Non-Invasive Ventilation in Pediatric Critical Care

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TBZUMS

NIV - Definition

- Mechanical respiratory support without endotracheal intubation
- Positive airway pressure (PAP) delivered through an interface
- Usually refers to Continuous (CPAP) or BiLevel (BPAP)
- For this talk I will include Heated Humidified High Flow Nasal Cannula (HHFNC)

NIV - Benefits

- General benefits of mechanical ventilation
  - Relieves some work of breathing by providing some pressure support
  - Stent airway open throughout the respiratory system
  - Recruitment and improved oxygenation
- General risks of invasive ventilation
  - No sedation or paralysis needed
  - Intact natural airway clearance mechanisms (no plugging of ETT, …)
  - No mechanical trauma related to ETT placement

Common clinical indications for NIV in peds CC

- Relief of significant work of breathing
  - Bronchiolitis
  - Status asthmaticus
  - Pulmonary edema
  - Acute chest syndrome
- Management of respiratory distress / failure
  - Dyspnea despite O2 supplementation
  - Hypoxemia
  - Respiratory acidosis

Other uses of NIV in peds

- Chronic respiratory failure
  - Neuromuscular diseases
    - Duchene
    - SMA
      - CCHS – depends on severity, NIV usually not preferred
- Neonatal respiratory distress syndrome
- Obstructive sleep apnea
- Bridge post extubation

When NOT to use NIV in peds

- **Cardiopulmonary arrest / significant altered mental status / unstable patient**
- **Impaired airway protective reflexes – High aspiration risks**
- **Facial injuries – precludes interface use**
- **Pneumothorax without chest tube in place**
- **Upper GI bleed – need to secure and protect airway**

Interfaces

Nasal Cannula

- Difficult to deliver any meaningful airway pressure
- Flow is set, NOT the pressure
- No adequate seal
- Mainly used to deliver supplemental O2 with uncertain FiO2 delivery

Nasal mask

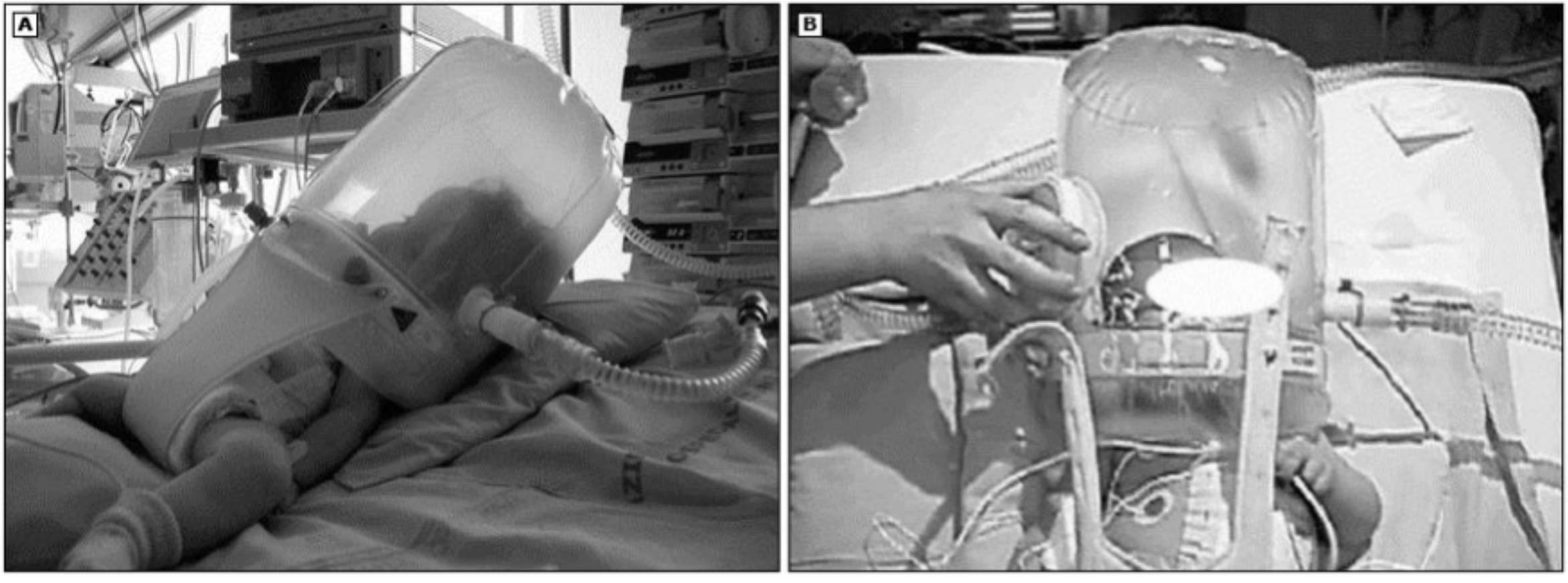
- Frequently well tolerated
- Loss of pressure due to mouth leak
- Preferred interface for treatment of OSA in children
- Allows for social interactions

Full face mask

- FFM is less tolerated in kids
- Concern for aspiration
  With vomiting
  Patient too weak to remove it if needed

Total Face

Don’t Smile… it will leak



Helmet

For reference only, not sure how commonly in use

Choice of interface will depend on many factors

- Local availability / experience
- Patient comfort / tolerance
- Adequate fit & size

NIV modalities used in peds CC

CPAP: Continuous positive airway pressure

- Best when primary problem seems to be hypoxemia
  - Great for alveolar recruitment
  - Atelectasis
- OSA / Dynamic airway collapse is a factor
- Does not provide pressure support in inspiratory efforts

BPAP: Bi-Level PAP

- Failed CPAP
- Need increased respiratory support
- Inadequate ventilation
- Higher mean airway pressure than CPAP set at same EPAP
  - Improved oxygenation
- Decrease WOB by assisting with inspiratory efforts
  - Improved ventilation

Difference between BPAP & NIPPV

- **BPAP**
  - **2 pressure levels: EPAP and IPAP**
  - **Patient triggers inspiratory breaths**
  - **Can also added cycled breaths (eg: BiPAP – ST mode in Trilogy vent)**
  - **BiPAP is a proprietary term**

- **NIPPV**
  - **Non Invasive Positive Pressure Ventilation**
  - **Includes other modes of ventilation commonly used invasively but delivered through a non-invasive interface (eg: Assist / Control mode)**

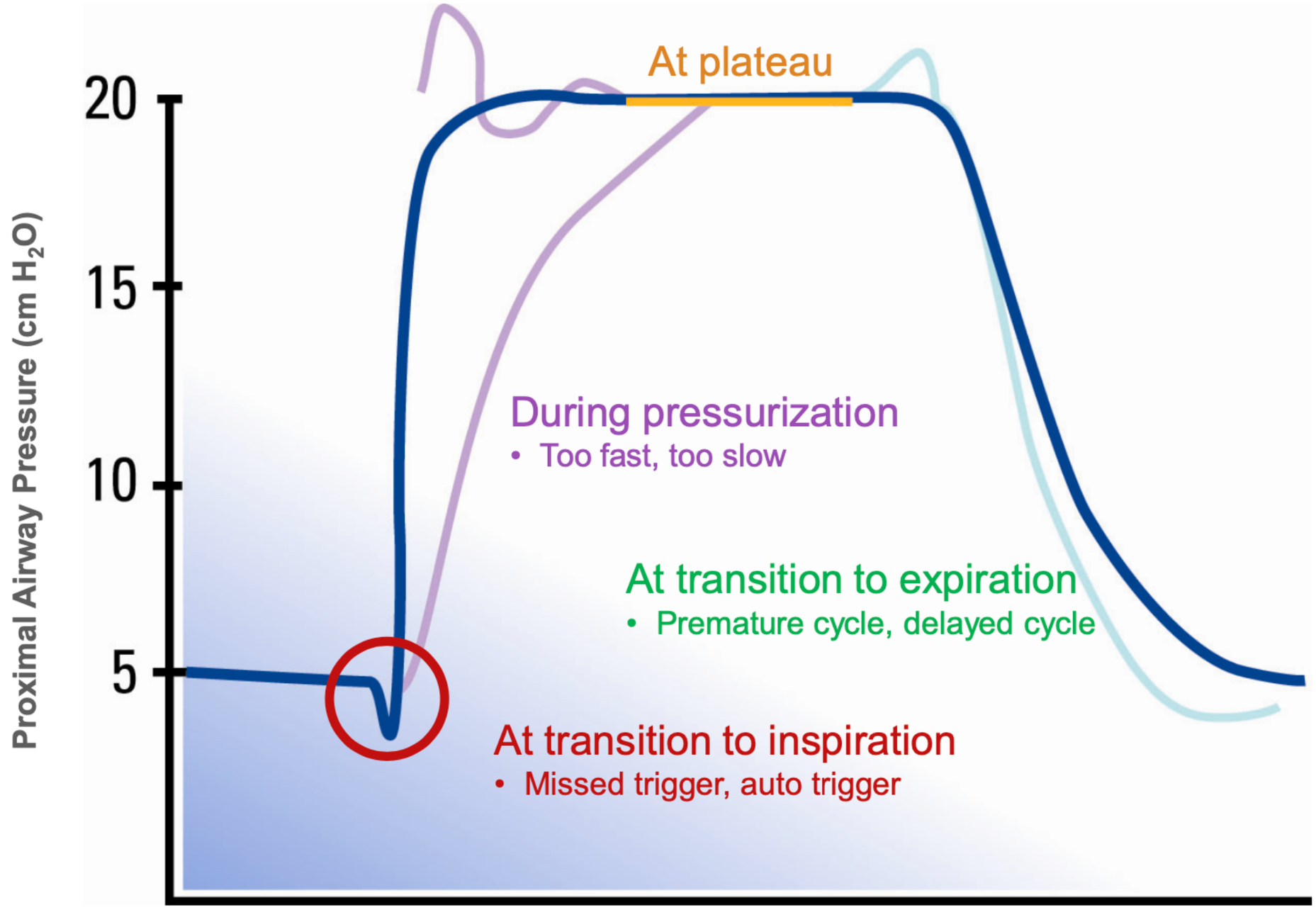
Complications with CPAP / BPAP

- Barotrauma
  - Risk of any PPV
- Aspiration risk
  - Airway is not protected
- Gastric distention
  - Increases vomiting and PAP intolerance
- Skin irritation / breakdown
- Nasal mucosa irritation / nose bleeds
- Eye irritation
  - Mostly with poor fitting masks

Utilizing Pressures Effectively

Increase IPAP to achieve:	Adequate tidal volume
	Respiratory rate (RR) < 25 bpm
	Decrease work of breathing
	Reduction in $PaCO_2$
Increase EPAP to:	**Overcome obstructive apneas and hypopneas**
	Improve oxygenation and FRC
	Counterbalance PEEPi

Types of Asynchrony



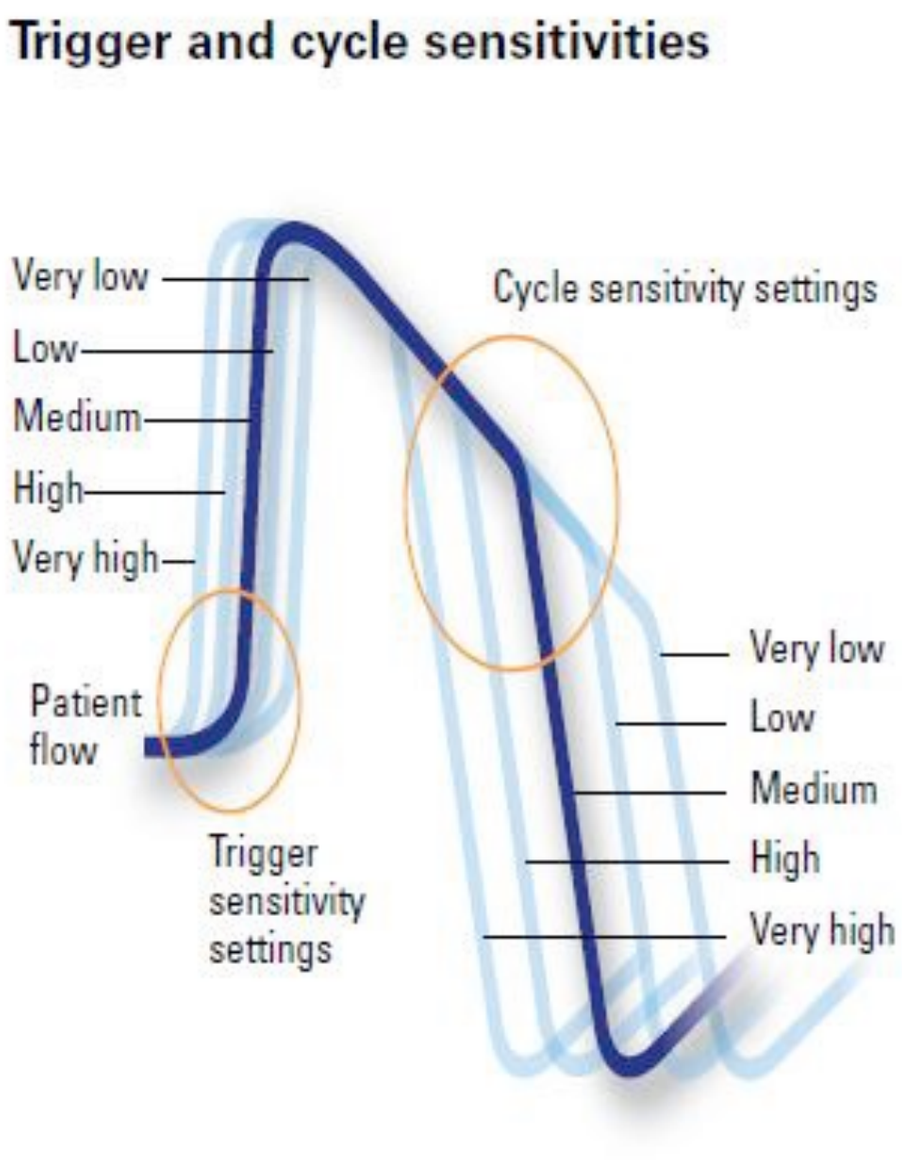
NIV inspiratory controls

- Risetime
- Trigger sensitivity
- Cycle sensitivity
- TiMin
- TiMax
- Ti

NIV Synchrony Features

- **Trigger and Cycle Sensitivity Settings**
  - **Adjustable trigger and cycle sensitivities allow further customization at the beginning and end of each inspiration, which further improves patient–device synchrony.**
- **Rise Time**
  - **Rise time determines how quickly the breath is delivered to the patient.**

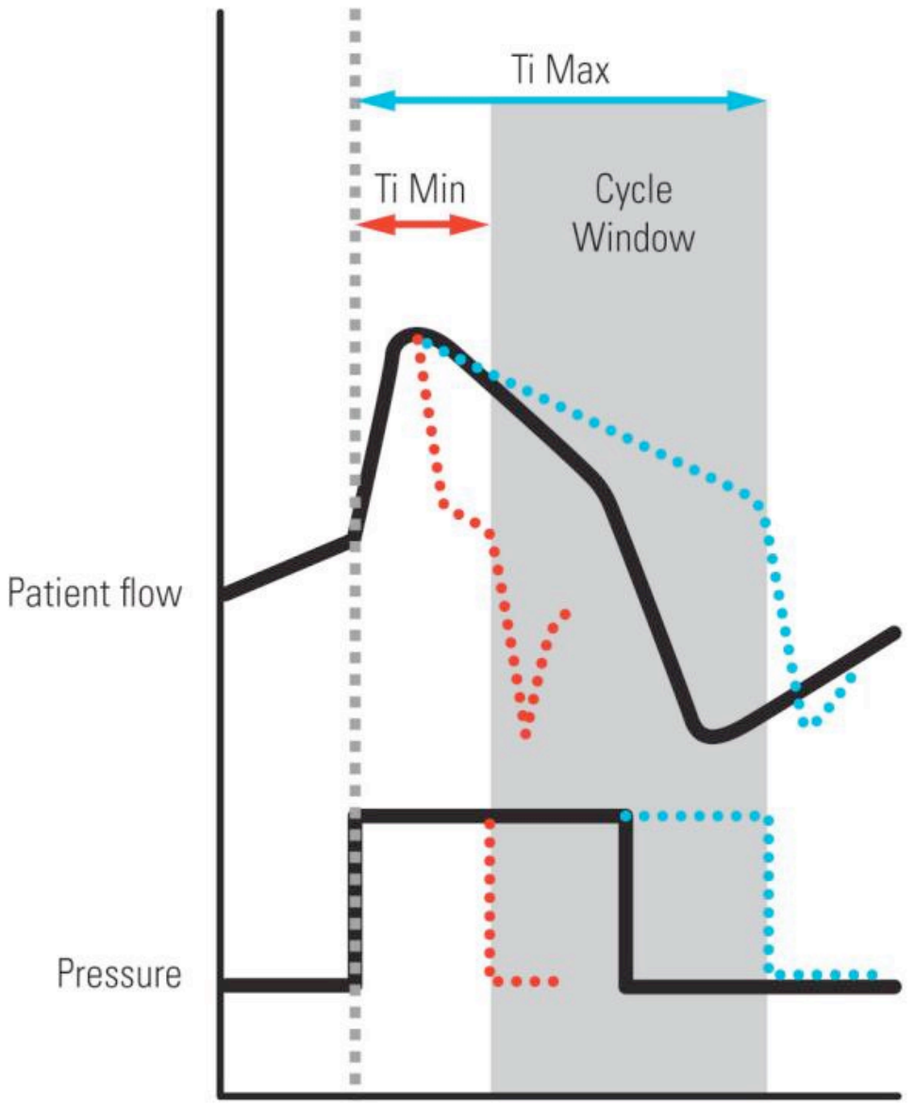
- **COPD Patient: Setting a rapid rise time and high cycle sensitivity can help decrease the inspiratory time and extend the expiratory time, resulting in improved patient–ventilator synchrony**
- **NMD Patient: A slower rise time and lower cycle sensitivity, along with an adequate Ti Min, ensure that patients with weak inspiratory effort have adequate time for gas exchange**



Customize Therapy for Patients with TiControl

Ti Controls allow clinicians to manage the patient's inspiratory time according to their disease state:

- **Ti Min = minimum amount of time patient spends in inspiration**
- **Ti Max = Maximum amount of time patient spends in inspiration**
- **Ti – Fixed inspiratory time**

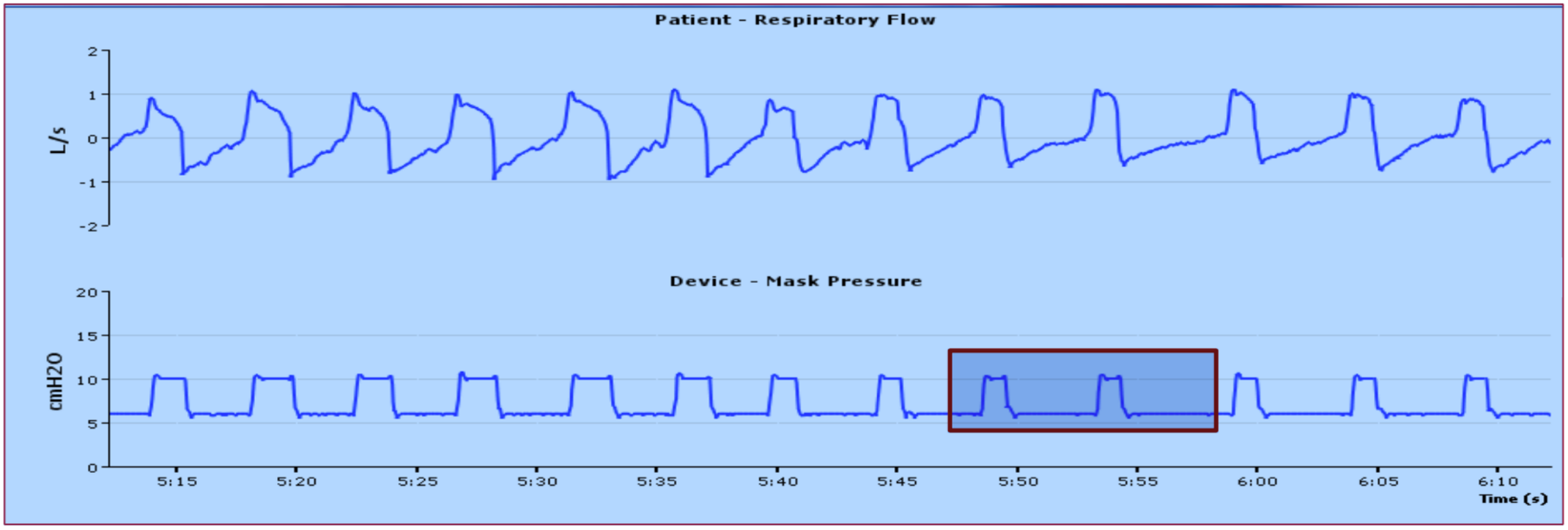


Obstructive Pulmonary Disease

- COPD patients typically require a longer expiratory time to avoid or minimize air trapping. This requires the technician to reduce the Ti Max or Ti time

- COPD patients also typically like a fast risetime (square wave form)

Ti Max: Maximum Time the Device Will Remain in IPAP

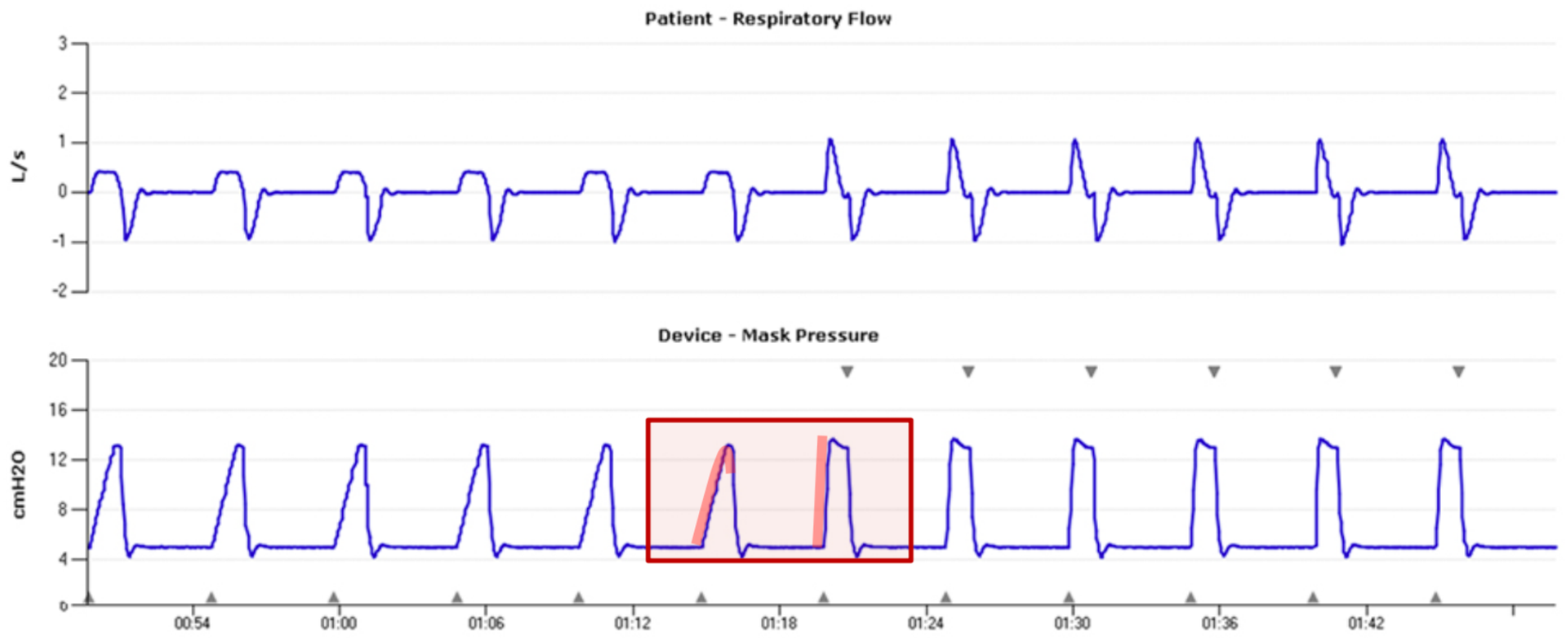


Problem: Patient requires longer expiratory time (ie, COPD)

Solution: **Best option – Shorten Ti Max time**

Additional options – **Select higher cycle sensitivity,**
Select faster Rise Time

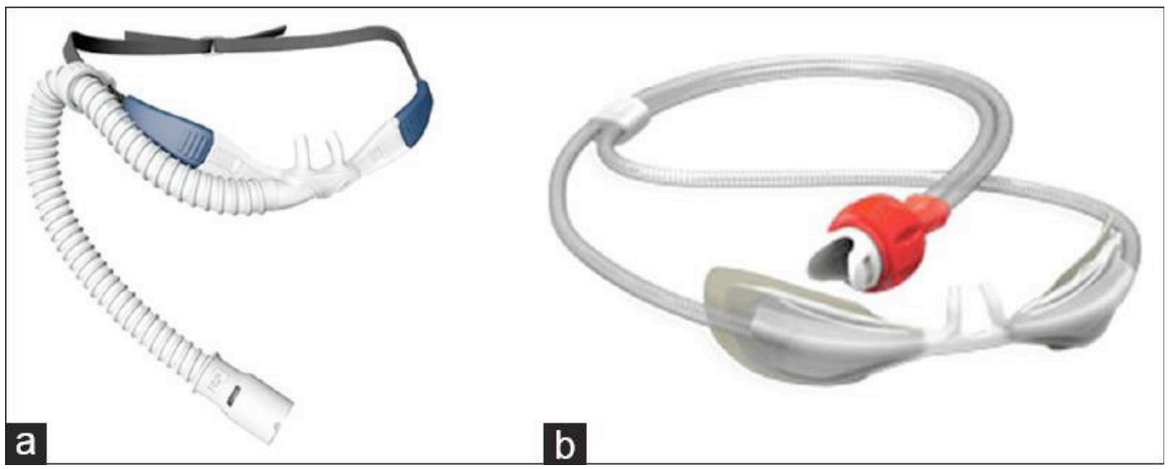
Rise Time: How Quickly Pressure Increases From EPAP to IPAP



Problem: Patient complains of air hunger

Solution: Decrease Rise Time

HHFNC


a
b


35
LPM
40
%O2
37
°C
HI
NO FLOW
FLOW
Precision Flow
PLUS
VAPOTHERM

HFNC

- Reported benefits
  - Improved patient comfort
  - Improved oxygenation
- Clinical outcomes uncertain

HFNC – Heated & Humidified Air

- Humidification
  - Humidifies and loosens secretions
    - Improves airway clearance
      - Decreases airway resistance
        - Decrease WOB
    - Avoids epithelial injury

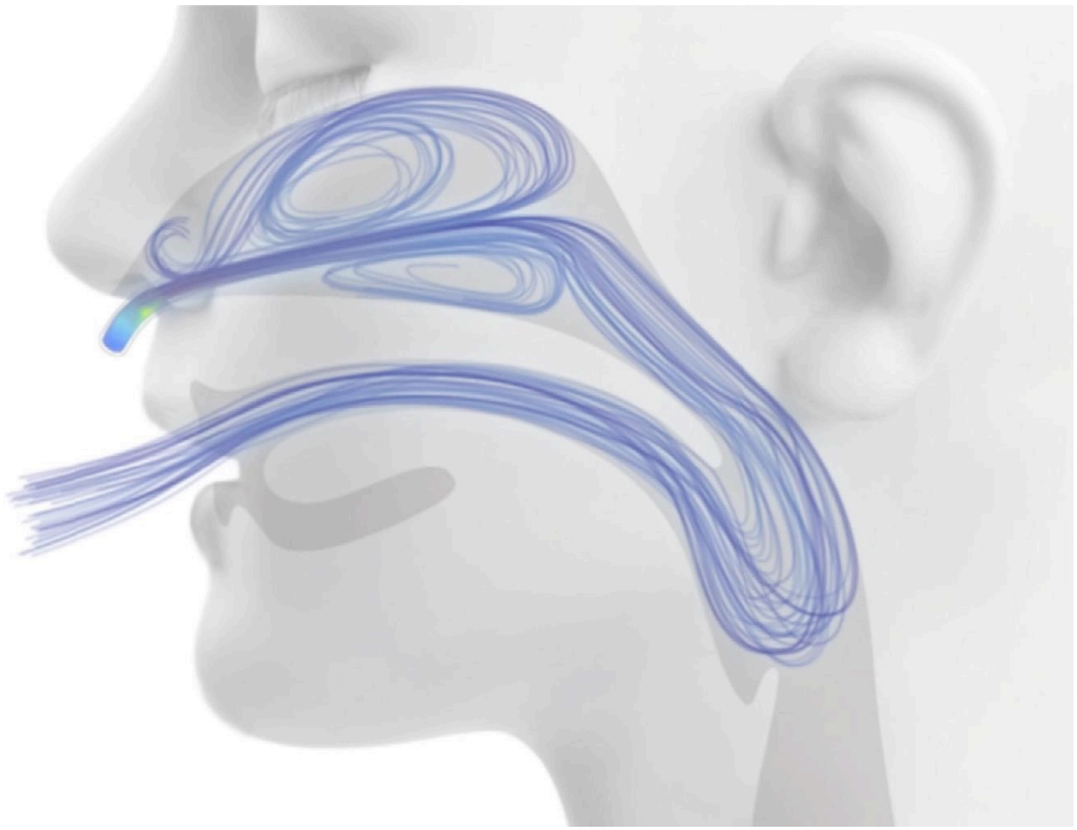
- Heating
  - Allows for higher flow rates to be used

HFNC – Washout of Nasopharyngeal Dead Space

- The nasopharynx space is an anatomic dead space

- High flow of O2 leads to efficient wash out of air in nasopharynx
  - Improves efficiency of ventilation
  - Enhances O2 delivery

- While infants have less dead space since sinuses are not completely pneumatized
  - It is a larger fraction of their tidal volume



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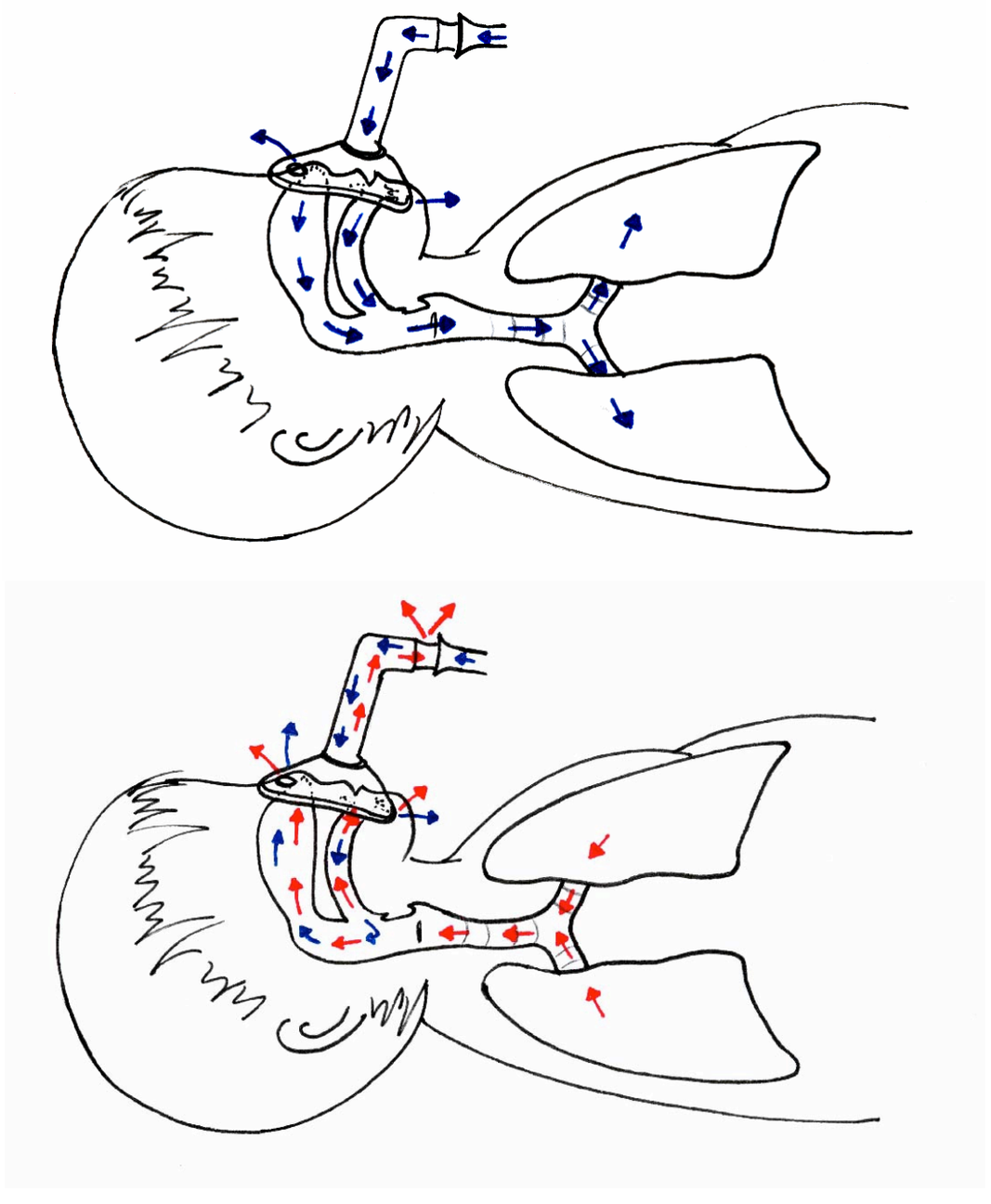

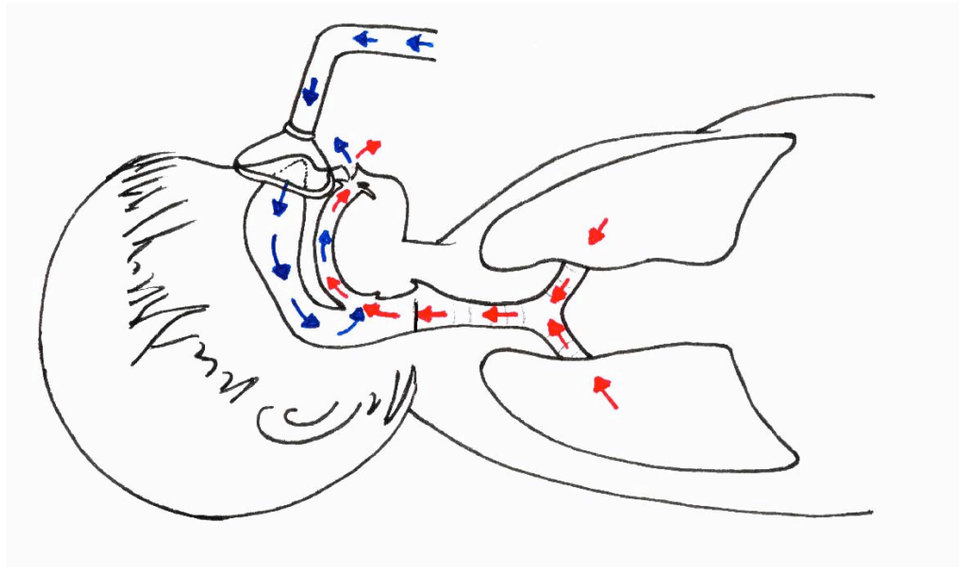

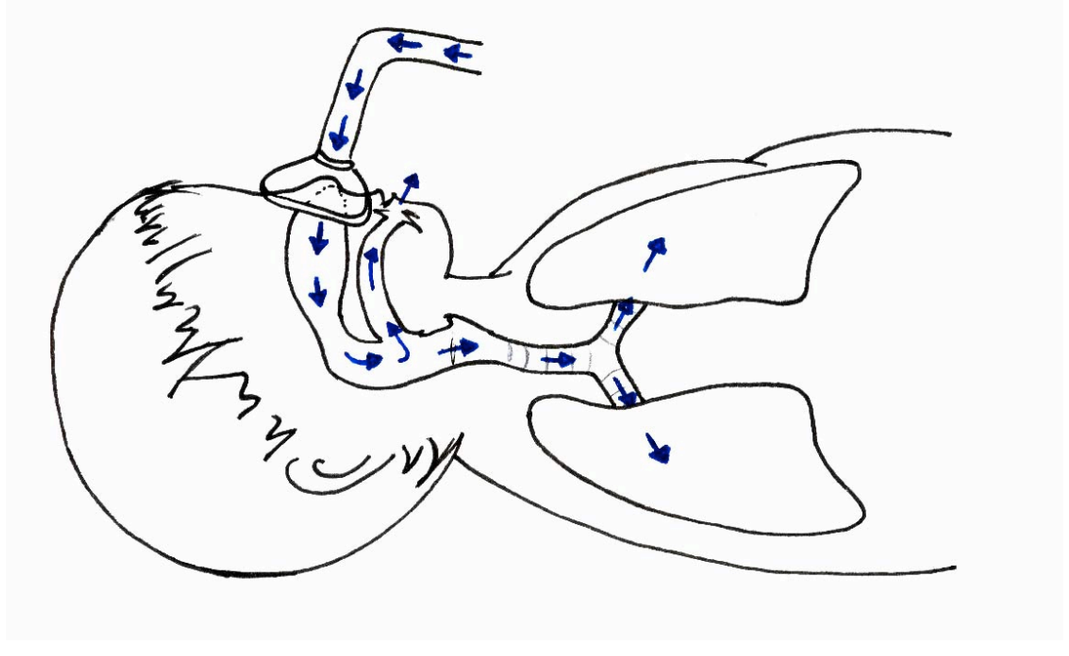

HFNC

- Often used to avoid intubation

- Air is heated & humidified
  - High flows are tolerated

- Maximum flow is determined by size of cannula
  - Size of cannula is determined by patient size

- Flow > 6 L/min may generate PEEP = 2-5 cm H2O

- For children < 2 yrs, Flow is usually < 8 L
  - For older children and adults – flow can go up to 60 L

Question?

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