

# NONINVASIVE VENTILATION



## INTRODUCTION (MICHAEL MOJICA M.D., 2/2014)

Noninvasive positive pressure ventilation (NPPV or NIPPV) is defined as the delivery of pressurized, oxygen enriched gas to the airway via the nose and/or oropharynx without an invasive device such as an endotracheal intubation, a tracheostomy or a laryngeal mask airway. Pressure can be delivery continuously or at varying levels (eg inspiratory and expiratory).

Noninvasive ventilation can avoid or reduce the complications of endotracheal intubation such as airway trauma (vocal cord dysfunction and subglottic stenosis), barotrauma (pneumothorax) and infectious complications such as ventilator-associated pneumonia. It does not require paralysis and can obviate the need for sedation.

Meta-analysis of randomized clinical trails in adults with acute respiratory failure due to cardiogenic pulmonary edema and COPD have demonstrated a decreased need for endotracheal intubation; decrease length of stay and improved mortality. Large, well-controlled trials in pediatric causes of acute respiratory failure in the emergency department setting are lacking. There have been limited pediatric studies demonstrating a benefit in acute respiratory failure due to pneumonia, bronchiolitis, asthma and acute chest syndrome in patients with sickle cell disease

## PHYSIOLOGY

An increase in mean airway pressure recruits atelectatic alveoli improving alveolar gas exchange (increasing oxygen delivery) and decrease the work of breathing (reducing oxygen utilization). In addition, noninvasive ventilation may increase tidal volume and minute ventilation in patients in respiratory failure and help to maintain airway patency with lower airway obstruction (e.g. asthma).

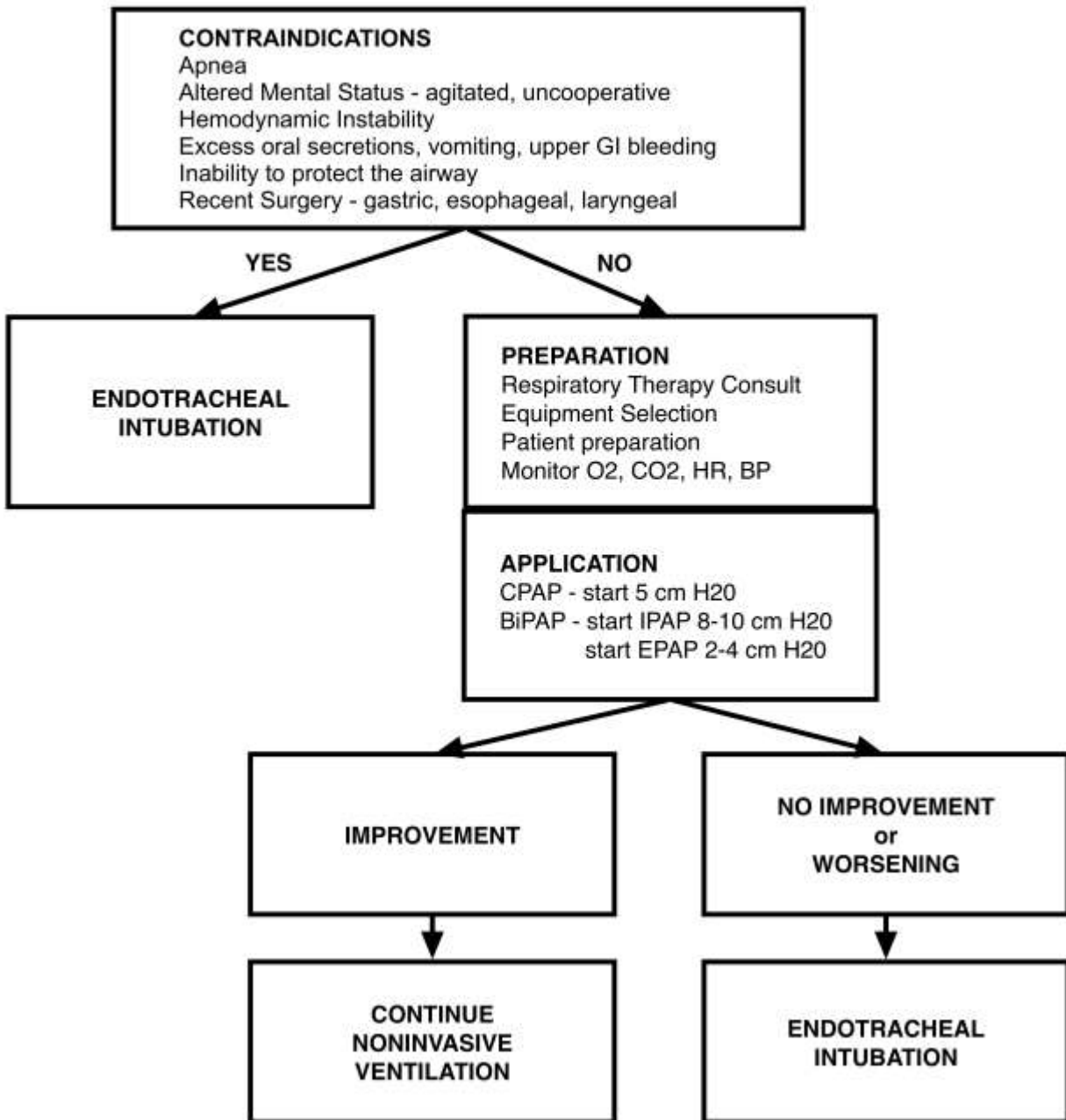
## PATIENT SELECTION

Patients are selected based on: the specific cause of respiratory distress/failure, likelihood of the reversibility, mental status and ability to cooperate. Contraindications are included in the patient selection algorithm below.

Patients should be monitored closely for mental status, vomiting, heart rate, blood pressure, oxygen saturation and end tidal CO<sub>2</sub>. An upright position should be maintained if possible. This limits atelectasis from a supine position, allows for a jaw thrust position to limit occlusion of the hypopharynx and prevents passive regurgitation.

Evidence of improvement may include: decreasing respiratory rate and work of breathing, increase in oxygen saturation, decrease in end tidal CO<sub>2</sub> and increased lung volumes on chest XRAY. Patients without improvement or a worsening progression of illness will require endotracheal intubation.

## Noninvasive Ventilation - Patient Selection Algorithm



## **EQUIPMENT**

Noninvasive ventilation can be delivered through specific devices or with traditional ventilators. Traditional ventilators have the benefit of fine control of oxygen delivery; better identification of air leaks and separates circuits for inspiration and expiration, which limit CO<sub>2</sub> rebreathing. Specific non-invasive ventilation devices have the advantage of ease of use.

## **INTERFACES**

A variety of interfaces are available including: nasal prongs, nasal masks, face masks (AKA oro-nasal masks - covering mouth and nose), full facemasks (covering mouth, nose and eyes) and hoods or helmet devices (covering the entire head). Nasal masks are better tolerated, are less claustrophobic and allow the patient to speak. Nasal masks often include chinstraps to prevent air leaks through the mouth. Facemasks and full facemasks have greater efficacy but must be removed to speak or for expectoration and vomiting. In addition they are claustrophobic and may require sedation due to increased anxiety and poor compliance.

## **MODES OF NONINVASIVE VENTILATION**

We will review the following four modes of noninvasive ventilation. They differ in terms of interfaces available and whether they provide continuous or varying pressures. In general, CPAP is indicated for hypoxic respiratory failure and BPAP for hypercapneic respiratory failure with or without hypoxia.

<b>CPAP</b>	Continuous Positive Airway Pressure
<b>BPAP</b>	Bi-level Positive Airway Pressure
<b>HHFNC</b>	Humidified High Flow Nasal Cannula
<b>NIPPV</b>	Nasal Intermittent Positive Pressure Ventilation

## **BPAP/BiPAP/BIPAP: BILEVEL POSITIVE AIRWAY PRESSURE**

(The terms BiPAP or BIPAP are often used interchangeably but refer to specific commercial products) BPAP provides two levels of positive airway pressure: inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP). IPAP mechanically assists ventilation. It increases tidal volume and increases CO<sub>2</sub> elimination. IPAP can be triggered by the patient's inspiration (S mode – Spontaneous) or at a back up rate if the patient does not breath (S/T mode – Spontaneous and Timed). EPAP serves a function similar to PEEP. It recruits alveoli and improves oxygenation Supplemental oxygen and aerosols may be delivered with BPAP.

BPAP is most effective when there is patient-ventilator synchrony. This requires an alert and cooperative patient. Adequate coaching and a gradual increase in pressure may decrease anxiety and increase cooperation.

A proper mask fitting is essential as air leaks reduce effectiveness. There is a balance between reducing air leaks and reducing excess pressure on the face that can cause anxiety and skin breakdown. A nasal mask induces less anxiety and claustrophobia and the patient can speak but air can escape form an opened mouth. A facemask is

preferred in the critically ill patient.

Sedation with a low dose of a benzodiazepine may be required. Low dose Ketamine (0.5-1.0 mg/kg bolus) followed by a continuous infusion of 0.25 mg/kg/hr) will provide sedation and bronchodilation in the patient with asthma.

### **BPAP SETTINGS**

Start IPAP at 8-10cm H<sub>2</sub>O.

Increase as needed to decreased work of breathing.

10-16 cm of H<sub>2</sub>O is sufficient in most cases but levels as high as 20-25cm H<sub>2</sub>O may be required. Pressure > 25 cm H<sub>2</sub>O cause gastric distension

Start EPAP at 2-4 cm H<sub>2</sub>O

Increase to 5-10 cm H<sub>2</sub>O as needed

Pressure support (PS) is the difference between IPAP and EPAP  
(PS = IPAP – EPAP).

IPAP should exceed EPAP by at least 2 cm H<sub>2</sub>O to ensure appropriate flow

### **CPAP – CONTINUOUS POSITIVE AIRWAY PRESSURE**

CPAP delivers a constant level of pressure support (inspiratory and expiratory) without regard to the respiratory cycle. It may be delivered through a variety of interfaces. A full facemask is typically used in older children and adults. Short bi-nasal prongs are preferred in neonates and infants due to the difficulty of maintaining an adequate facemask fit and seal.

### **CPAP SETTINGS**

Pressure is usually started at 5 cm H<sub>2</sub>O

Increased by 1 cm H<sub>2</sub>O as needed and tolerated

Typical levels are 5-10 cm H<sub>2</sub>O with a maximum of 15 cm H<sub>2</sub>O

### **HHFNC: HUMIDIFIED HIGH FLOW NASAL CANNULA**

Warm (35-37 C) and humidified nasal oxygen is better-tolerated than normal wall oxygen. The pressure from high flow rates can open the soft palate by separating it from the posterior pharyngeal wall. It also provides an oxygen reservoir in the nasopharynx.

When HHFNC is used in conjunction with a non-rebreather facemask it can increase the fraction of inspired oxygen (FiO<sub>2</sub>) to 100% (both nasal and facemask at 15 liters/min in adults). While oxygen via a non-rebreather face mask at 15 liters/min is often thought to provide 100% FiO<sub>2</sub> it typically only provides 60% FiO<sub>2</sub> due to accumulation and rebreathing CO<sub>2</sub> in the mask, hypopharynx and nasopharynx.

### **HHFNC SETTINGS**

Infants – Start at 2-4 liters/min

Increase as needed and tolerated to 8 Liters/min

Older children and Adults – Up to 40 liters/min

## **NIPPV: NASAL INTERMITTENT POSITIVE PRESSURE VENTILATION**

NIPPV can be thought of as bi-level CPAP (Low CPAP and High CPAP). It provides a baseline pressure (CPAP) and intermittent higher pressures. It is used primarily in infants. The higher pressure is set at a preset rate to decrease work of breathing and is not coordinated to the patients breathing efforts.

<b>NIPPV - SETTINGS</b>
Start low setting (Low CPAP) at 5 cm H <sub>2</sub> O Increase by 1 cm H <sub>2</sub> O as needed
Start high setting (High CPAP) at 8 cm H <sub>2</sub> O Increase by 1 cm H <sub>2</sub> O as needed
To increase oxygenation increase the time on the high CPAP setting
To increase ventilation increase the number of cycles between high and low CPAP settings

<b>MODE SUMMARY</b>				
	<b>PATIENT</b>	<b>FLOW</b>	<b>INTERFACE</b>	<b>AEROSOL</b>
BIPAP	Older Child	Bi-level	Nasal/Face mask	Yes
CPAP	Infant	Continuous	Nasal prongs, Nasal/Face mask	No*
HHFNC	Infant	Continuous	Nasal prongs	No*
NIPPV	Infant	Bi-level	Nasal prongs	No*
*Can be delivered by separate face mask				

## **APPENDIX - CARDIAC EFFECTS OF POSITIVE PRESSURE VENTILATION**

### Right Heart Effects

- A. Normal Inspiration (Negative Pressure Ventilation)
  - Decrease in inter-thoracic pressure (ITP)
  - Increased intra-abdominal pressure (as diaphragm descends)
  - Increased pressure gradient (abdominal >> ITP)
  - Increased systemic venous return (Preload)Increase RVEDV  
Increase right heart output
  
- B. Inspiration with Positive Pressure Ventilation
  - Increase in inter-thoracic pressure (ITP)
  - Decreased systemic venous return (Preload)Decreased RVEDV  
Decreased right heart output

### Left Heart Effects

Aortic transmural pressure – Pressure Aorta – Intrathoracic pressure  
Aortic transmural pressure = afterload

PPV – Increased ITP – Decreased Aorta Transmural pressure (afterload) – Increased Left heart output