NIV for Ped Respiratory Distress

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NIV

NIV FOR PEDIATRICS

Importance of Respiratory Distress in Children

- Infants & small children are at higher risk for respiratory distress because of:
  - Small airways = high airway resistance
  - Compliant chest wall = low FRC
  - Relatively "inefficient" diaphragm
    - Diaphragm should set off the inward motion of the rib cage to maintain tidal volume constant
    - It can only do to a limited extent and will result in paradoxical thoraco-abdominal movements

Overview of Respiratory Distress in children

- **Common Causes**:
  - Asthma
  - Pneumonia
  - Bronchiolitis
  - Pulmonary Edema
- **Symptoms**:
  - Tachypnea
  - Retraction
  - Cyanosis

NIV (Noninvasive Ventilation)

- NIV is a general term ≈ noninvasive interface ≈ no ETT
- More specific terms: NIPPV, HFNC ≈ NIV methods
  - NIPPV: CPAP or BiPAP (my purpose from NIV)
  - HFNC: humidified, warmed air-oxygen mixtures, often with an ability to independently set flow and FiO2
    - It is not a form of positive pressure delivery

How NIPPV works?

- Increase airway pressure to keep alveoli open
- Enhances gas exchange and reduces WOB

Advantages of NIV over invasive MV

- Avoids complications of intubation procedure and ETT (laryngeal damage/tracheal stenosis, secondary pneumonia)
- Reducing the need for an artificial airway
- Reduced risk of nosocomial infections
- Decreased need for sedation
  - patients may be more alert, interactive, and better able to participate in rehabilitation and physical therapy
- Increased tolerance for enteral feeds
- Potential for care outside of the ICU
- An improved ability to ambulate
- Patients can achieve high O2 flow rates and FiO2 + small intrinsic PEEP
  - which can reduce WOB and promote increased alveolar ventilation
- The ability to maintain speech, cough, and gag reflexes
- Flexibility in the suspension of the therapy

Indications

- Mild to moderate respiratory failure
  - Acute exacerbation of asthma
  - Bronchiolitis
  - PARDS
  - CF
  - OSA
  - Neuromuscular disorders
  - Cardiac disease
- Preintubation
- Post-extubation

Contraindications

- Ongoing emesis
- Respiratory arrest (apnea) or need for immediate intubation (severe respiratory failure)
- Unable to protect the airway
  - impaired cough or swallowing
- Excessive secretions (tracheal, UAW)
- Hemodynamic instability, severe hemorrhage
- Agitated, confused, uncooperative or unmotivated patients
- Facial deformities or conditions that prevent mask fit
  - facial burns, severe facial trauma, craniofacial surgery
- Untreated pneumothorax
- Brain injury with unstable respiratory drive
- Recent esophageal or gastric surgery (relative contraindication)

Predictors of Success

- Predicting NIV success is **difficult**
- It is often **attributed to** :
  - the availability of **patient-specific interfaces** or **therapy intolerance**
- One study suggests that the **FiO2** level **after 1 hr** of NIV may be a predictive factor for success
  - **non-responders** had a **median FiO2** requirement of **0.8** compared with **0.48** for **responders**

Complications of NIPPV

- **Severe:**
  - Air leaks
  - Gastric perforation
  - aspiration
- **Minor:**
  - skin irritation / breakdown
  - nasal dryness
  - Conjunctivitis
  - Gastric distention

Physiological Factors Unique to Children Promoting Complications of NIPPV

Complication	Factor
Aspiration	Immaturity of airway protective reflexes
Exacerbation of GERD	Impaired GE sphincter function
Upper airway obstruction	High nasal resistance, immature oral-motor integrative function
Oral gas leaks	Tendency to mouth-breathe with nasal obstruction
Anxiety, need for sedation	Concern in new situations, developmental disorders with impaired cognitive skills

GERD, gastroesophageal reflux disease; GE, gastroesophageal.

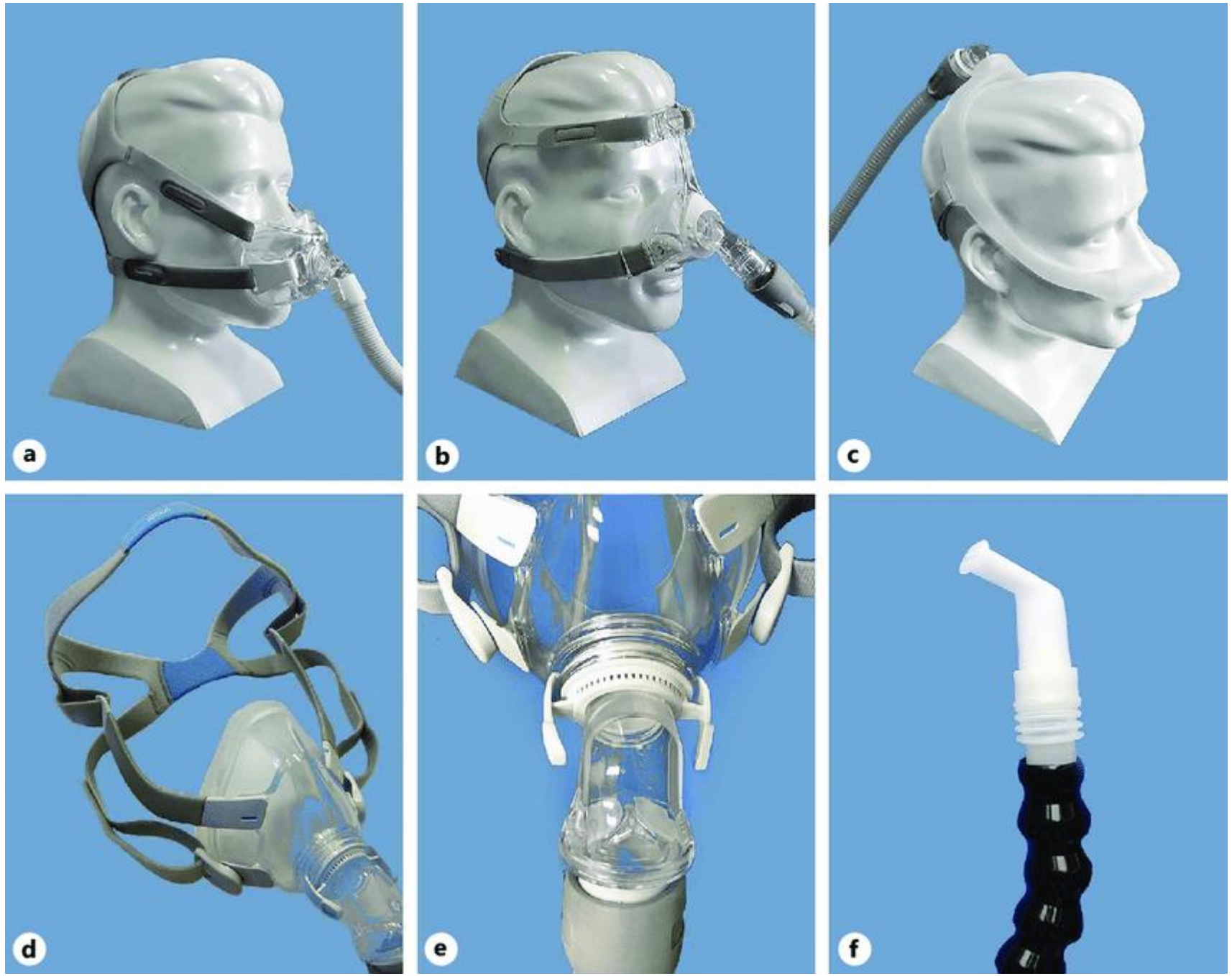
Devices & Interfaces

- **Devices:**
  - ICU ventilators, Home ventilators
- **Interfaces:**
  - Nasal prongs
  - Nasal pillows
  - Nasal masks
  - Oronasal masks
  - Total face masks
  - Extended nasal prongs or nasal tubes

- Primary interfaces in small infants are nasal prongs and nasal masks
  - Both are associated with system leaks, which may need a chin strap

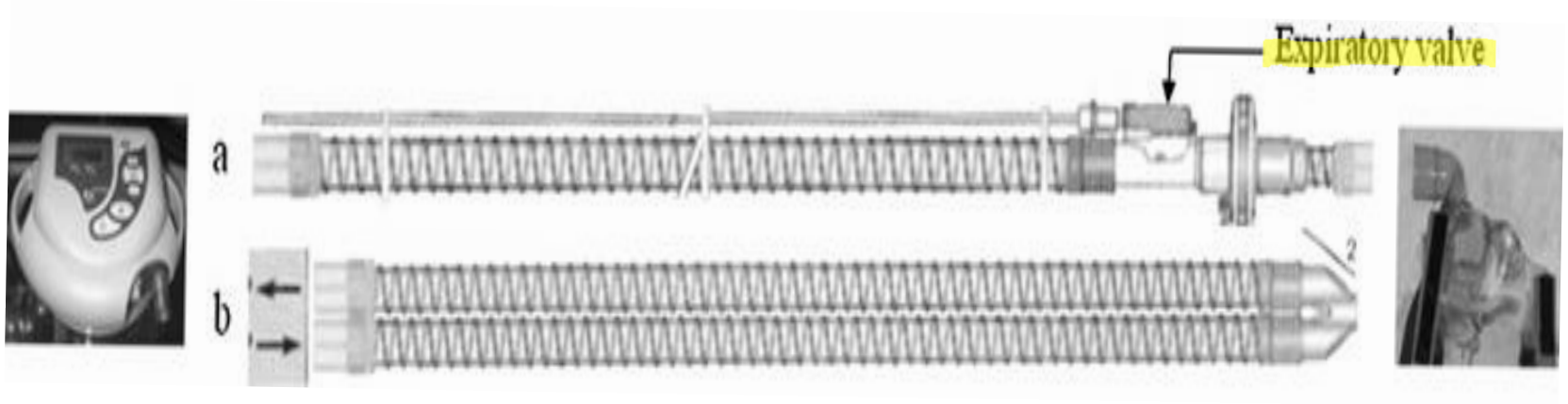
Devices & Interfaces

Devices & Interfaces



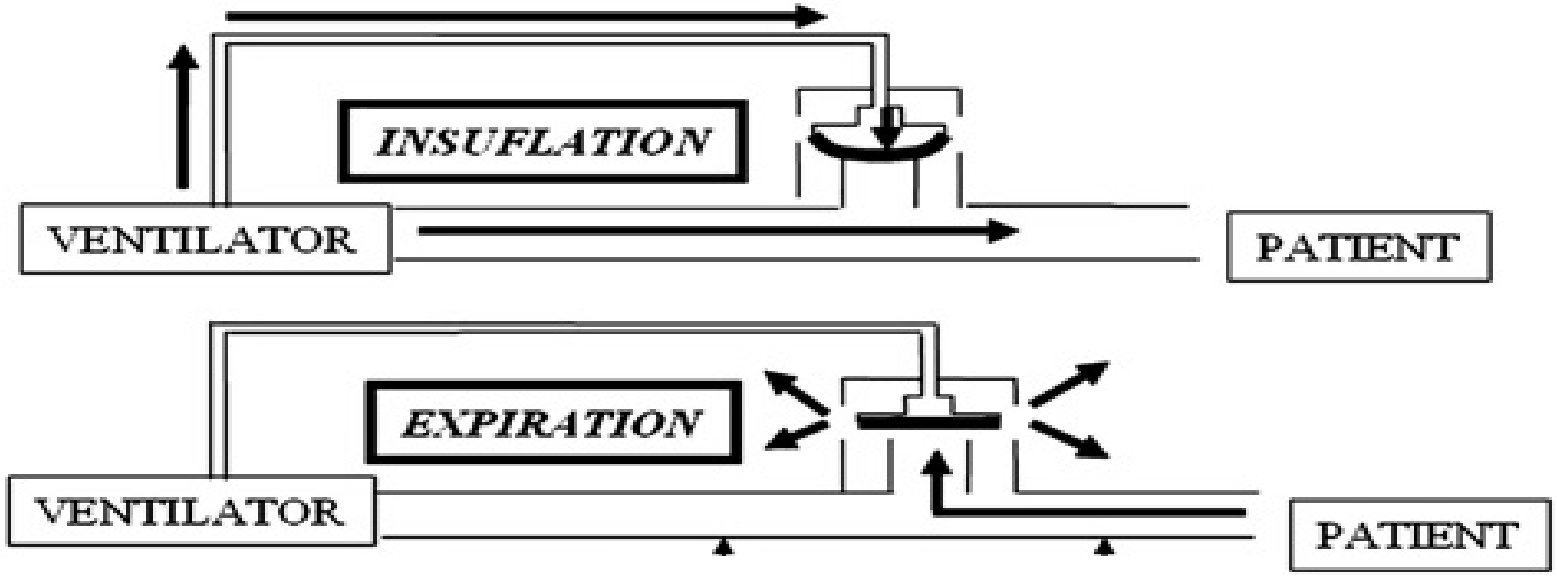
Devices & Interfaces

Circuit with Exp. Valve

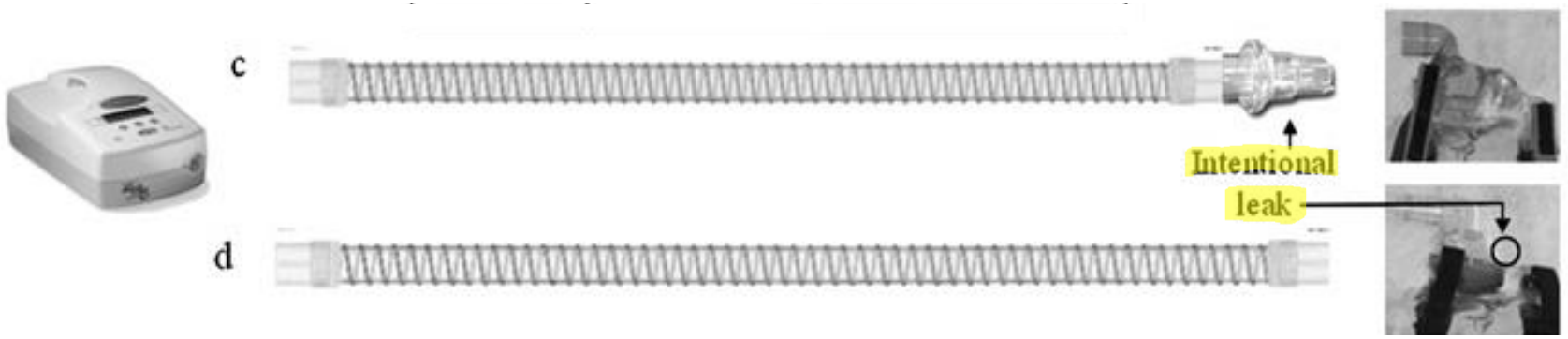


a) **Single circuit**: the valve is interposed **in the circuit**
b) **Double circuit**: the valve is included **in the ventilator**

Interface should be **non-vented**

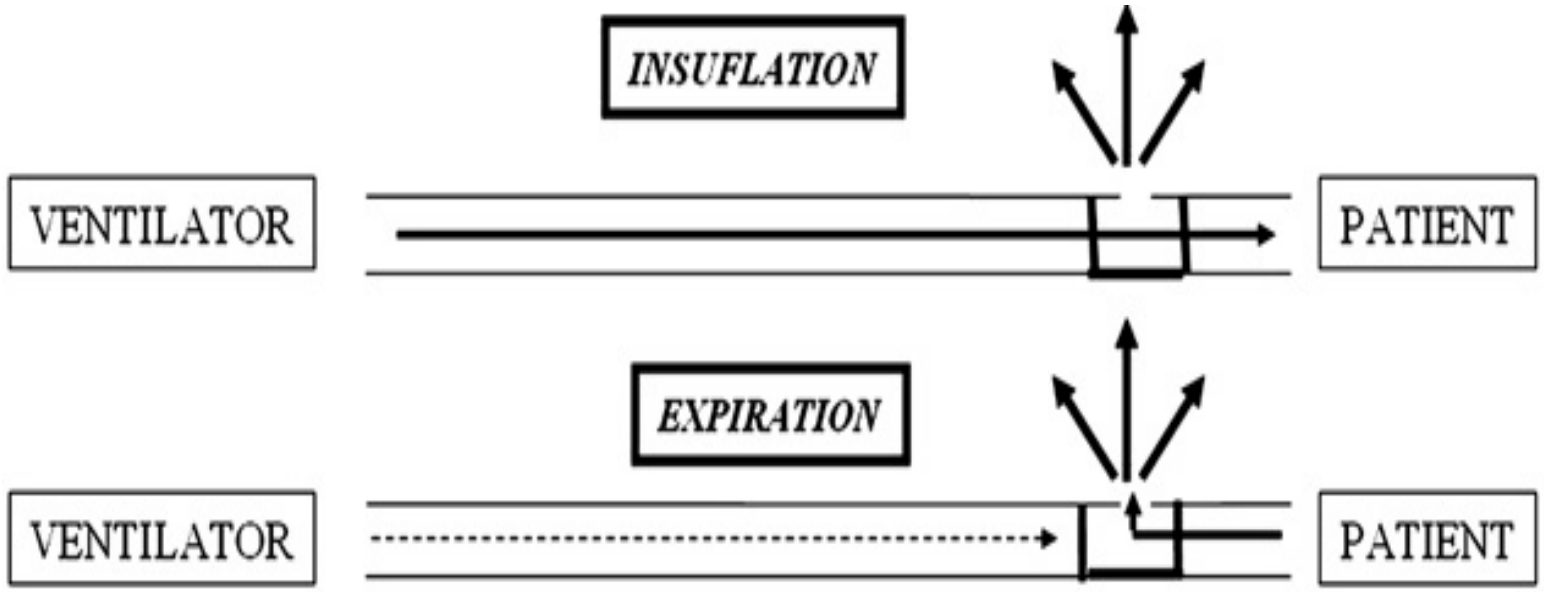


Circuit with Intentional Leak



c) The leak is interposed **in the circuit** (**Interface** should be **non-vented**)

d) The leak incorporated **at the mask** (**vented mask**)



NIPPV
Which mode, which device and which interface?

	Infant (0-12 mo)	Small child (12-24 mo)	> 2 yr
AHRF (acute hypoxemic RF)	Nasal CPAP (nasal prongs or mask) or BiPAP with a modified circuit	Nasal CPAP or BiPAP with nasal or full face mask	NIPPV with nasal or full face mask
Upper airway obstruction	Nasal or nasopharyngeal CPAP	CPAP or BiPAP by nasal mask	CPAP or BiPAP
Tracheo-bronchomalacia	CPAP with relatively high pressure levels	CPAP with relatively high pressure levels	CPAP with relatively high pressure levels
Chronic RF in NMD	BiPAP	BiPAP	BiPAP
CHF or acute pulmonary edema	Nasal CPAP	Nasal or full face CPAP or BiPAP	Nasal or full face CPAP or BiPAP

Devices AND Interfaces






Devices AND Interfaces

limitations

- The biggest logistical limitations of NIV in infants and children are the interfaces and delivery devices

- Some delivery systems require a vented circuit to allow for leak compensation and exhalation
- Some others that utilize the internal exhalation valve require a closed circuit

  - Many interfaces have interchangeable system connections that allow for the exchange of vented and nonvented interface elbows

Challenge of Triggering

- Patient triggering is a significant problem for children often due to small tidal volumes, leaks, residual volume of gas within the interface, and poor respiratory muscle strength

- Triggering improves as leaks are minimized and using total face masks

  - Chin straps and nasal prong occluding devices may help to reduce leaks

  - Auto-track triggering in some devices accommodate variable leaks in the system, which will improve effective triggering, provided the delivery device can detect patient effort

Challenge of Triggering

- Mask interfaces are often associated with large residual volumes, making it difficult to generate enough flow within the circuit to trigger
- Many infants successfully receive unsynchronized NIV using a pressure-limited time-cycled strategy
- Some clinicians attempt to synchronize patient interaction using pneumatic signals, such as flow or pressure

Challenge of Sedation

- Use of sedation to improve patient tolerance of NIV needs careful consideration
  - Patients may not tolerate the interface or excessive flow sometimes associated with NIV
- If anti-anxiety medication is needed to facilitate patient tolerance, it is important to choose an agent, such as midazolam, that produces minimal respiratory depression

Challenge of Monitoring

- Patients receiving **CPAP** or **BiPAP** should be monitored by **POX** with specific **saturation targets** based on Dx and acuity of the disease process
- **POX** is a good indicator of **oxygenation** but not for ventilation
- The **adequacy of ventilation** must include some periodic form of **CO2 measurement**
  - **Noninvasive**: trans-cutaneous monitoring
  - **Invasive**: arterial, venous, or capillary **blood gas analysis**

Challenge of Monitoring

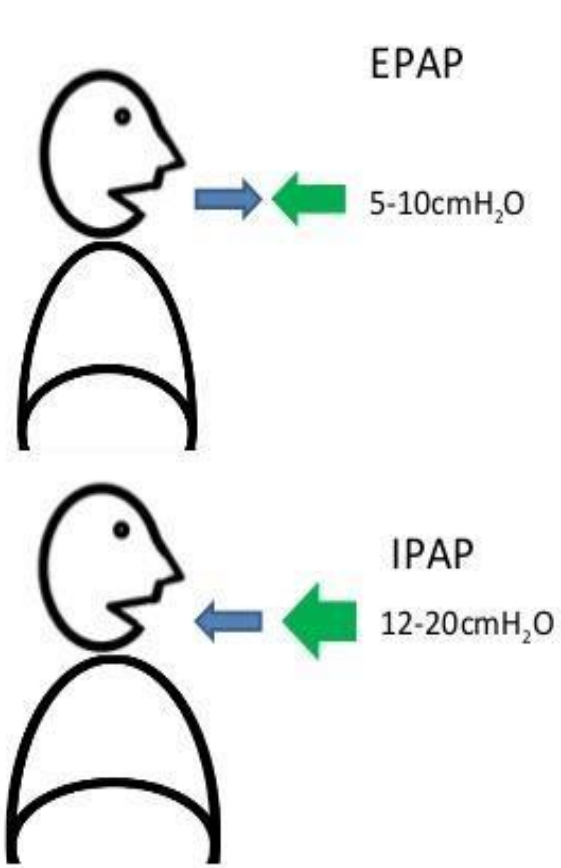
- End-tidal PCO2 is often inaccurate secondary to dilution from the high flow of gas from the delivery device
- Other observations related to WOB and LOC are valuable clinical indicators of the overall oxygenation and ventilation status

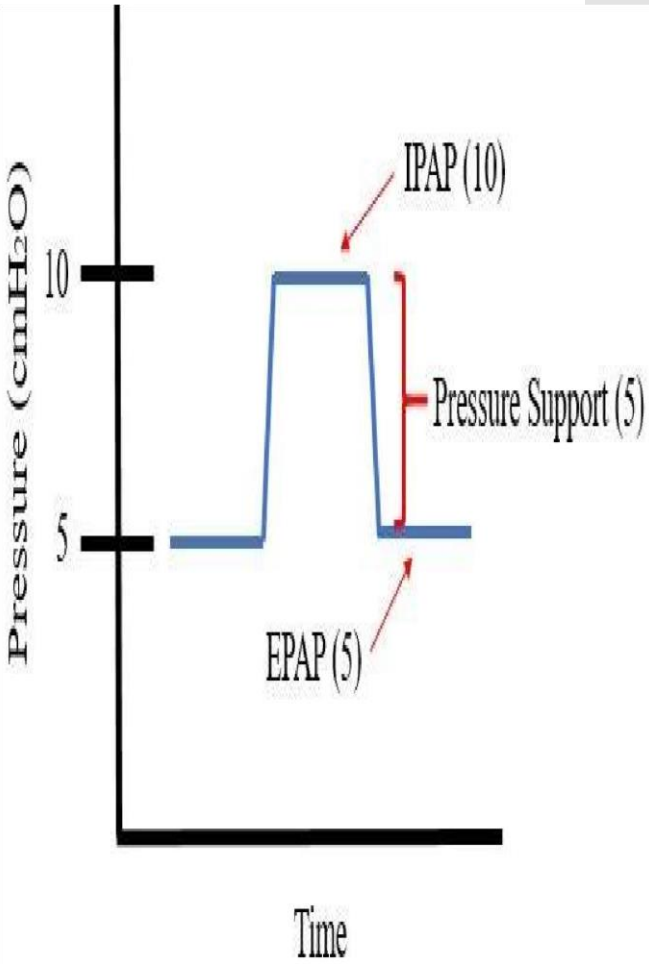
- CXR can provide useful diagnostic information if clinical symptoms are present
  - It is a useful tool in evaluating the adequacy of lung inflation during NIV
  - It may also provide useful information regarding the appropriate EPAP levels to use during NIV

Bipap

BIPAP

- EPAP (PEEP)
  - Recruits alveoli
  - Increases VQ matching
  - Improves oxygenation
- IPAP – EPAP (pressure support)
  - Increases tidal volume
  - Reduces CO_2
  - Improves Ventilation and decrease work of breathing





CPAP

- Its goal is to restore adequate FRC to correct, reverse, or minimize alveolar collapse
- It effectively reduce WOB via unloading the work of inspiratory muscles
- It allows effective inflation in excess of the opening P. of the lungs

- The level of CPAP for this goal is:
  - Usually 5–8 cm H2O in infants but varies with disease process
  - Variable in children based on the indications and the severity of disease
  - Low lung compliance may require CPAP levels >10 cm H2O

CPAP

- It should only be used with an adequate respiratory drive
- Pressures should be incrementally increased to achieve the targeted O2 sat goal at an FiO2 of 0.50 –0.60 up to a CPAP level of 10–12 cm H2O
- When CPAP level is adequate, WOB should improve, as decreased RR and retractions, and improved O2 sat

CPAP Devices and Weaning

- **CPAP devices** are designed to operate under **2 basic principles**
  1. To provide a **constant pressure** with **variable flow**
  2. To provide **constant flow** resulting in **variable pressure**

- **Pressure-constant delivery devices** are **preferred** to provide a **consistent pressure** and **prevent alveolar collapse** by **sustaining lung recruitment**

CPAP Devices and Weaning

- For acute lung disease, FiO2 and CPAP levels should be weaned as tolerated to maintain acceptable oxygenation levels :
- When resolution or resolving disease processes has been identified
- In infants, FiO2 should be weaned first to min acceptable levels before weaning CPAP levels
- In nocturnal CPAP for OSA, the CPAP level is maintained while FiO2 is titrated to maintain predetermined saturation levels
- Weaning of CPAP may involve intermittent trials of HFNC (1st) or standard nasal cannula (then) at increasing intervals
- CPAP can be trialed off when the patient has been stable at a level of
  5–6 cm H2O with a FiO2 of 0.40

BiPAP

First step is to determine the appropriate mode of ventilation

- It is patient-specific and require patience on the part of the clinician
- It is important to select the correct patient interface that permits tolerance and maximizes triggering capabilities

S: spontaneous mode

- It is patient-triggered and provides an inspiratory PS without a backup RR
- Patient must have a good respiratory drive and be able to effectively trigger breaths

BiPAP

T or C: (timed or controlled) mode

- It offers a set pressure delivery at a preset mandatory RR
- It also allows additional patient-triggered breaths as needed
- it can lead to asynchrony when patient breathing efforts conflict with the set RR

ST: spontaneous/timed mode

- It is a patient-triggered mode that provides inspiratory PS with a backup time-based frequency
- This may offer patient safety and comfort, provided triggering is effective

BiPAP: Primary Setup

- If RR is set, it will be age-specific and reflect the level of support needed to ensure adequate ventilation
- EPAP should provide a resting pressure level that minimizes alveolar collapse and should be increased in the presence of lung volume loss
  - It has a direct relationship with oxygenation and should be titrated based on O2-sat
  - It should not exceed 7–8 cm H2O in most infants or 10–12 cm H2O in most children, although this is patient-specific

BiPAP: Primary Setup

- IPAP is applied to EPAP and translates to volume delivery
  - It has a linear relationship with tidal volume
  - It should be titrated to adequate chest expansion and CO2 removal
- T_i should be sufficient for breath delivery
  - Excessively long T_i is uncomfortable for patients and may increase WOB if patients are forced to exhale against inspiratory flow

BiPAP: Secondary Setup

- **Trigger sensitivity**:
- so that the patient can **easily** initiate a **spontaneous** or **assisted** breath **without auto-triggering**
  - It is **difficult** due to **leaks** that have a **large impact** on triggering mechanism
- **Rise time**:
- time to reach the **preset pressure** during **PSV** or **PCV**
  ≈ **how quickly** the P increase from **EPAP** to **IPAP**
  - It should be set to **maximize patient comfort**
  - In **restrictive lung disease** a **slower rise** may improve the **distribution** of ventilation
  - In **increased airway resistance** a more aggressive rise may prefer
  - Set a **short rise time** if the patient has a **high RR**

BiPAP: Secondary Setup

- **Breath transition cycle** or **cycle time**:
- the **transition period** from **inhalation to exhalation** during **PS** ventilation
  - It may be **flow-** or **time-based**
  - **Cycle setting** should lower the **threshold for transition** in the presence of **large system leaks**

- **Ramp time**:
- allows gradual increase in the **pressure delivery** to assist with patient **tolerance** and **comfort**
  - The **period** during which the therapy pressure increase from a **low start pressure** to the **prescribed Tx pressure**
  - It can be set between **5** and **45 min** or can be **switched off**

Weaning

- When patients **can trigger** the device, the **weaning** approach is **similar** to that of **invasive** ventilator

- When **significant leaks** are present and patients are **unable to trigger** spontaneous or assisted breaths, spontaneous breaths are usually **not supported**

  - In this case, a **traditional weaning strategy** of **incrementally** reducing the mandatory breathing frequency shifts more work to the patient and **may** substantially **increase** the **WOB** because **spontaneous breaths are not supported**

Weaning

- The increased WOB for patients with limited reserves may result in them not tolerating this strategy

- **Another approach:**

- to set the mandatory frequency at a physiological level, based on patient age and disease process, and wean the IPAP until the IPAP and EPAP settings are nearly equal

  - This approach may offer a more gradual shift of the respiratory muscle work

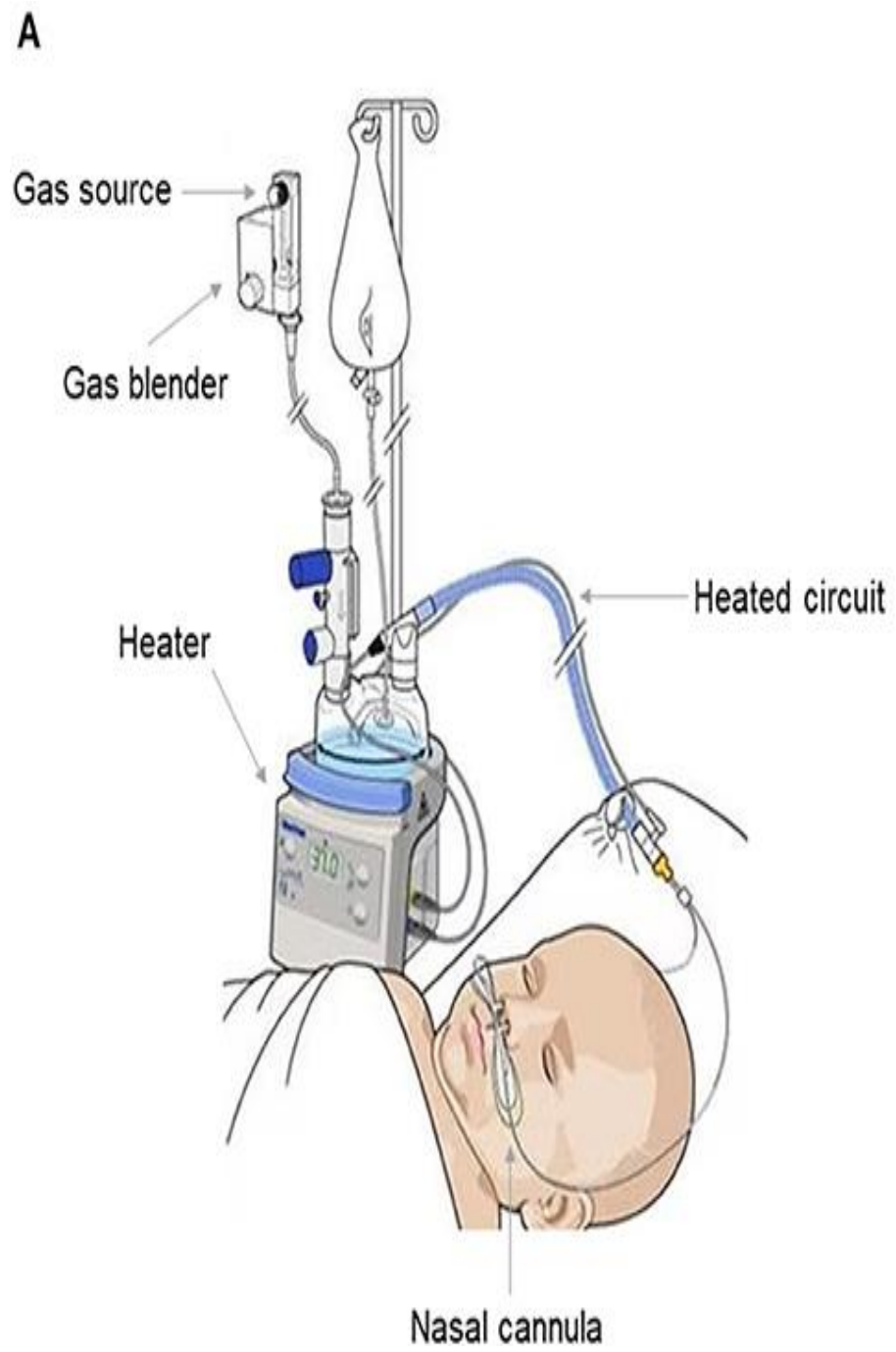
HFNC

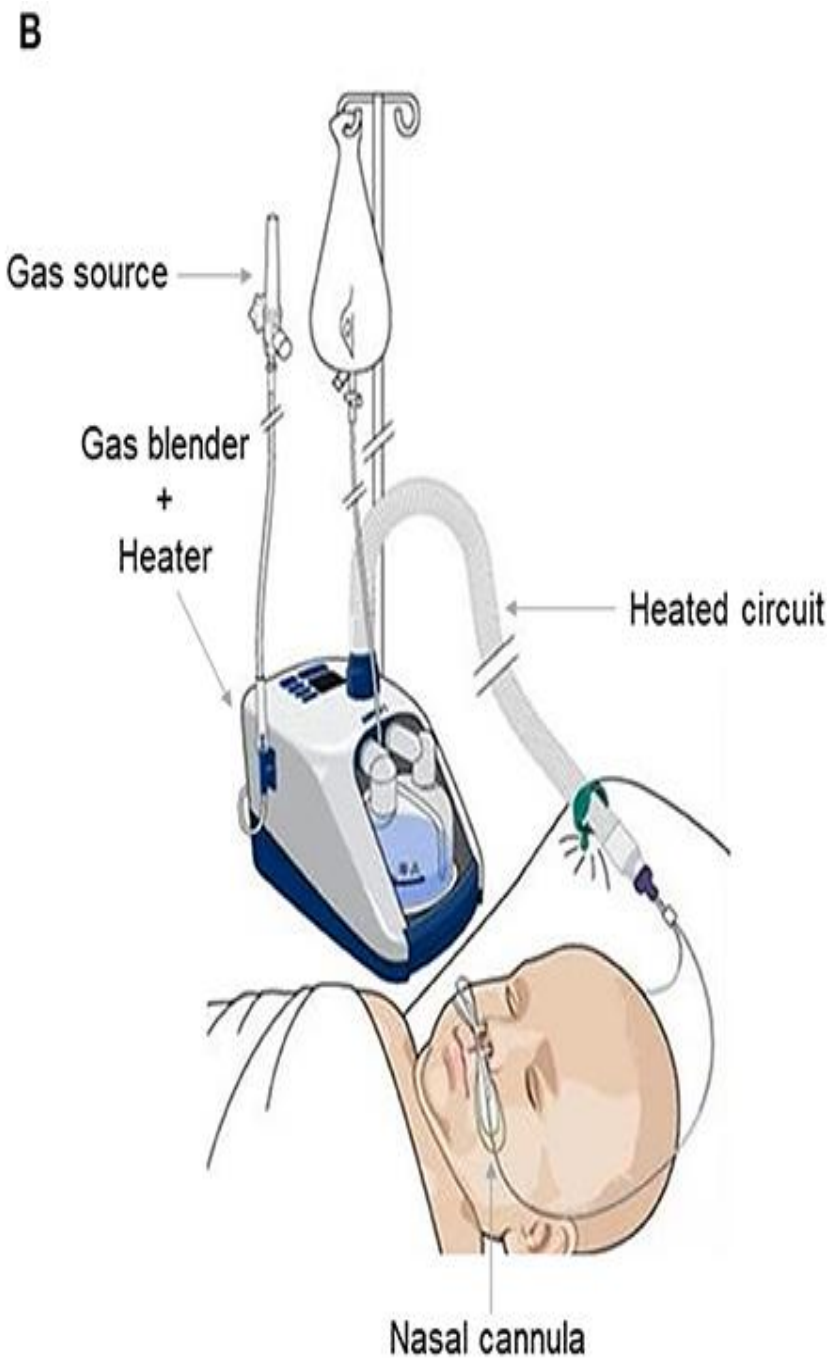
Alternatives to NIPPV

- The high flow may be sufficient to produce a CPAP effect, and may flush a portion of the CO2 contained within the anatomical dead space

- The definition of high flow varies with age of the patient
  - Flows 1 L/min are generally considered high flow in the neonatal patient
  - Flow ranges for older children are not well established in the literature
    - Flows 3 L/min meet the criteria for high flow in toddlers
    - Flows 5 L/min are considered high flow in older children

HFNC


A
Gas source
Gas blender
Heater
Heated circuit
Nasal cannula


B
Gas source
Gas blender
+
Heater
Heated circuit
Nasal cannula

Alternatives to NIPPV

- Assumed benefits of HFNC are realized from maximum mucocilliary clearance, reduced inflammatory reactions, inhibition of bronchoconstrictor reflex, reduced airway resistance, and a variable degree of washout of the nasopharyngeal dead space

- The evidence for positive pressure delivery with HFNC is mixed and highly variable
- HFNC responders could be assessed based on HR and RR within 1st hr
- Responders may be safely cared for on the pediatric wards

Safety

- **Alarm settings**
  - **High tidal volume** and **high RR alarms** should be set at **levels 20–30% above baseline delivery**
  - **High-pressure alarms** should be set at **5–10 cm H2O above IPAP** (PIP)
  - **Low-pressure alarms** should be set **above EPAP** but **below IPAP**
- Traditionally, **apnea times** are set at **10–15 sec** for **infants**, **15–20 sec** for **pediatrics**, and **20–30 sec** for **adolescents**

Safety

- **Backup ventilation settings :**
- **should reflect full ventilator support**

- **Other safety measures are:**

  - the use of remote monitoring, including video monitoring and central nurse call monitoring for HR, saturation, and disconnection, especially if the patient is cared for outside of the ICU setting


Thanks All
Only Kindness Remains