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NON INVASIVE VENTILATION

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Introduction

Negative pressure ventilators (Tank and Cuirass ventilators) were the only non-invasive methods of assisting ventilation for many years mainly for ventilating large number of victims of Polio during their acute illness. In 1980s it was recognized that delivery of continuous positive airway pressure by close fitting nasal masks for treatment of obstructive sleep apnoea could also be used to deliver an intermittent positive pressure. This was followed by improvements in the interface and establishment of role of NIMV in patients of COPD. The use of NIMV has increased in last decade in various conditions to avoid complications of intubation.

Advantages of NIMV

- Preservation of airway defense mechanism
- Early ventilatory support: an option
- Intermittent ventilation possible
- Patient can eat, drink and communicate
- Ease of application and removal
- Patient can cooperate with physiotherapy
- Improved patient comfort
- Reduced need for sedation
- Avoidance of complications of endotracheal intubation: upper airway trauma, sinusitis, otitis, nosocomial pneumonia
- Ventilation outside hospital possible
- Correction of hypoxaemia without worsening hypercarbia
- Ease to teach paramedics and nurses

Disadvantages

- Mask uncomfortable/claustrophobic
- Time consuming for medical and nursing staff
- Facial pressure sores
- Airway not protected
- No direct access to bronchial tree for suction if secretions are excessive
- Less effective?

Mechanism of Action

1. Improvement in pulmonary mechanics and oxygenation: In COPD, oxygen therapy often worsens hypercarbia and respiratory acidosis. NIMV augments alveolar ventilation and allows oxygenation without raising PaCO2
2. Partial unloading of respiratory muscles: NIMV reduces trans-diaphragmatic pressure, pressure time index of respiratory muscles and diaphragmatic electromyographic activity. This leads to alteration in breathing pattern with an increase in tidal volume, decrease in respiratory rate and increase in minute ventilation. NIMV also overcomes the effect of intrinsic PEEP
3. Resetting of respiratory centre ventilatory responses to PaCO2: In patients with COPD, ventilatory response to raised PaCO2 is decreased especially during sleep. By maintaining lower nocturnal PaCO2 during sleep by giving NIMV, it is possible to reset the respiratory control centre to become more responsive to an increased PaCO2 by increasing the neural output to diaphragm and other respiratory muscles. These patients are then able to maintain a more normal PaCO2 throughout the daylight hours without the need for mechanical ventilation.

Prerequisites for successful Non-Invasive support

- Patient is able to cooperate
- Patient can control airway and secretions
- Adequate cough reflex
- Patient is able to co-ordinate breathing with ventilator
- Patient can breathe unaided for several minutes
- Haemodynamically stable

- Blood pH>7.1 and PaCO2 <92 mmHg
- Improvement in gas exchange, heart rate and respiratory rate within first two hours
- Normal functioning gastrointestinal tract

Indications of NIMV

(A) Acute respiratory failure

1. Hypercapnic acute respiratory failure

- Acute exacerbation of COPD
- Post extubation
- Weaning difficulties
- Post surgical respiratory failure
- Thoracic wall deformities
- Cystic fibrosis
- Status asthmaticus
- Acute respiratory failure in Obesity hypoventilation Syndrome

2. Hypoxaemic acute respiratory failure

Evidence is less convincing to show efficacy of NIMV in hypoxaemic respiratory failure. The possible indications are:

- Cardiogenic pulmonary oedema
- Community acquired pneumonia
- Post traumatic respiratory failure
- ARDS
- Weaning difficulties

(B) Chronic Respiratory Failure

(C) Immunocompromised Patients

(D) Do Not Intubate Patients

Selection Criteria

(A) Acute Respiratory Failure

At least two of the following criteria should be present:

- Respiratory distress with dyspnoea
- Use of accessory muscles of respiration
- Abdominal paradox
- Respiratory rate >25/min
- ABG shows pH <7.35 or PaCO2 >45mmHg or PaO2/FiO2 <200

(B) Chronic Respiratory Failure (Obstructive lung disease)

- Fatigue, hypersomnolence, dyspnoea
- ABG shows pH <7.35, PaCO2 >55 mmHg, PaCO2 50-54 mmHg
- Oxygen saturation <88% for >10% of monitoring time despite O2 supplementation

(C) Thoracic Restrictive/ Cerebral Hypoventilation Diseases

- Fatigue, morning headache, hypersomnolance, nightmares, enurasis, dyspnoea
- ABG shows PaCO2 >45mmHg
- Nocturnal SaO2 <90% for more than 5 minutes sustained or 10% of total monitoring time

Contraindications

- Respiratory arrest
- Unstable cardiorespiratory status
- Uncooperative patients

- Unable to protect airway- impaired swallowing and cough
- Facial Oesophageal or gastric surgery
- Craniofacial trauma/burn
- Anatomic lesions of upper airway

Relative Contraindications

- Extreme anxiety
- Massive obesity
- Copious secretions
- Need for continuous or nearly continuous ventilatory assistance

Choice of Ventilator

NIMV can be given by conventional critical care ventilators or portable pressure or volume limit ventilators. When critical care ventilator is chosen for applying NIMV, there is problem of alarms due to presence of variable leaks. Therefore a close monitoring of leaks is mandatory. It is easy to give NIMV by especially designed portable pressure ventilator. These provide a high flow CPAP or cycle between high inspiratory and low expiratory pressures (Bilevel positive airway pressure generators) These devices are sensitive enough for detection of inspiratory efforts even in presence of leaks in the circuits.

Interface

Interfaces are devices that connect ventilator tubing to the face allowing the entry of pressurized gas to the upper airway. Nasal and oronasal masks and mouth pieces are currently available interfaces. Masks are usually made from a non irritant material such as silicon rubber. It should have minimal dead space and a soft inflatable cuff to provide a seal with the skin. Face masks and nasal masks are the most commonly used interfaces. Nasal masks are used most often in chronic respiratory failure while face masks are more useful in acute respiratory failure.

Modes of Ventilation

All modes of ventilation can be used for applying non-invasive ventilation

1. CPAP: It is not a true ventilator mode as it does not actively assist inspiration. CPAP by nasal mask provides pneumatic splint which holds the upper airway open in patients with nocturnal hypoxaemia due to episodes of obstructive sleep apnoea. CPAP increases FRC and opens collapsed alveoli. CPAP reduces left ventricular transmural pressure therefore increases cardiac output. Thus it is effective for

treatment of pulmonary oedema. Pressures are usually limited to 5-12 cm of H2O, since higher pressure tends to result in gastric distension requiring continual aspiration through nasogastric tube.

2. PSV: Non-invasive PSV can be administered with standard critical care ventilator or bilevel portable devices. PSV mode has unique ability to vary inspiratory time breath by breath, permitting close matching with the patient's spontaneous breathing pattern Drawbacks of PSV: (a) Patient-ventilator asynchrony in COPD patients having rapid respiratory rate and exacerbation of asynchrony in presence of air leaks. (b) Breathing discomfort as inspiratory force is required to trigger the ventilator.

3. Volume limited ventilation: In this mode, ventilators are usually set in assist-control mode with high tidal volume (10-15 ml/kg) to compensate for air leak. This mode is suitable to the patients with obesity or chest wall deformity who need high inflation pressure and in patients with neuromuscular diseases who need high tidal volume for ventilation

4. Proportional assist ventilation (PAV): This is a newer mode of ventilation. In this mode ventilator has capacity of responding rapidly to the patients' ventilatory efforts. By adjusting the gain on the flow and volume signals, one can select the proportion of breathing work that is to be assisted.

Goals of NIMV

Short Term

- Relieve symptoms
- Reduce work of breathing
- Improve or stabilize gas exchange
- Good patient-ventilator synchrony
- Optimize patient comfort
- Avoid intubation

Long Term

- Improve sleep duration and quality
- Maximize quality of life
- Enhance functional status
- Prolong survival

Protocol for Non Invasive Ventilation

Procedure for patient setup

- Explain to the patient what you are doing and what to expect

- Setup the ventilator by the bed side

- Keep the head of the patient's bed at >45 degree angle

- Choose the correct interface
- Turn on the ventilator and dial in the settings
- Attach O2 at 2 litres per minute
- Hold the mask gently over the patient's face until the patient becomes comfortable with it. Strap the face mask on using the rubber head strap and minimize air leak without discomfort.
- Connect humidification system.
- Monitor- respiratory rate, heart rate, level of dyspnoea, O2 saturation, blood pressure, minute ventilation, exhaled tidal volume, abdominal distension and ABG

Initial Ventilatory Settings

- Initial ventilator setting should be very low ie. IPAP of 6 cm H2O, and EPAP of 2 cmH2O
- Increase EPAP by 1-2 cm increments till the patient triggers the ventilator in all his inspiratory efforts.
- Increase IPAP in small increments, keeping it 4cmH2O above EPAP, to a maximum pressure, which the patient can tolerate without discomfort and major leaks.
- Titrate pressure to achieve a respiratory rate of <25 breaths/min and Vt >7ml/kg
- Increase FiO2 to improve O2 saturation to 90%

Weaning

It is similar to T-piece weaning trials

Complications and Side effects

- Air leak
- Skin necrosis- particularly over bridge of nose
- Retention of secretions
- Gastric distension
- Failure to ventilate

- Sleep fragmentation
- Upper airway obstruction

Conclusion

Use of NIMV has increased during the past few years. In acute exacerbation of COPD it is now considered the ventilator mode of first choice. For treatment of acute pulmonary oedema, CPAP alone is very effective. NIMV reduces the chances of endotracheal intubation in hypoxaemic respiratory failure. It is also being used to facilitate the weaning from invasive ventilation. NIMV is first choice in patients with neuromuscular diseases and chest wall deformity. Central hypoventilation and patients of obstructive sleep apnoea not responding to CPAP are also acceptable indications.

Further Reading

1. Dr. Rajesh Chawla. Non Invasive Mechanical Ventilation- A practical guide. 1st ed. Feb. 2002. published for ISCCM (Delhi Chapter)

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3. International Consensus Conference in Intensive Care medicine: Noninvasive positive pressure ventilation in acute respiratory failure. Intensive Care Medicine (2001) 27:166-178

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