BC Children's Hospital
An agency of the Provincial Health Services Authority

Pediatric Respiratory Support

BC Children's Hospital PICU Physicians
& Respiratory Therapists

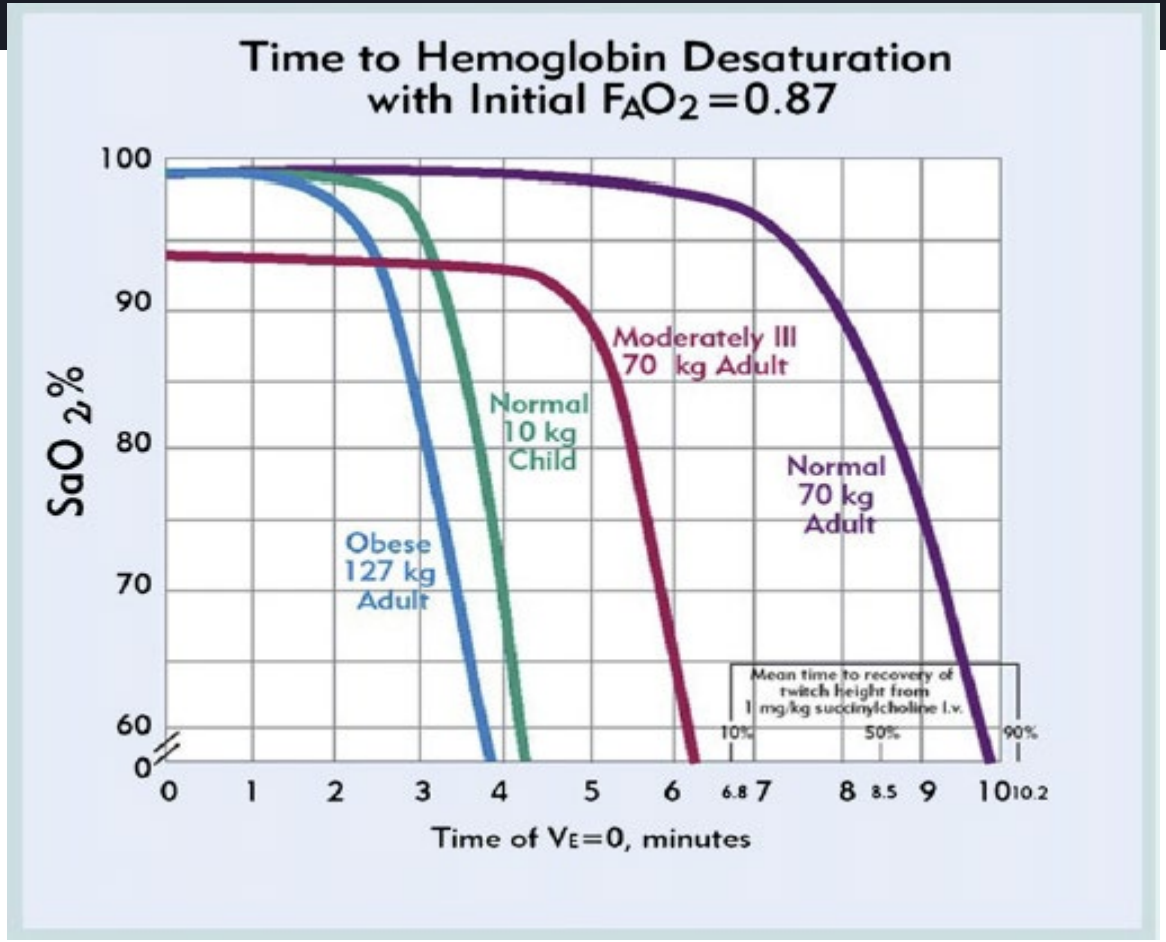
March 4, 2025

Options for Oxygenation/Ventilation in Children

- Low flow oxygen
- High Flow Nasal Cannula (HFNC) Therapy
  - 2L/kg/min
  - maybe useful in some children with bronchiolitis with desaturation not responding to low flow oxygen
- BiPAP (Bi-level positive airway pressure)
  - ventilator delivers an inspiratory positive pressure
  - expiration returns to baseline continuous positive end expiratory pressure
  - good for oxygenation and ventilation problems
  - early initiation in asthma not responding to aggressive medical therapy
- Invasive positive pressure ventilation

- Children more prone to respiratory failure
  - greater airways resistance at baseline
  - pliable chest walls predispose to reduced FRC and atelectasis
  - desaturate much quicker with apnea – airways close above FRC

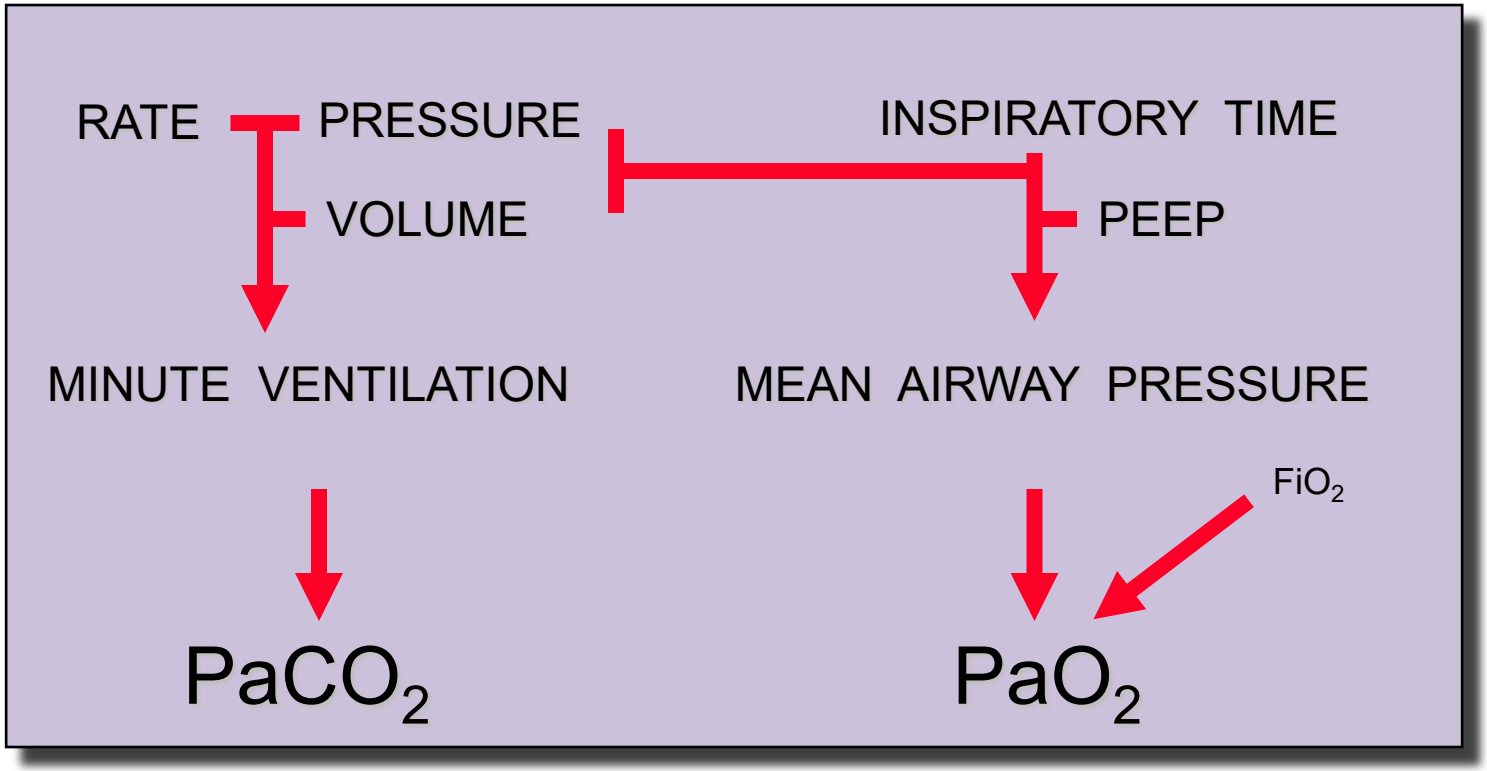
Less Time


Time to Hemoglobin Desaturation
with Initial $F_AO_2 = 0.87$
SaO 2,%
100
90
80
70
60
0
Moderately Ill
70 kg Adult
Normal
10 kg
Child
Normal
70 kg
Adult
Obese
127 kg
Adult
Mean time to recovery of
twitch height from
1 mg/kg succinylcholine I.v.
10%
50%
90%
0 1 2 3 4 5 6 6.8 7 8 8.5 9 10 10.2
Time of $V_E = 0$, minutes

Types of Respiratory Failure

- oxygenation failure
- ventilation failure
- combined oxygenation and ventilation failure

Basic Concepts - Initial Settings on MV



Oxygenation Support

- simple nasal cannula oxygen
- high flow nasal cannula (HFNC) therapy
- non invasive ventilation (BiPAP)
- invasive PPV

Ventilation Support

- non invasive ventilation (BiPAP)
- invasive PPV

Heated and Humidified High Flow O_2 Therapy

Goal: deliver an adequate oxygen flow rate to meet or exceed the patient's peak inspiratory flow

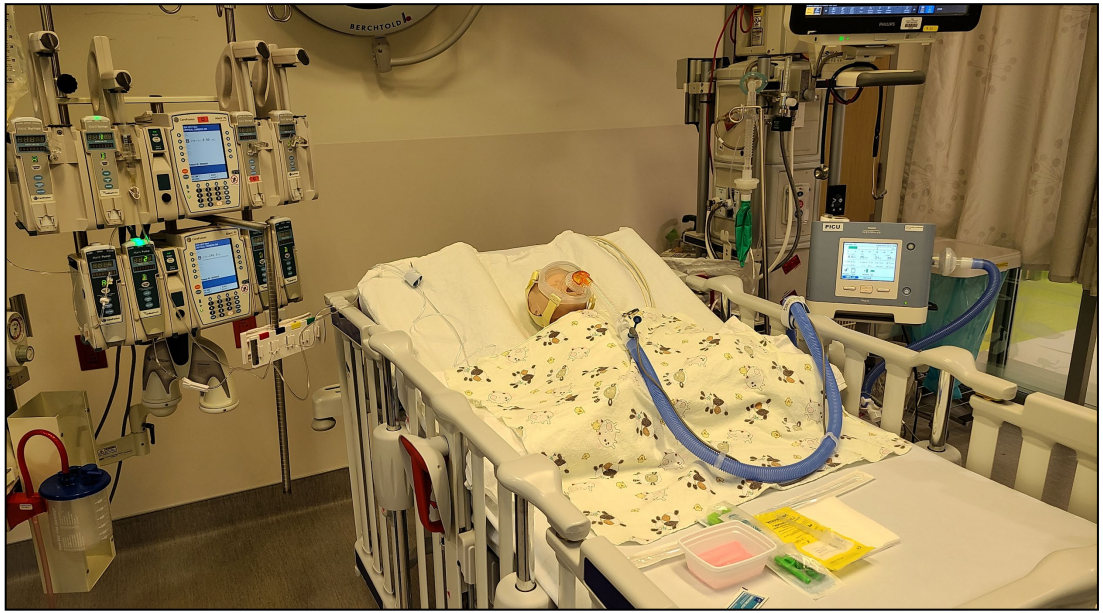
- establishes control of FiO_2 delivery (as not diluting with room air)
- reduce WOB by supporting inspiratory flow demand
- humidification to optimize secretion clearance/reduce heat loss
- reduction of upper airway dead space
- **predominantly supports oxygenation**

Initial Flow Rate for HFNC Therapy is the same for all patients regardless of medical condition

- **≤12Kg: 2 L/kg/minute**
- **>12Kg: 2 L/kg/minute for the first 12kg + 0.5L/kg/minute for each kg thereafter (max flow 50 L/min)**

Increase flow to the prescribed rate over a few minutes, or as tolerated.

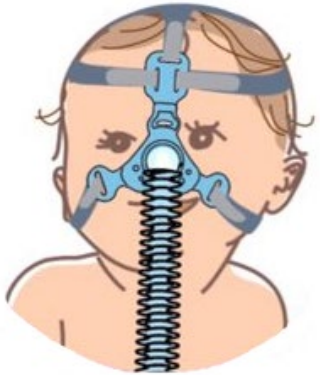
Noninvasive PPV (NIV or BiPAP)



Useful for both oxygenation and ventilation failure

Multiple options: nasal/face/full face mask

Total face masks allow quick fitting, and eliminate nasal bridge challenges by sealing around the perimeter of the face where patients have less pressure sensitivity and smoother facial contours.



Settings on BiPAP

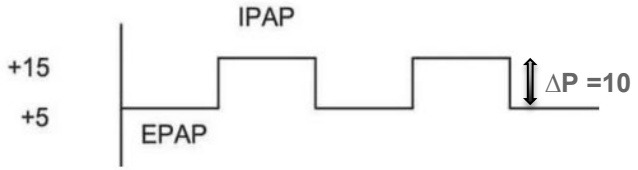
BiPAP is defined as the application of two positive airway pressures

1. **IPAP** (**I**nspiratory **P**ositive **A**irway **P**ressure)= absolute/total pressure or peak pressure

2. **EPAP** (**E**xpiratory **P**ositive **A**irway **P**ressure) = PEEP (Positive End Expiratory Pressure) or CPAP (Continuous Positive Airway Pressure)

Different ventilators use different nomenclature, so it is vital to be aware of the ventilator you are using and the nomenclature associated with the pressure delivery

Terminology



1. IPAP (Inspiratory Positive Airway Pressure)

- Typically start at an IPAP of 10 or 12cmH_2O
- Adjusting to achieve adequate tidal volume (Vt) or chest rise, CO_2 clearance, patient comfort
- IPAP is set independently of EPAP
- Interchangeable terminology: peak pressure or total/absolute pressure

2. EPAP (Expiratory Positive Airway Pressure)

- Typically start at 5 or 6cmH_2O
- Interchangeable terminology: PEEP (Positive End Expiratory Pressure) or CPAP (Continuous Positive Airway Pressure)

3. ΔP (Pressure Gradient) = IPAP – EPAP

- IPAP of 15 cmH_2O and EPAP of 5 cmH_2O offers a pressure gradient (ΔP) of 10 cmH_2O

Hamilton T1 Ventilator

Common noninvasive **modes/settings** in Hamilton T1

1. **NIV** (noninvasive ventilation):
   - Every breath is spontaneous
   - Settings: Δ Psupport + PEEP/CPAP
   - e.g. Δ Psupport 6 cmH_2O + PEEP/CPAP 6 cmH_2O = total inspiratory pressure 12 cmH_2O

2. **NIV-ST** (spontaneous/timed noninvasive ventilation):
   - Every breath is spontaneous as long as the patient is breathing above the set rate. A backup rate can be set for mandatory breath
   - Settings: Δ Pinsp + PEEP/CPAP, RR
   - e.g. Δ Pinsp 8 cmH_2O + PEEP/CPAP 8 cmH_2O = total inspiratory pressure 16 cmH_2O

Trilogy Ventilator

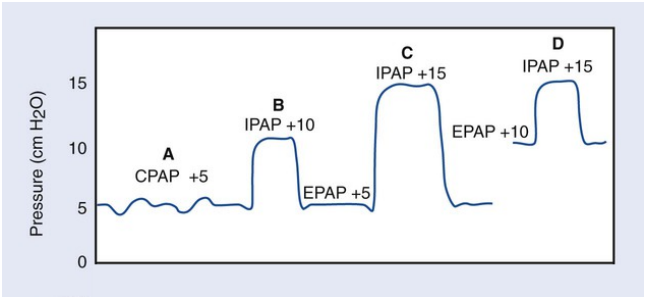
Common noninvasive **modes/settings** in Trilogy

1. **S** (**S**pontaneous):
   - Every breath is spontaneous
   - Settings: IPAP, EPAP
   - e.g. IPAP 12 cmH_2O / EPAP 6 cmH_2O gives ΔP =6 cmH_2O

2. **S/T** (**S**pontaneous/**T**imed):
   - Every breath is spontaneous as long as the patient is breathing above the set rate. A backup rate can be set for mandatory breath
   - Settings: IPAP, EPAP, RR
   - e.g. IPAP 18 cmH_2O / EPAP 8 cmH_2O gives ΔP =10 cmH_2O

Patient Management on BiPAP

- Optimize FRC by increasing PEEP/EPAP, optimize Vt by increasing ΔP or IPAP (absolute pressure)
  - A safe escalation of pressure would be to increase the ΔP or IPAP by 2 cmH_2O each time, and increase the PEEP/EPAP by 1 or 2 cmH_2O
    e.g. (IPAP/EPAP) 12/6 → 14/7 → 16/8 → 18/8 → 18/10 → 20/10 → 20/12
  - Consider intubation at higher pressures
    - Call PICU for advice and support



- Optimize airway patency
  - Positioning/frequent check for mask leak
  - Airway suctioning (oropharyngeal, nasopharyngeal),
  - Medications such as salbutamol
  - Prone positioning

- Optimize patient comfort
  - Sedation may be required
  - NG tube placement prior to initiation reduces gastric distension
  - Optimize settings for patient comfort/confirm each breath is triggered and delivered

Basic Ventilator Initial Settings

Infants and children are NOT ventilated like neonates

Vt	6-8mL/kg
RR	15-30
Ti	0.6-1.2
PEEP	5-10
Target MV	100-200mL/min/kg

Initial Settings

Age	<1 month	1 mo – 1 yr	1 - 3 yrs	4 - 5 yrs	6 - 10 yrs	> 10 yrs
Target MV (ml/min/kg)	200	175	150	125	125	100
Vt (ml/kg)	6-7	6-8	6-8	6-8	6-8	6-8
RR (br/min)	30 - 35	25-35	20-26	18-24	16-22	14-20
Ti (sec)	0.6	0.6-0.7	0.7-0.75	0.75-0.8	0.8-0.9	0.8-1.0

- When setting Vt, use the lesser of the Ideal/Predicted Body Weight or the Actual Body Weight.
- Monitor and limit driving pressure &/or plateau pressure (plateau < 30cmH2O)
- If using lower Vt for lung protection, increase RR to maintain MV
- Pay attention to I:E ratio if increasing RR

Basic Ventilator Strategies

- Normal lungs/acute lung injury
  - lung protective
- Obstructive lung disease
  - minimize gas trapping

What Pressure Settings do I start with?

- Depends on the primary disease process
  - normal lungs
  - airspace disease
  - obstructive disease

Normal Lungs – Basic Approach – Do no harm

- Paralyzed vs spontaneously breathing?
- TV 6-8mls/kg
- PEEP 5-6cm H_2O
- I time/RR age dependent
  - paralyzed (see table)
  - spontaneously breathing – determined by the patient
- Reassess patient frequently

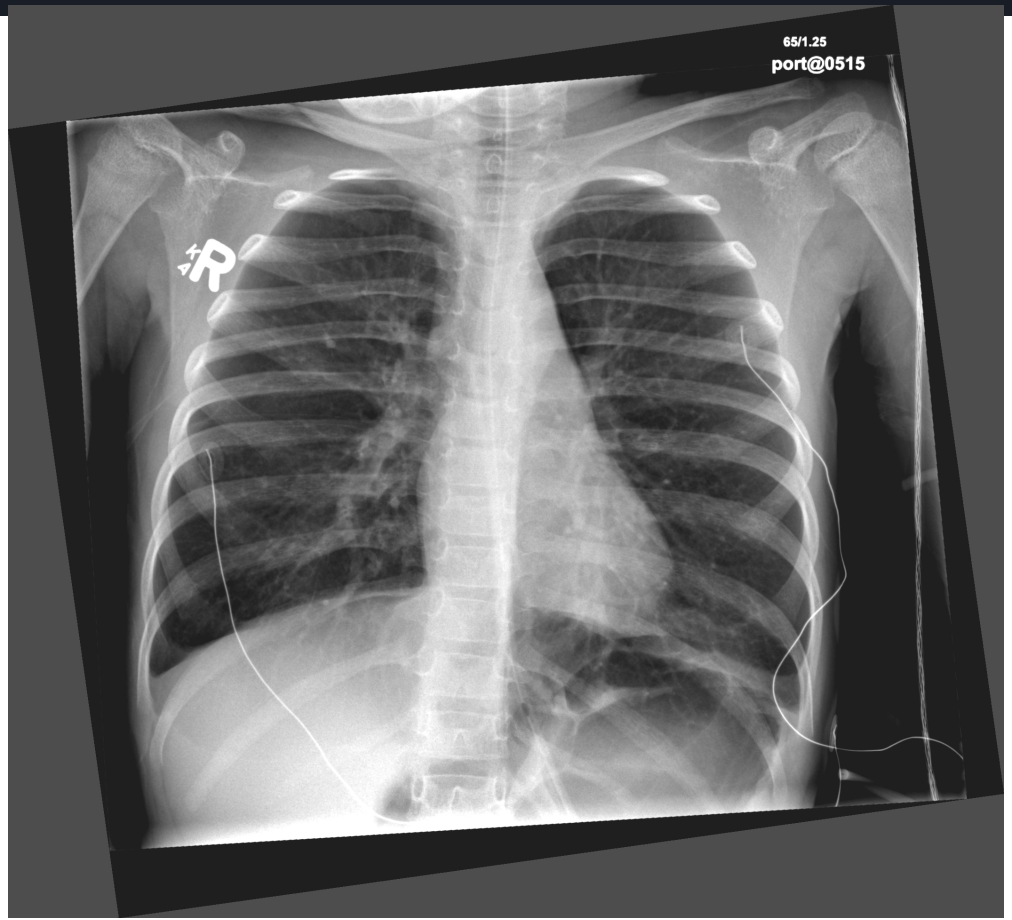
Acute Lung Disease – Basic Approach – Lung Protection

- Paralyzed vs spontaneously breathing?
- TV 5-6mls/kg
- PEEP 6-8cm H_2O
  - may increase to 10cm H_2O or more depending on saturations
- I time/RR age dependent
  - paralyzed (see table)
  - spontaneously breathing – determined by the patient
- Reassess patient frequently

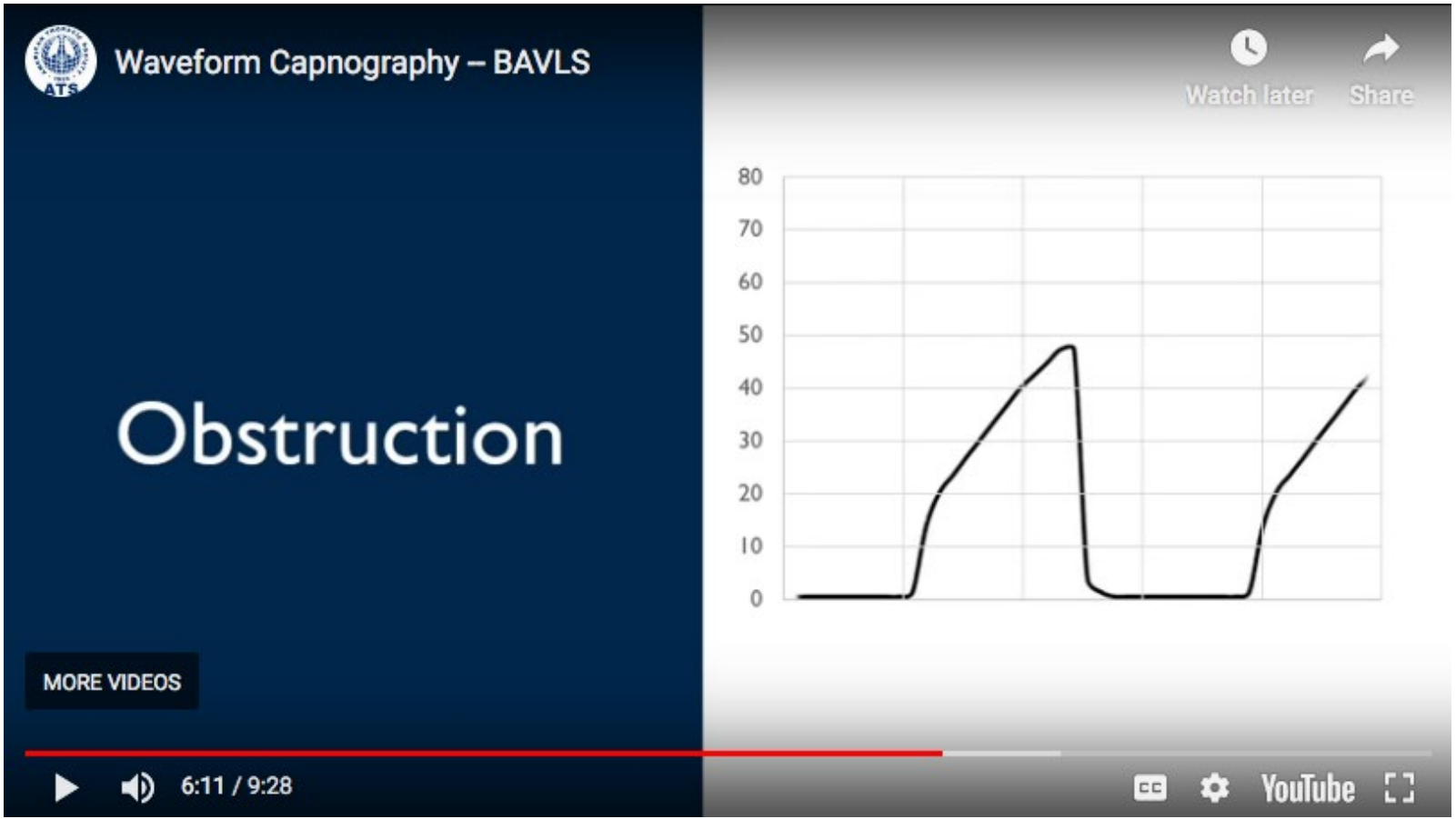
Obstructive Lung Disease – Basic Approach – Avoid Gas Trapping

- BiPAP best initial option
- Targets
  - avoid worsening gas trapping / offset intrinsic PEEP
  - unload respiratory muscles / reduce resistance to exhalation
- Settings
  - TV < 8mls/kg
  - Long E time/short I time (patient age dependent/set by patient while spontaneously breathing)
    - Observe patient trigger
  - EPAP set to match intrinsic PEEP in spontaneously breathing patient
  - FIO_2 to maintain sats > 92%
- Call PICU for advice and support

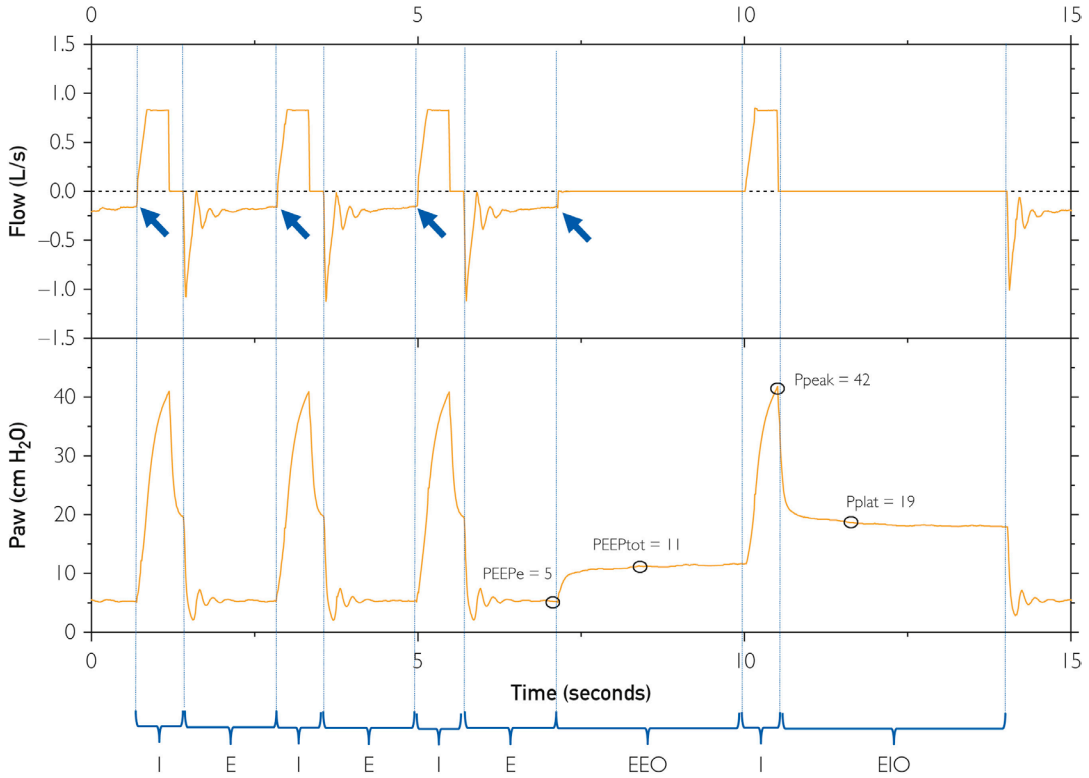
Airway Obstruction Strategy



Capnometry - Obstruction



Expiratory Flow Obstruction



Asthma Emergencies

- Can't ventilate
  - disconnect to manual ventilator with 100% oxygen
  - gentle manual breaths with long expiratory time to allow lung decompression and improve venous return
- Hypotension
  - as for "can't ventilate" – long expiratory time to improve venous return
  - give fluid bolus
  - exclude/treat tension pneumothorax
  - bolus IV adrenaline 10mcgs/kg
- Worsening hypoxemia
  - 100% oxygen/minimize PEEP/minimize gas trapping

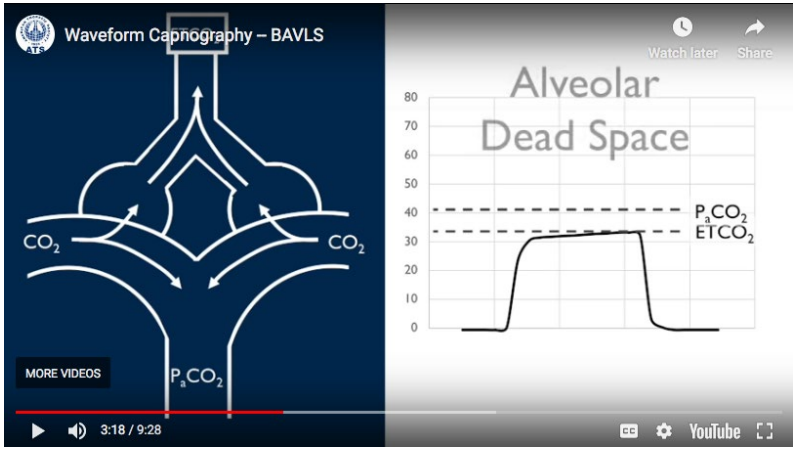
Managing the Patient on MV

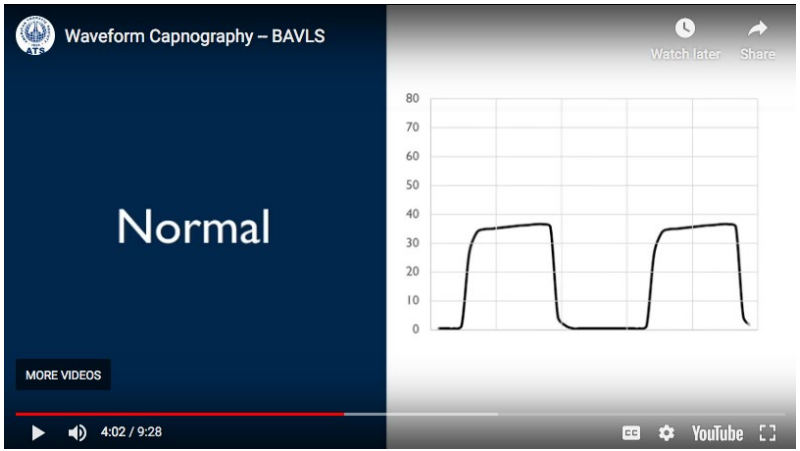
- Sedation/analgesia +/- paralysis
- NG to drain the stomach/provide nutrition
  - D5NS routine 75% maintenance until nutrition initiated
  - provide nutrition
    - BiPAP is NOT a contraindication to feeding by NG
- Patient positioning to reduce pressure sores
  - prone positioning for acute lung injury/atelectasis

Monitoring the Patient on MV

- Clinical exam
  - routine vital signs/routine clinical exam/chest rise equal bilaterally
  - patient - ventilator synchrony/trigger
- CXR
  - confirm ETT above carina
  - understand disease process
  - identify air leak
- Monitors
  - saturation
  - $ETCO_2$/transcutaneous CO_2
  - BP/heart rate
  - ventilator waveforms – know the basics
  - intermittent blood gases
    - capillary/venous/arterial

Capnography





Troubleshooting Patient with New Onset Hypoxemia

- **D**isplacement
- **O**bstruction
- **P**neumothorax
- **E**quipment

Troubleshooting New Onset Hypoxemia on Ventilator

- Disconnect from ventilator
  - attach to manual ventilator and manually ventilate with 100% high flow oxygen
  - check $ETCO_2$
- Assess patient using MASH
  - chest **Movement** with bagging
  - **A**rterial saturations?
  - **S**kin color?
  - **H**emodynamic stability?
- Difficult to bag?
  - tube or patient?
    - suction down ETT
    - directly check ETT placement through the cords
    - CXR

BCEHS BC Emergency Health Services
Provincial Health Services Authority

BC Children's Hospital

CHILD HEALTH BC

Provincial Health Services Authority

PHYSICIAN TO PHYSICIAN

CRITICAL CARE SUPPORT FROM BCCH PEDIATRIC INTENSIVE CARE UNIT (PICU)

Most Responsible Physician (MRP) identifies the need for pediatric consult for transport or advice from the BCCH Pediatric ICU (PICU)

MRP/delegate phones Patient Transfer Network (PTN):

1-866-233-2337

Requests a call with BCCH Pediatric Transport Advisor

PTN connects with PICU Pediatric Transport Advisor & MRP to collaborate on an ADVICE CALL

New option available:
Zoom videoconferencing for consultations for MRP + PICU Transport Advisor + additional specialists as needed

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