinical criteria
  - Diaphoresis
  - Nasal flaring
  - Increasing respiratory effort
  - Tachycardia (increase in HR >40 bpm)
  - Cardiac arrhythmias
  - Hypotension
  - Apnea
- Laboratory criteria
  - Increase of $PETCO_2$ >10 mm Hg
  - Decrease of arterial pH <7.32
  - Decline in arterial pH >0.07
  - PaO_2 <60 mm Hg with an FIO_2 >0.40 (P/F O_2 ratio <150)
  - SpO_2 declines >5%

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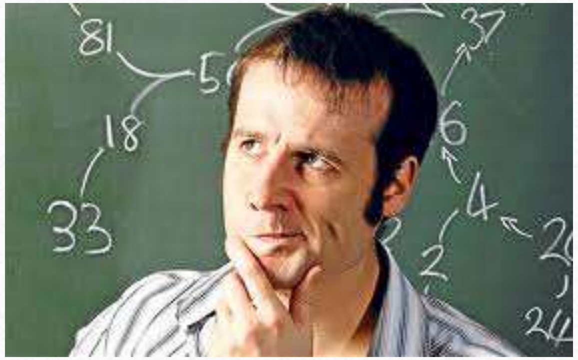
TRICK #6

- Know how to read "problems" on your vent



Air Leak

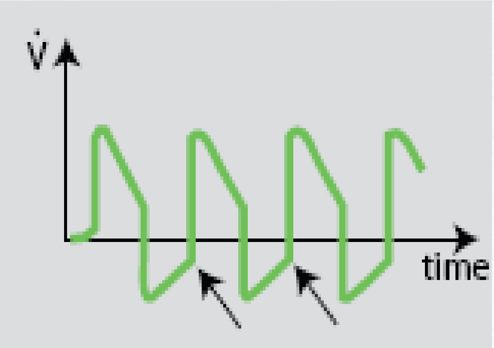
PRESSURE SIMV
LOOPS
44.5
Vte
25
Rate
1:3.5
I:E
29
Ppeak
7
PEEP
Vt (ml) - Flow (l/min)
Paw (cmH2O) - Vt (ml)
22
Rate
23
Insp Pres
0.60
Insp Time
10
PSV
6
PEEP
1.0
Flow Trig
21
%O2

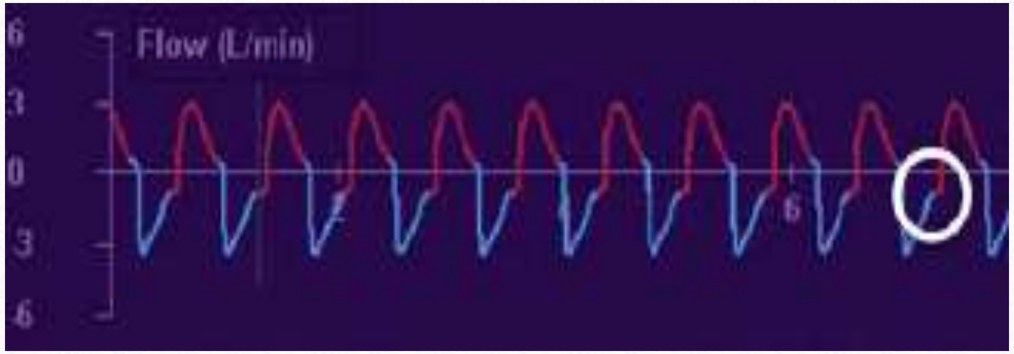
Autocycling

Secretions

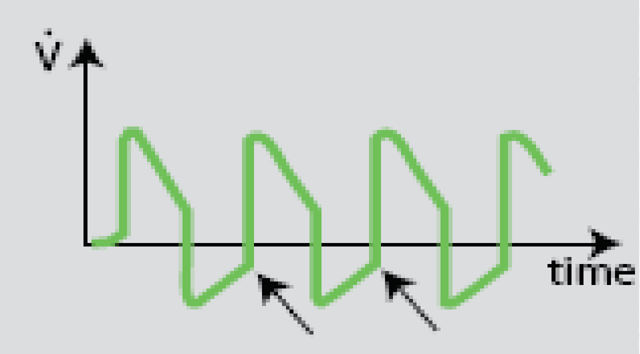
PRESSURE SIMV
MAIN
16
bpm
Rate
21
cmH2O
Ppeak
34.3
ml
Vti
31.8
ml
Vte
21
%
FiO2
Paw (cmH2O)
10.7
Flow (l/min)
0.1
Vt (ml)
0.8

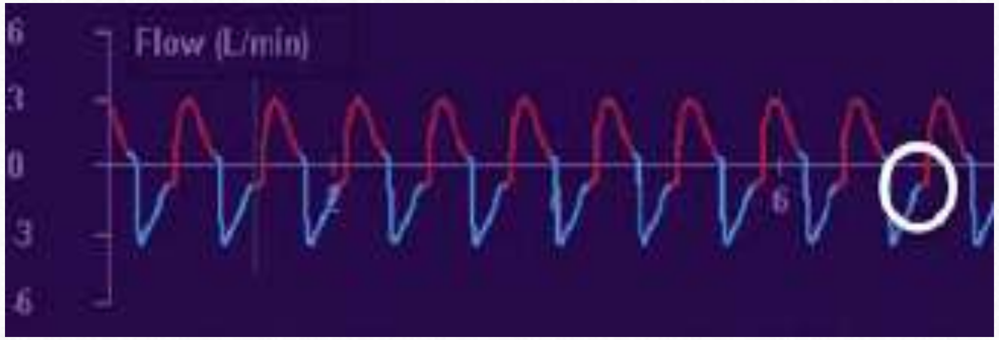
Auto PEEP





- If the respiratory rate is set high or the expiratory time is not long enough there is a risk for auto PEEP.
- The patient does not have enough time to exhale and it is evident on the flow curve that flow will not return to zero before the next breath starts.



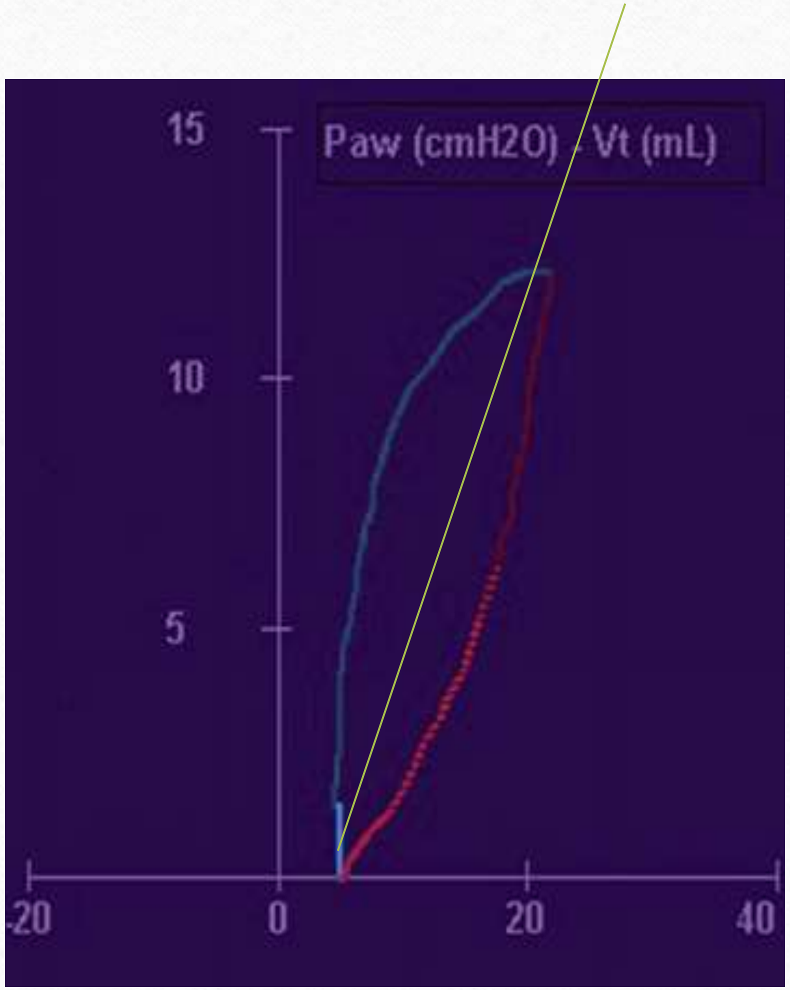


<u>Considerations aimed at alleviating this condition could be:</u>

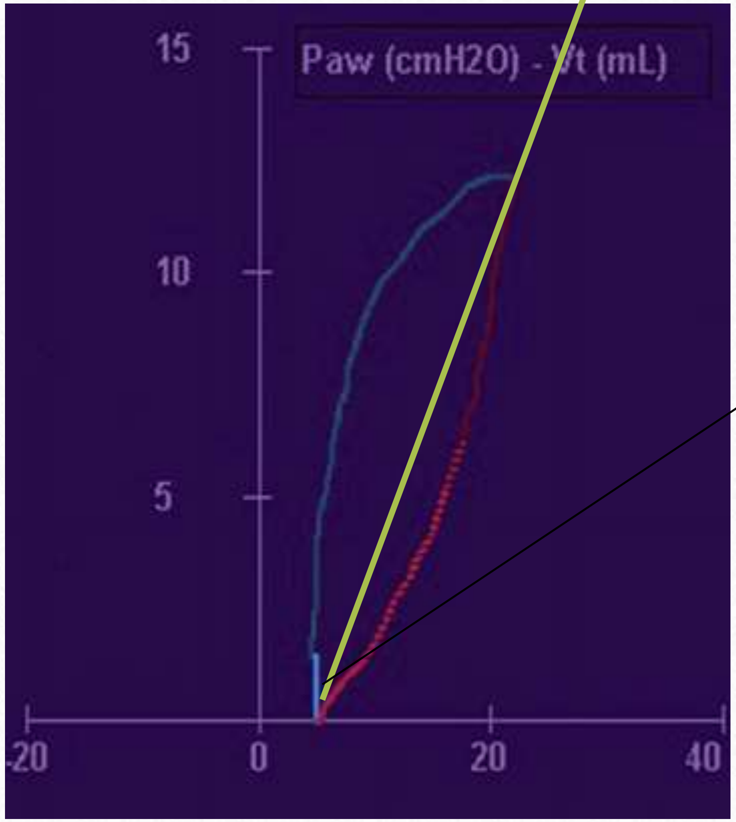
1. Decreasing the set respiratory rate;
2. Decreasing the inspiratory time to give more expiratory time;
3. If the patient is triggering the respiratory rate, consider that :
    - the tidal volume is not appropriate (too small) and the patient may be experiencing hypoventilation, or
    - the patient may be hypoxemic and attempt to increase mean airway pressure by creating a higher PEEP. In this case, an increase in the PEEP level may be appropriate.

Pressure–volume loop

- If an imaginary line is drawn to connect the origin of the loop with the PIP, it can estimate the dynamic compliance of the lung.
- Compliance is mathematically determined by
- Δ volume/ Δ pressure
- Is graphically displayed on the LOOP screen.

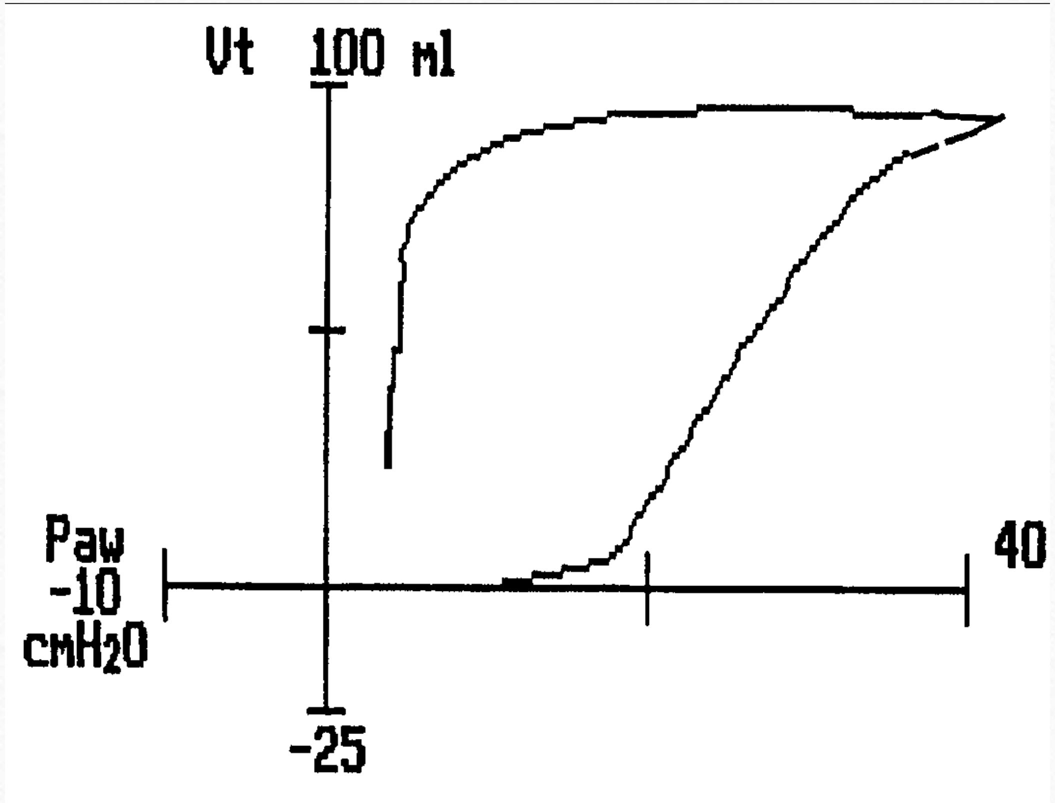


Pressure–volume loop

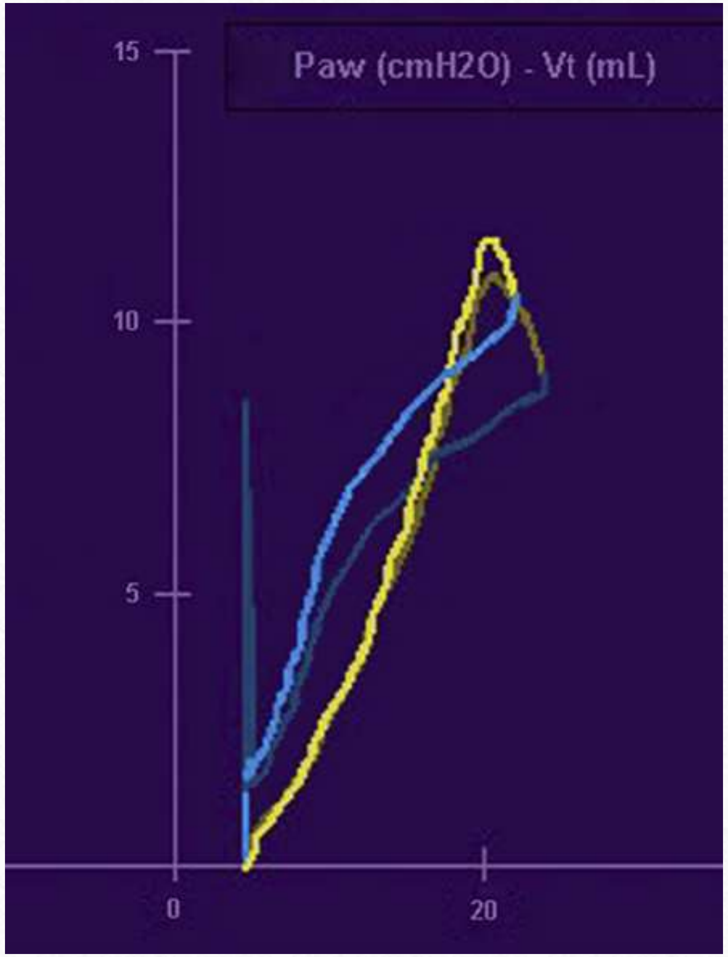


- A loop indicating **good compliance** will be described as upright (compliance axis>45)
- A loop indicating **poor compliance** is described as flat, or lying on its side.

OVERDISTENTION

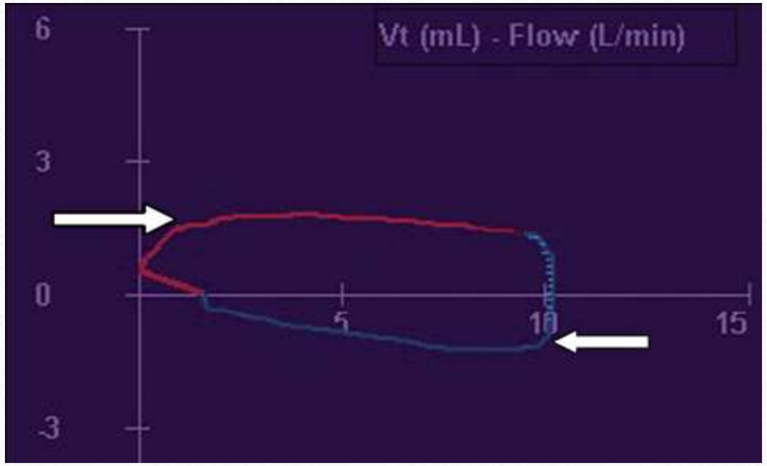


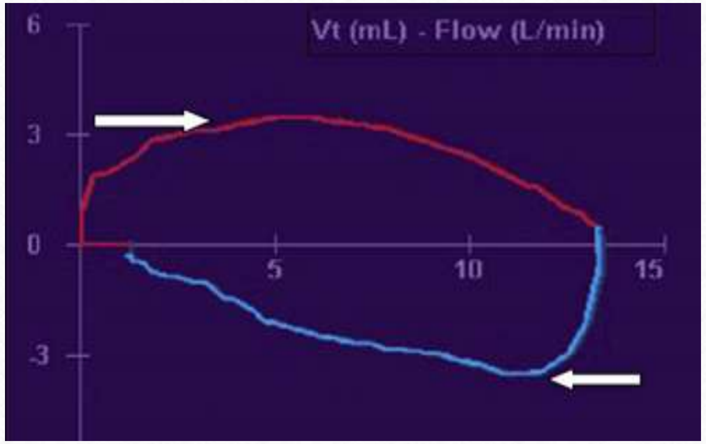
Pressure–volume loop



- Inadequate hysteresis, producing a narrow loop, may be indicative of inadequate flow

Flow–volume loop





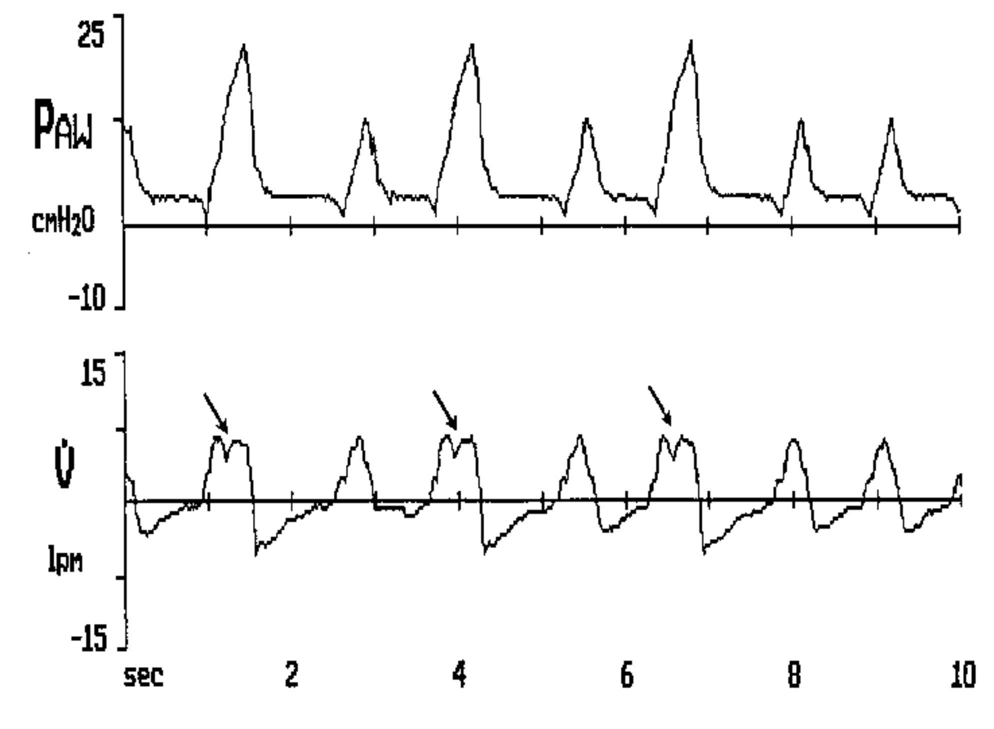
- The effect of altering resistance by use of a bronchodilator.
- After treatment, resistance improves, and there is a demonstrable difference in the appearance of the loop.

FLOW SYNCHRONY

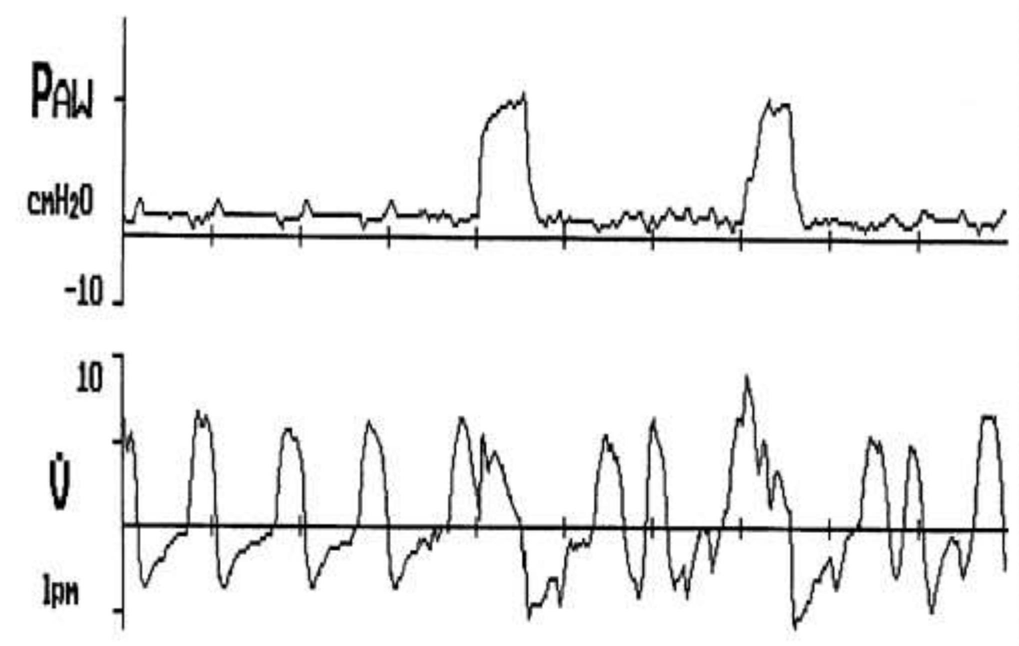
- Defined as the ideal matching of inspiratory flow of a ventilator breath to the patient's inspiratory demand during assisted or supported ventilation.

- Asynchrony: Inadequate inspiratory flow at any point during inspiration causing an increased or irregular patient effort.
  - –leads to increased WOB
  - –"fighting" the ventilator

FLOW ASYNCHRONY



TRIGGER INSENSITIVITY



INSPIRATORY SYNCHRONY

Optimal inspiratory patient - ventilator synchrony is a function of:

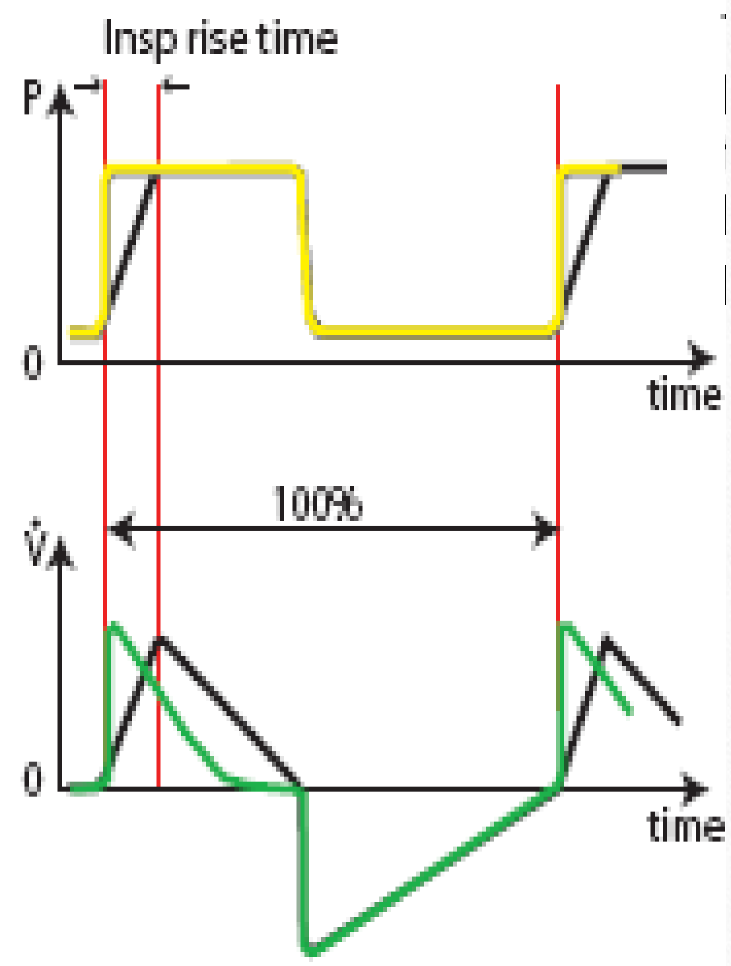
- inspiratory flow pattern
- adequate inspiratory flow
- appropriate trigger sensitivity
- ETT effects
- appropriate lung inflation

PATIENT- VENTILATOR INTERACTIONS

Expiratory synchrony

- end-expiratory lung volume
- premature termination of exhalation & intrinsic PEEP
- expiratory resistance

INSPIRATORY RISE TIME



- Inspiratory rise time is the time taken to reach peak inspiratory flow or pressure at the start of each breath, expressed either as a percentage of the respiratory cycle time or in seconds.

INSPIRATORY RISE TIME

- The flow and pressure rise time can be adapted in accordance with the patient.
- The Inspiratory rise time has to be set to a comfortable value for the patient and can be evaluated by the shape of the flow and pressure curves

CONCLUSION

- Children have natural propensity to have lung collapse
- Ventilation aims to restore oxygenation, lung volumes, decrease work of breathing
- Set Ventilator to cause least harm, most benefit and comfort to the patient

CONCLUSION

- Rare for a child to "fight" ventilation
  - Hypoxia
  - Blocked tube
  - Inadequate settings
- DO NOT SEDATE/PARALYSE WITHOUT CAUSE
- Sedation Protocols – keep patient comfortable, not agitated – allow spontaneous breathing

CONCLUSION

- Tricks of the Trade:
  - Recognise sick kids and goals of ventilation
  - Know your ventilator & settings
  - Learn how to manage different diseases
    - Lung protective strategies
  - Be safe
  - Daily assessment trial of readiness to extubate
  - Know how to read problems on the vent

REFERENCES

- Available on request
- Acknowledgements:
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Thank you