Acute Non-Invasive Ventilation

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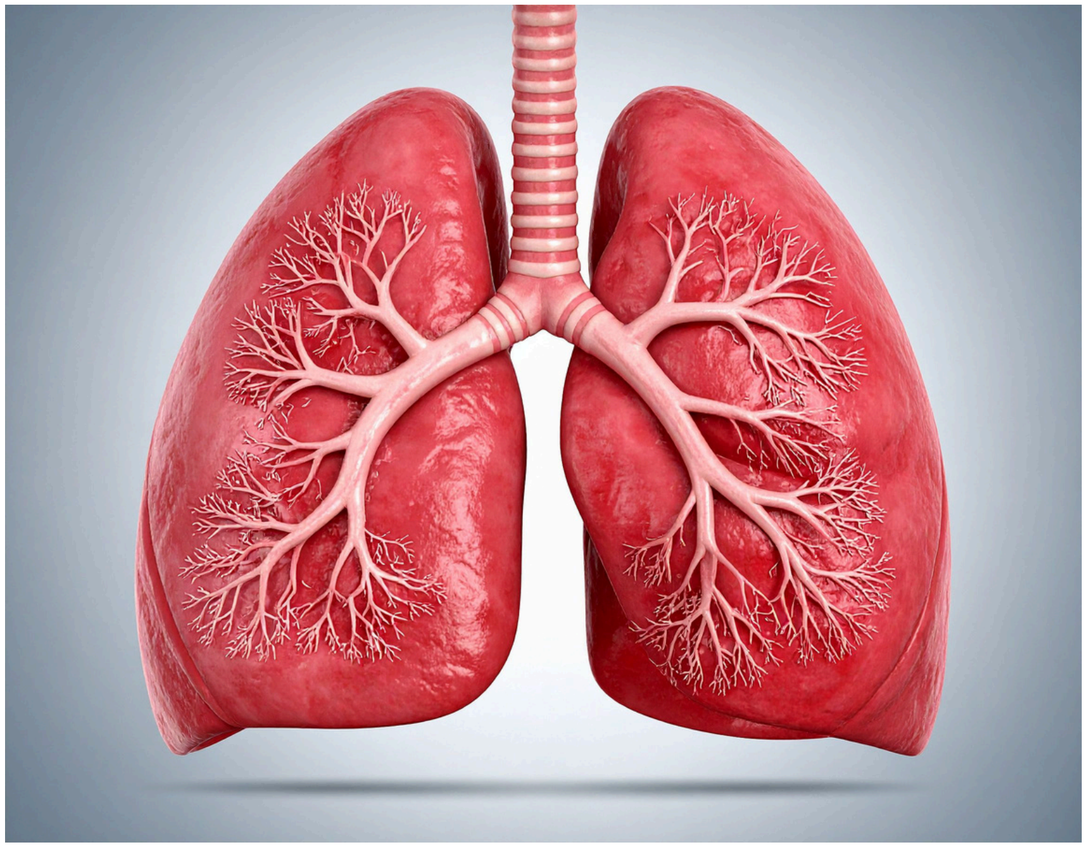
Objectives:

- Review basic respiratory terms
- Review the mechanics of breathing and pediatric respiratory physiology
- Discuss the mechanics of CPAP and BiPAP
- Review NIV interfaces and machines for delivery
- Review clinical assessments for patients on NIV
- Discuss potential complications of NIV
- Discuss both non-pharmacological and pharmacological supports
- Discuss contraindications for NIV

Basic Terms



- **FiO2** - Fraction of Inspired Oxygen. Oxygen concentration/percentage of oxygen (%)
  - Room air FiO2 = 0.21 or 21% O2
  - Oxygen (pure) FiO2 = 1.0 or 100% O2
- **SpO2** - % hemoglobin that are carrying O2 in the arterial blood
- **Tidal Volume (Vt)** - The amount of gas that moves into and out of the lungs with each breath. Can be completely controlled by the ventilator or a measurement of the patient's spontaneous breath
- **Minute Ventilation (MV)** - measured in L/min, it is a function of respiratory rate and tidal volume. RR x Vt = MV
- **PEEP** - Positive End Expiratory Pressure. The amount of pressure in the lungs at the end of each breath, used to keep alveoli open

Basic Terms

- **Pressure Support (PS)** - the amount of assistance the patient is receiving from the ventilator
- **IPAP** - Inspiratory Positive Airway Pressure. Total pressure delivered on inspiration
- **EPAP** - Expiratory Positive Airway Pressure. The pressure delivered on exhalation, interchangeable with PEEP
- **PIP** - Peak Inspiratory Pressure. The highest pressure delivered throughout the breath
- **Functional Residual Capacity (FRC)** - The amount of air left in the lungs after normal, passive exhalation

Mechanics of Breathing

Each respiratory cycle begins with inspiration and ends with expiration.

Inspiration

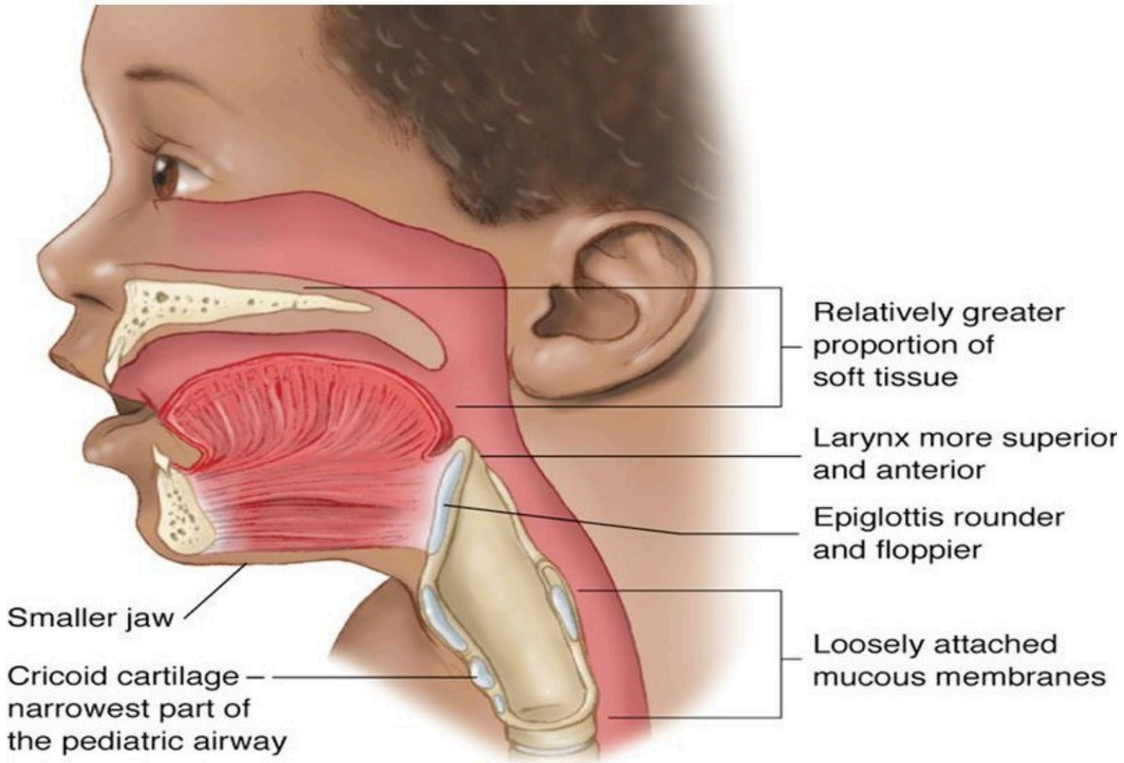
- Diaphragm and external intercostals contract, causing enlargement of the thoracic cavity.
- As a result, intra-pleural pressure decreases, and so does alveolar pressure, forcing the lungs to expand and air to move in

Expiration

- The diaphragm and external intercostals relax, reducing thoracic cavity volume
- This increases intrapulmonary pressure above atmospheric pressure
- Air is forced out, due to the elastic recoil of the lungs

As volume increases, pressure decreases and as volume decreases, pressure increases. Air moves from high to low pressure in and out of the lungs

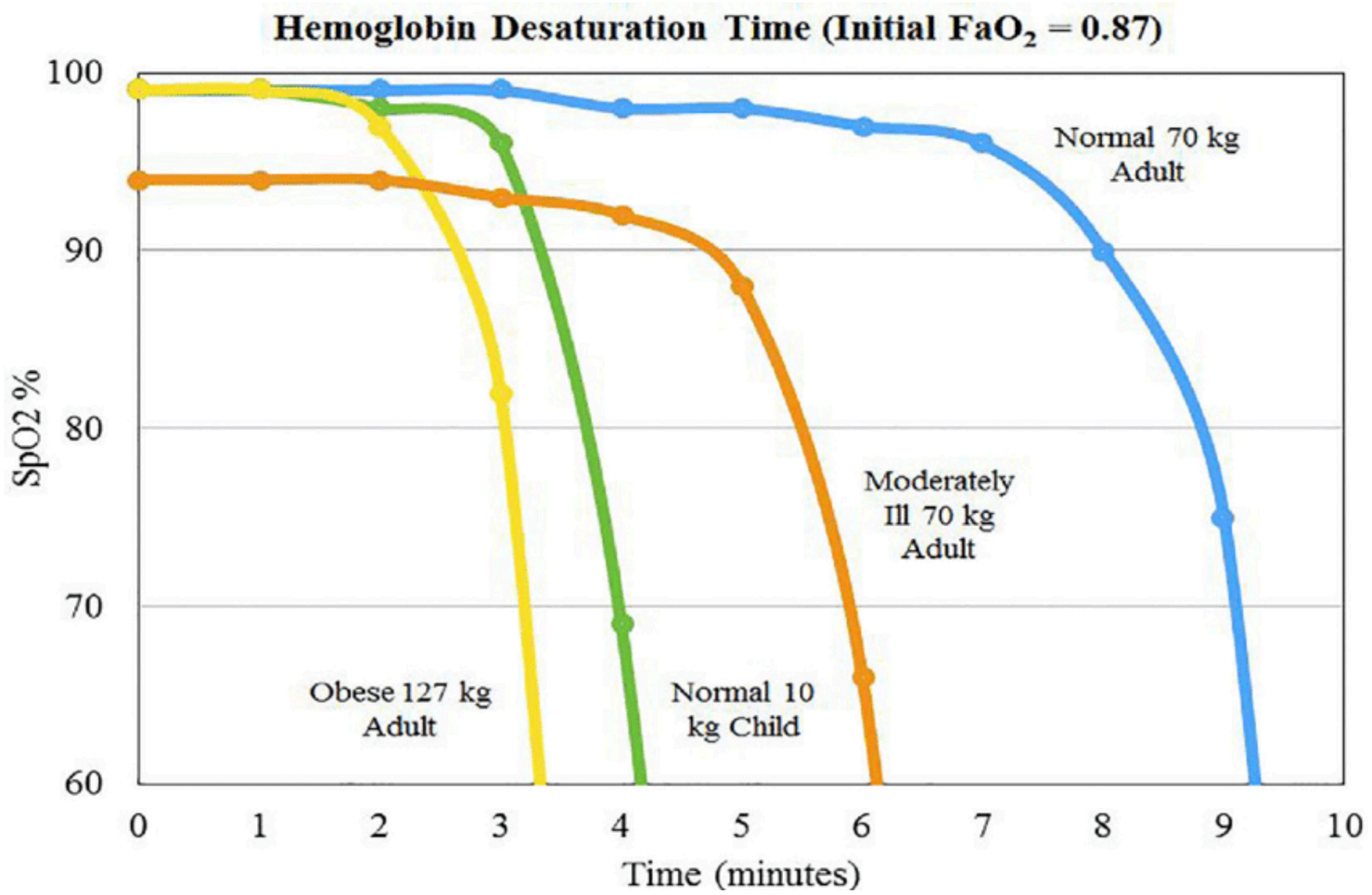
Pediatric Physiology



Children are more prone to respiratory failure:

- Greater airway resistance at baseline due to small airway diameter. At a greater risk for obstruction from inflammation and mucous
- Compliant chest walls predispose them to decreased FRC and atelectasis (collapse or partial collapse of the lung)
- Compliant chest walls and poorly developed intercostal muscles - reliance on diaphragm to create negative pressure
- Higher rate of oxygen consumption due to higher metabolic rate and higher respiratory rate
- Smaller and fewer alveoli, limiting surface area for gas exchange
- Infants are obligatory nose breathers (until 6 months of age)

Time to Desaturation



Adapted from Patel and Nouraei (2015)

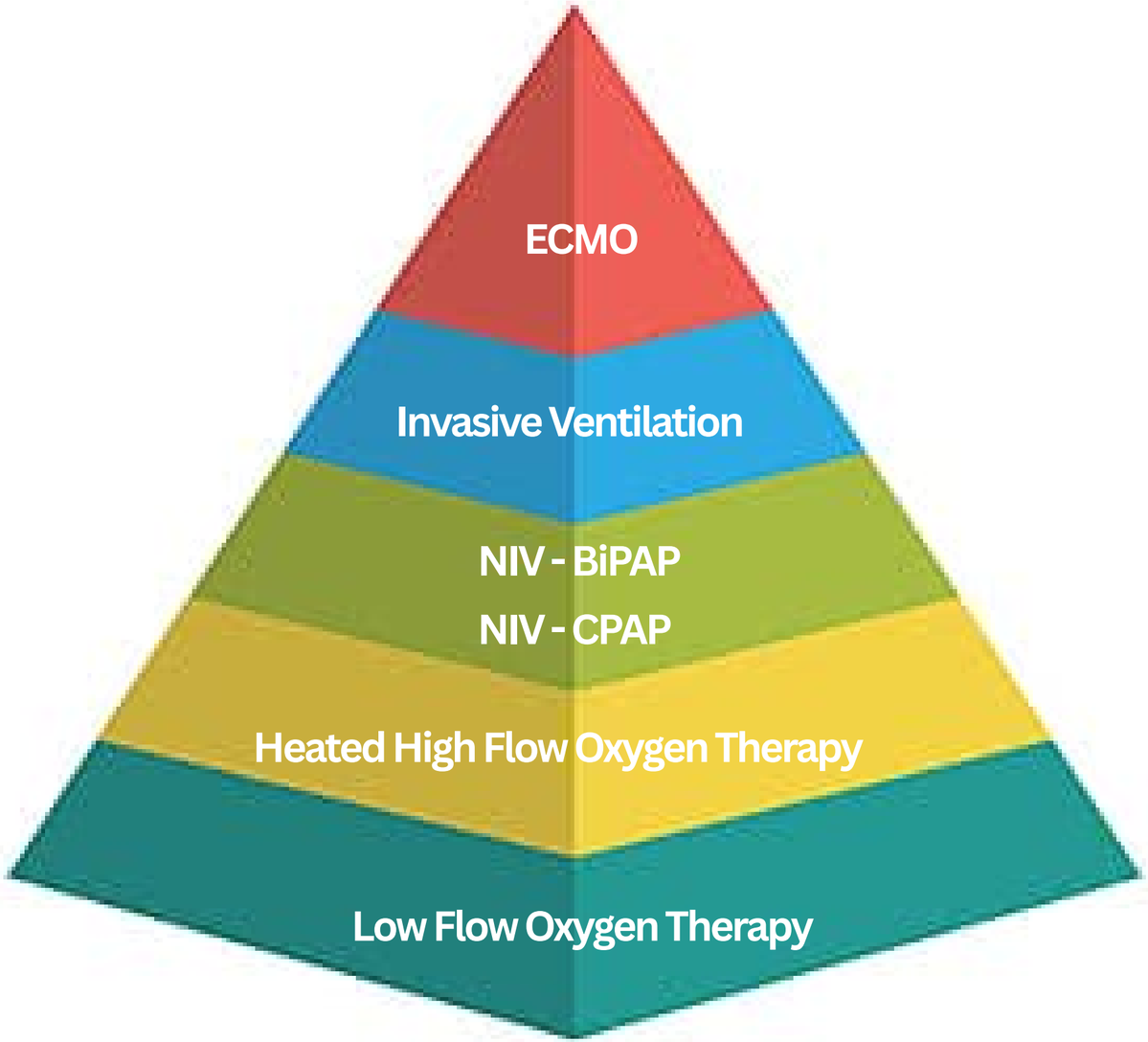
Distress, Failure, Arrest

Respiratory Distress - the body is working really hard to breath leading to inadequate gas exchange.

Respiratory Failure - the body is no longer able to maintain adequate gas exchange (ventilation) or adequately deliver oxygen to the body's tissues (oxygenation). In children, often the precipitating factor to respiratory failure is fatigue.

Respiratory Arrest - The cessation of breathing altogether. Progressive respiratory failure is the most common cause of cardiopulmonary arrests in children.

Respiratory Support



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Types of NIV

CPAP

- Continuous Positive Airway Pressure
- A constant level of supportive airway pressure
- Improves oxygenation

BiPAP

- Bilevel Positive Airway Pressure
- 2 levels of positive pressure applied through inspiration & expiration
- Improves ventilation/CO2 clearance

Both deliver positive pressure through a non-invasive interface such as a facemask, nasal mask or nasal pillows.

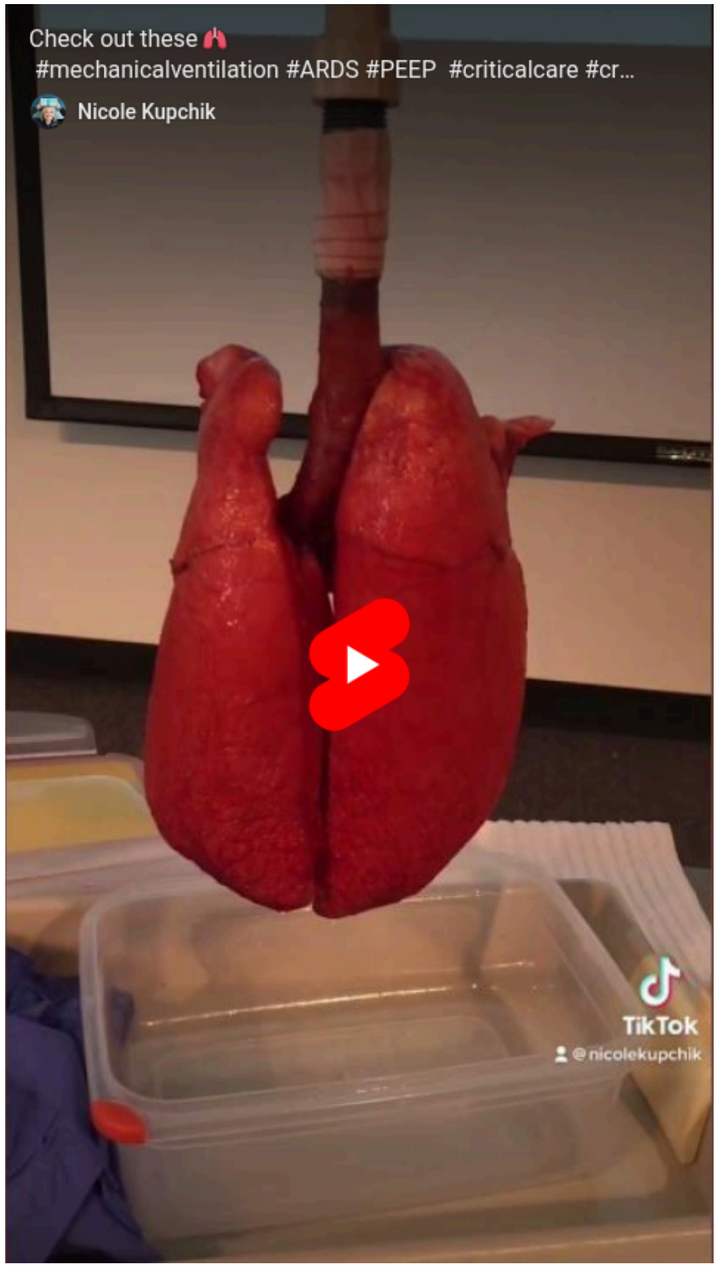
CPAP

- Steady pressure throughout all phases of respiration, and assists in preventing atelectasis
- Can be used to “stent” open upper airways in cases of obstruction
- Determining settings is based on the amount of pressure required to overcome the work of breathing, improve pulmonary mechanics and oxygenation, and the child’s size and weight
- Typical CPAP settings would begin with EPAP (expiratory positive airway pressure) of 5 cmH2O

PEEP & Alveoli Recruitment

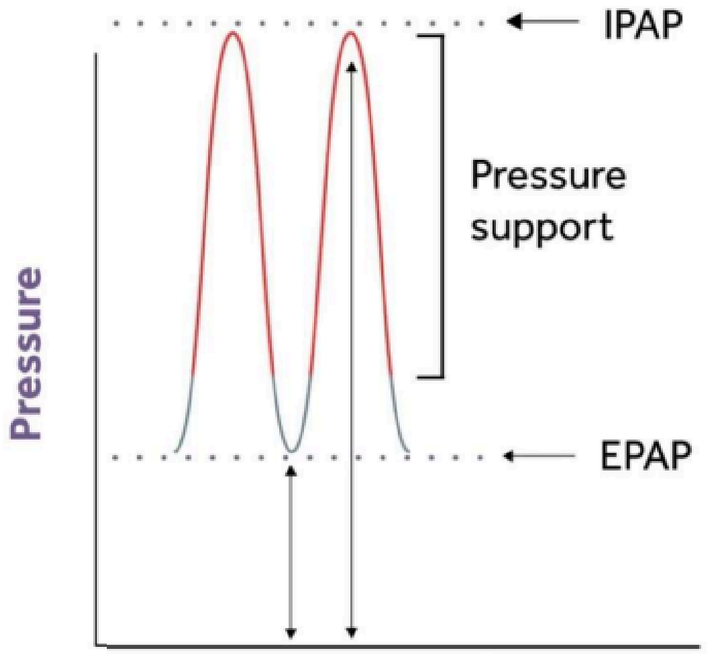
PEEP (positive end expiratory pressure) recruits alveoli by maintaining positive airway pressure at the end of expiration, acting as a “splint” to prevent collapsed or unstable alveoli from closing

Can also reopen already collapsed alveoli



BiPAP

- Two different pressure settings:
  - Inspiratory Positive Airway Pressure (IPAP)
  - Expiratory Positive Airway Pressure (EPAP)
- Inspiratory pressure is higher than expiratory
- Pressure Gradient △P or Pressure Support (PS) is the difference between IPAP and EPAP. This difference helps to assist with spontaneous breaths and augments tidal volume (Vt) in each breath
- BiPAP considered a higher level of care than CPAP
- Common initiation settings:
  - IPAP 10 - 12 cmH2O
  - EPAP 5 cmH2O



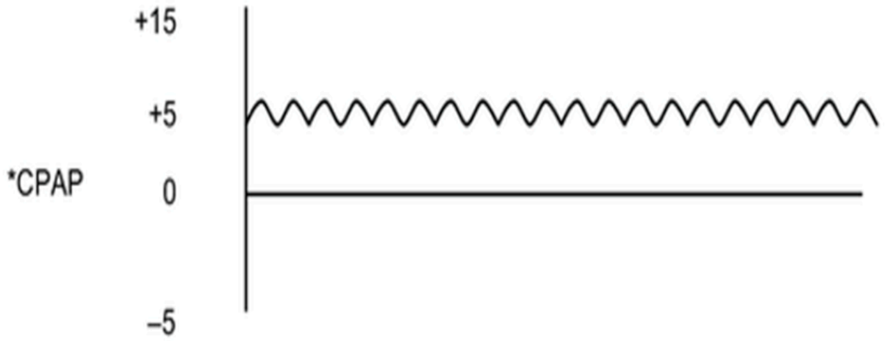
BC Pediatrics Society (2023)

-This is analogous to peak pressure
-Adjust to achieve adequate tidal volume or chest rise and CO2 clearance
-Typical range is 10-12 to start

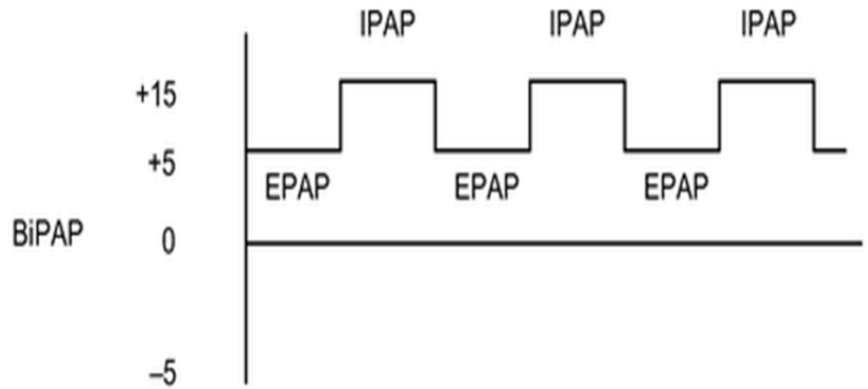
-This is analogous to PEEP
-Adjust with goal to optimize resting lung volume
-To support lung inflation in a more efficient manner
-Typical is 5-6 to start

Note that by definition, IPAP is set independently of EPAP (ie: 12/6 offers a pressure gradient or pressure support of 6)

CPAP vs BiPAP



Patient breathes at one constant pressure level above normal baseline



Patient breathes at 2 different levels - the inspiratory pressure level (IPAP) and the expiratory pressure level (EPAP)

Clinical Indications

- Bronchiolitis
- Asthma
- Pneumonia
- Acute Respiratory Failure
- Acute Respiratory Distress Syndrome
- Post-Extubation Support
- Neuromuscular Disease

NIV Interfaces

Fisher & Paykel Interface

Prongs should fill the nares completely without blanching the nostril. Keep hat tied. Chin strap may be used.

Infant Mask Interface

Mask must fit snuggly around patient's nose without occluding the eyes, nares or touching the septum.

NIV Interfaces

Fisher & Paykel Infant Nasal Prongs Interface

Nasal prongs sit 2mm from nasal septum to prevent pressure necrosis. Check septum regularly. Suction nares before applying prongs.

Giraffe Nasal Interface

There is a leak compensation dial on the giraffe interface. Turning the dial left or right brings the mask closer or farther away from the face to help seal leaks.

NIV Interfaces

Fireman’s Mask aka Scuba Mask - Full Face

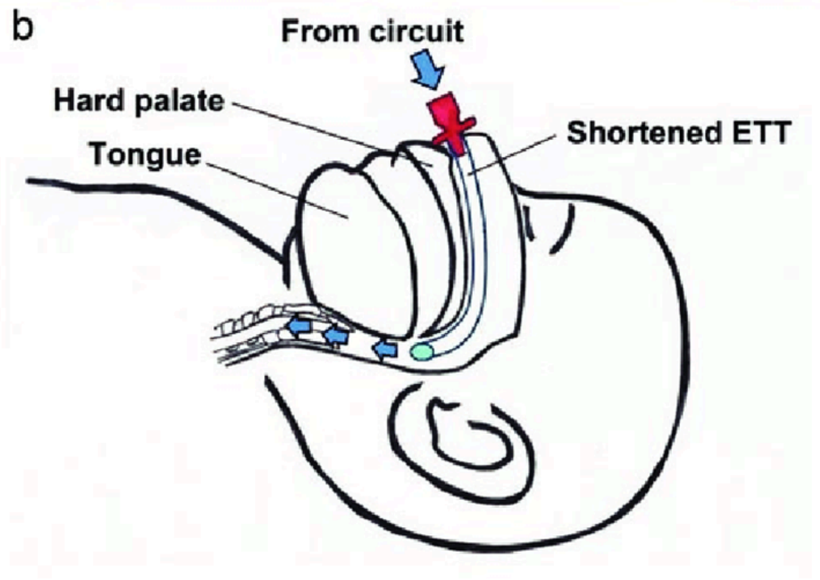
Consider using high flow support during meals or hygiene when the full face mask needs to be removed.

Nasal Face Mask

Pacifiers work well to seal leaks.

NIV Interfaces

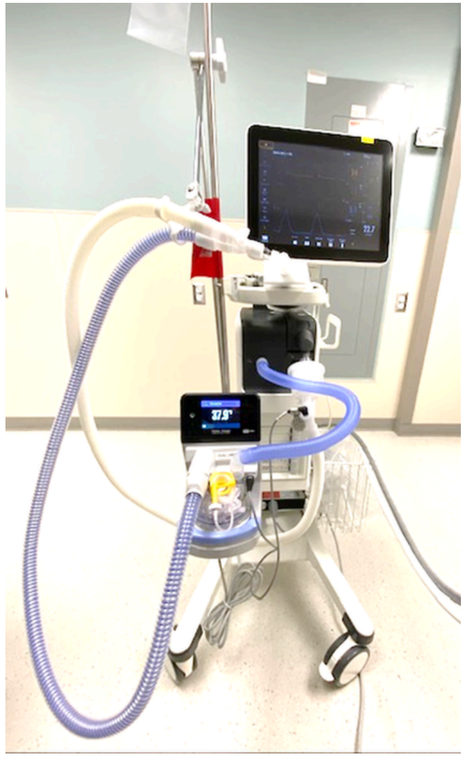
Mouth and Nose Coverage Interface



Endotracheal Tube as a NIV Connector

The end of the ETT should be measured to end at the base of the tongue.

Machine Options for Delivery



Conventional Ventilator

Trilogy EV300

Trilogy 202

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Assessment

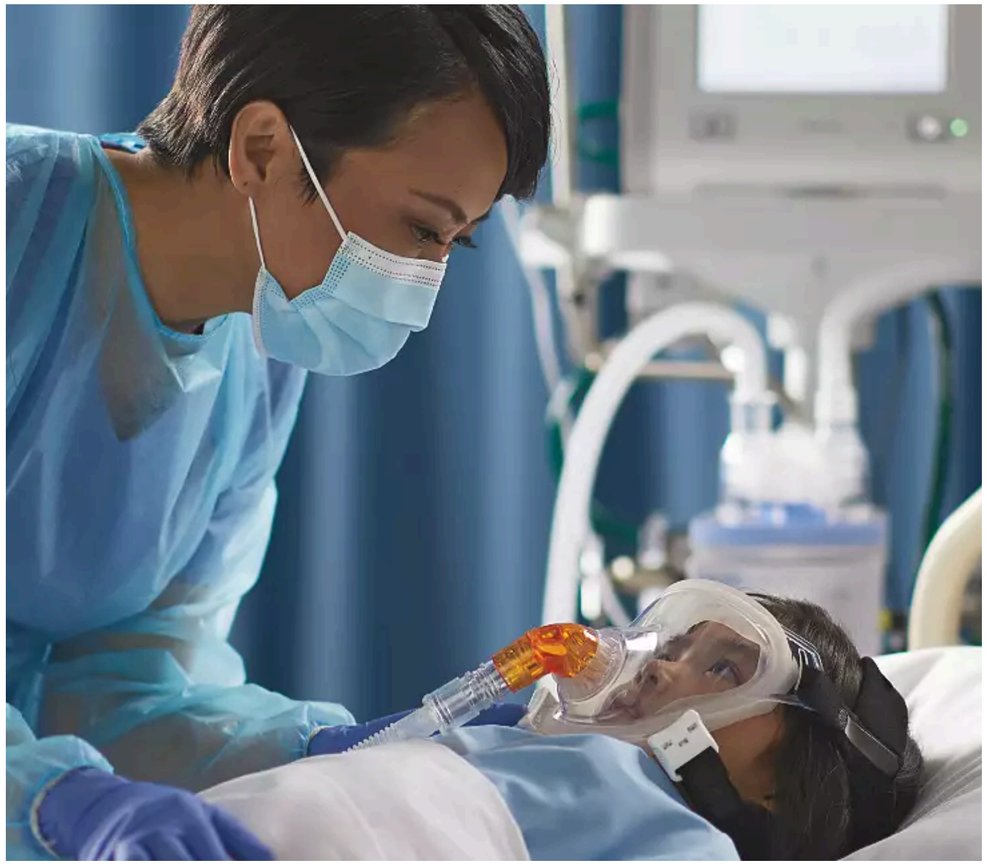
- Assess skin integrity hourly during regular patient care/checks
- Interfaces can be cleaned with a mild soap and water using a soft toothbrush
- Securing the interface too tight can increase leaks. Use a chin strap to keep mouth closed
- Check that ears aren’t folded over under the head gear

Assessment

Hourly visual assessment: PINCH

- **P:** Patient is positioned to prevent pressure on face
- **I:** Interface is in the proper position and is neither too tight nor too loose
- **N:** Nares are not obstructed by the mask
- **C:** Circuit is not causing traction on the face
- **H:** Headgear or hat is properly in place

Potential Complications



- Large leaks around the interface that cause patient/machine desynchrony
- Eye irritation (leaks or pressure injury)
- Skin irritation and pressure ulcers
- Gastric distention from excess flow from ill-fitting masks. Patient may require an NG/OG for gastric decompression
- Aspiration
- Pneumothorax
- Decreased cardiac output (less common)
- Not tolerating NIV

Non-Pharmacological Support

- Swaddling/bundling patient (neonate or infant)
- Bundling care (NG, bloodwork)
- Distraction
- Timing of assessments
- Parental involvement/support

Pharmacological Support

Ketamine

- Respiratory sparing dissociative sedative
- Bronchodilatory (preferred in asthma)
- Can cause nausea and vomiting
- Increases HR and BP
- Intranasal (short-acting. Lasts ~ 1hr)
- Continuous IV infusion

Dexmedetomidine

- Respiratory sparing sedative
- Causes hypotension, bradycardia
- Intranasal (lasts up to 2hr)
- Continuous IV infusion (monitor HR, BP)

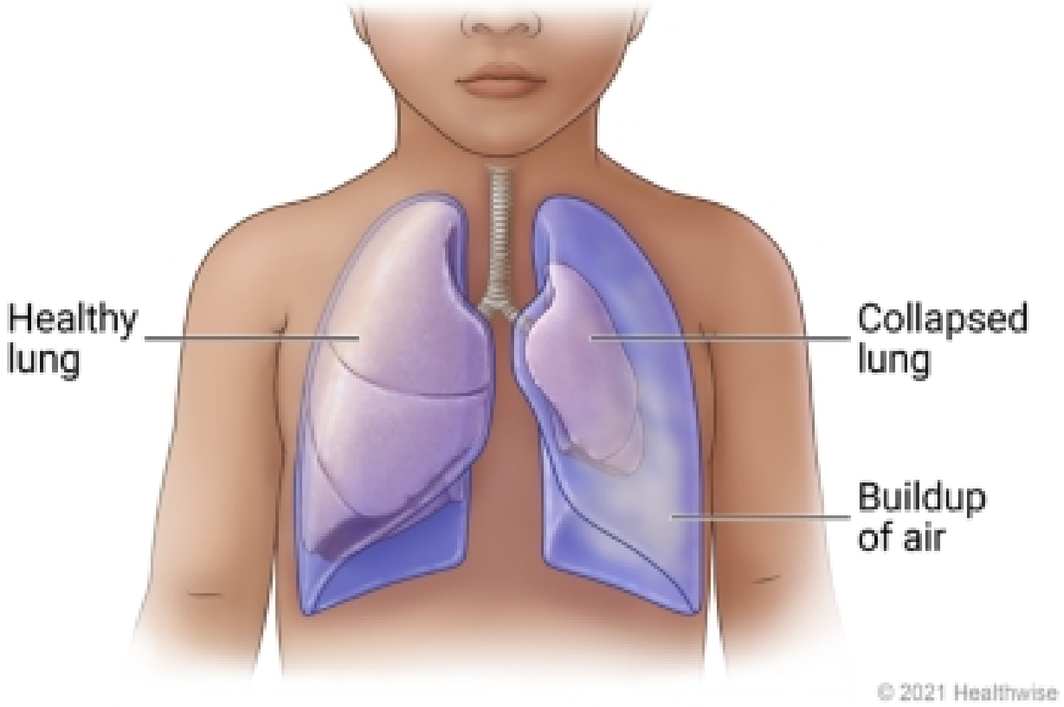
*Purpose of the pharmacological support is to make the device more comfortable for patients, not to achieve deep levels of sedation

Pharmacological Support

Chloral Hydrate

- Minimize unpleasant taste and gastric irritation by administering with water or infant formula
- Use with caution in neonates
- Can cause respiratory depression at high doses

Contraindications for NIV



- **Not intended for full ventilatory support.** Patients must be able to protect their airway and maintain spontaneous breathing
- Recent airway or upper GI surgical procedures
- Swallowing issues or high risk for aspiration
- Undrained pneumothorax (no chest tube in situ)
- Facial trauma, burns, or excoriations
- Uncooperative patients where pharmacological support is not an option

Thank you!

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