Marmara Medical Journal 2016; 29 (Special issue 2): 32-35
DOI: 10.5472/MMJsi.2902.08

REVIEW ARTICLE

Noninvasive mechanical ventilation

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ABSTRACT

Noninvasive mechanical ventilation (NIMV) has been widely applied to the patient with respiratory failure since 1990's around the world. The respiratory function of the patient with respiratory failure should be supported by using positive pressure ventilation until primary problem of the patient is treated. Positive pressure should be given noninvasively or invasively. If the patient is conscious (except unconsiousness due to CO2 retention) and has intact bulber function(sufficient cough reflex and swallowing function) and has stable clinical picture, we have to use NIMV instead of invasive mechanical ventilation (IMV). NIMV can be applied to the patient outside of the intensive care unit. The side effects of mechanical ventilation are significantly decreased during NIMV than that of IMV.

Keywords: Noninvasive ventilation, Respiratory insufficiency

Indications

Increased respiratory work that can be progressed to respiratory failure (respiratory rate>35/min, intercostal retractions, supraclavicular retractions, paradoxical breathing), respiratory failure and respiratory arrest are indications of mechanical ventilation in all diseases. Mechanical ventilatory support can be provided noninvasively if the patient is conscious (except unconsciousness due to CO2 retention) and has intact bulbar function (sufficient cough reflex and swallowing function) and has stable clinical picture. Mechanical ventilatory support is delivered to the patient through interfaces (nasal, oro-nasal, full face, helmet) during noninvasive mechanical ventilation (NIMV), but by using endotracheal tube or tracheotomy cannula during invasive mechanical ventilation (IMV). If NIMV is contraindicated, respiratory support should be given by using IMV. It is possible to avoid complications of intubation and IMV by using NIMV.

Definition: NIMV is delivery of positive pressure ventilation to support respiratory function of the patient through interfaces.

Indications of mechanical ventilation

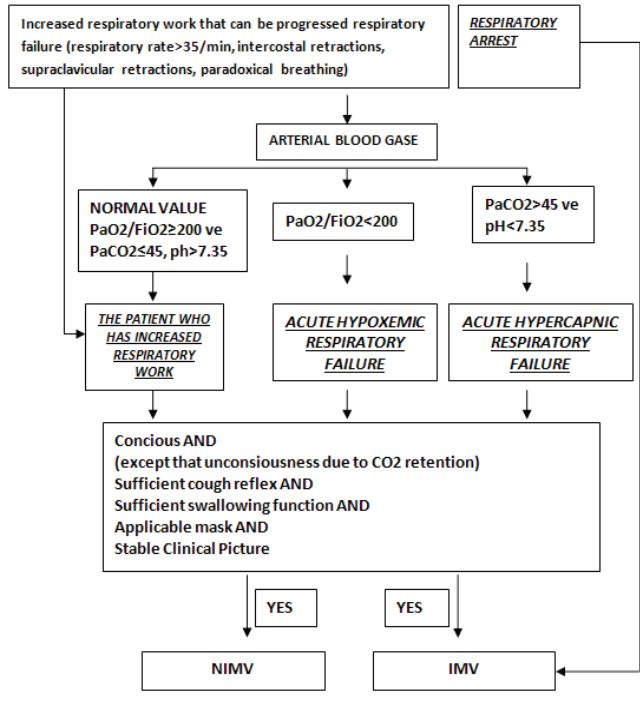

Figure 1. Algorithm for indications of mechanical ventilation. NIMV: Non invasive mechanical ventilation, IMV: Invasive mechanical ventilation

The respiratory function of the patient with respiratory failure should be supported by using mechanical ventilation, until primary problem of the patient is treated. There is no

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difference in terms of degree of support between NIMV and IMV. The same respiratory support is delivered through mask during NIMV or by using endotracheal tube during IMV. The patient should be evaluated in conjunction with arterial blood gas and respiratory effort. The patient may have extreme unacceptable respiratory effort to reach normal blood gas value. This patient has tendency to respiratory failure. Mechanical ventilatory support must be given to patient without waiting for the results of arterial blood gas. Acute respiratory distress syndrome (ARDS) and shock are referred to as the clinical situations that are unstable; in such cases, if the patient's ventilatory support is lost for a short period of time, hypoxemia will create serious irreversible problems. In the clinical pictures like this, IMV is a more secure modality.

Place of NIMV

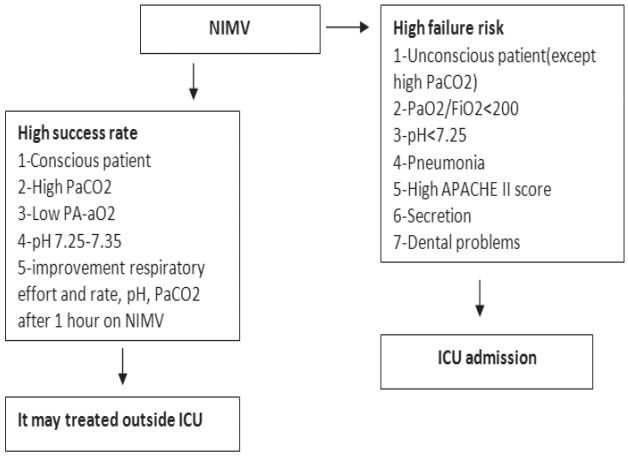

Figure 2. Choose the place to administer NIMV

Contraindications of NIMV

Table I. Contraindications of NIMV

1-Cardiac or respiratory arrest
2-Unconsciousness (except that hypercapnia)
3-Organ failure other than respiratory failure
-Severe encephalopathy
-Shock
-Unstable hemodynamic picture due to cardiac problems
-Severe upper gastrointestinal beleeding
4-Cannot protect airway(the patient who has insufficient cough reflex or dysfunction of swallowing)
5-Cannot remove secretions
6-The risk for aspiration
7-Upper airway obstruction
8-Facial surgery, trauma or defomity

NIMV practice

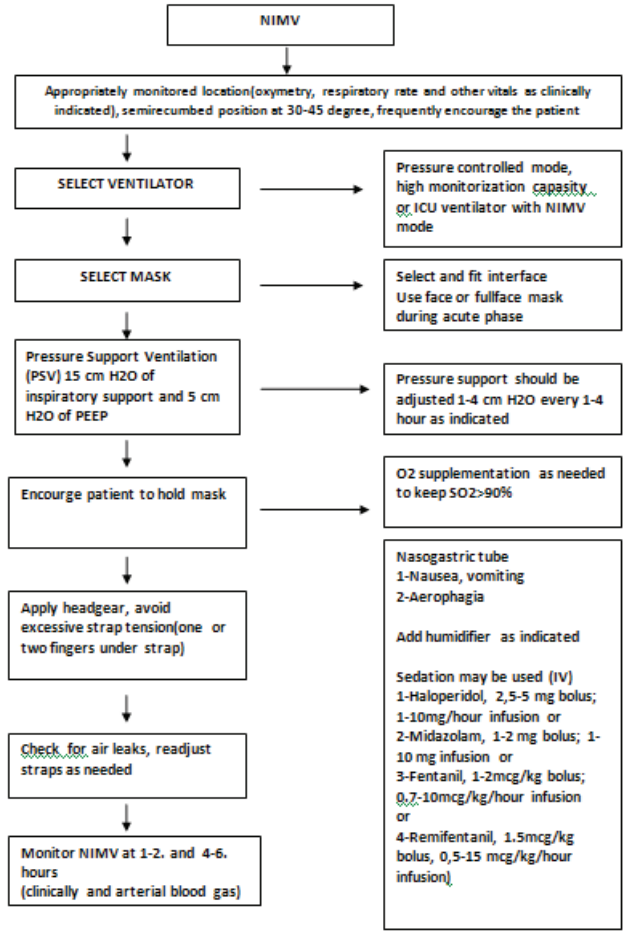

Figure 3. NIMV practice

The success of NIMV is highly dependent on patient cooperation. The physician should serve the role of facilitator, motivating the patient, explaining the purpose of equipment, and preparing the patient for process. Patients should be reassured and frequently encouraged.

The support of mechanical ventilator is given by a controlled mode (volume or pressure control) to the patients who are unconscious or have respiratory center depression, because the failure rate of NIMV is high in these groups of patients. Effective ventilation, by reducing the level of PaCO2, allows the patient to recover consciousness and then pressure support ventilation (PSV) or one of the other assisted modes can be applied. Mechanical ventilatory support of 25-30 cm H2O of pressure or 500 mL of volume during controlled ventilation as initial adjustment can

be given. If the patient compliance to ventilator is not so good, less tidal volume can be achieved by given pressure so it is important to remember that the patient may remain hypoventilated. If the patient keeps awake, success of NIMV increases significantly in the assisted modes like PSV. Another option in these patients is the application of Average Volume Guaranteed Pressure Support (AVAPS) mode.

Assessment of success

NIMV will be successful if the amount of expired tidal volume is more than 5 ml/kg or 300 mL. If the expired tidal volume is less than 300 mL, recovery of the patient does not occur. So, it is not feasible for us to wait first hour to assess NIMV. The 20% change in respiratory rate, PaCO2, PaO2 or pH at first and/or forth hour, a good or bad way is considered meaningful. The changes of respiratory effort are monitored. Generally, clinical improvement is firstly observed, and then improvement of gas exchange develops. If the patient lung reserve is not good, clinical picture of the patient may begin to recover, but improvement of pH and PaCO2 may delay.

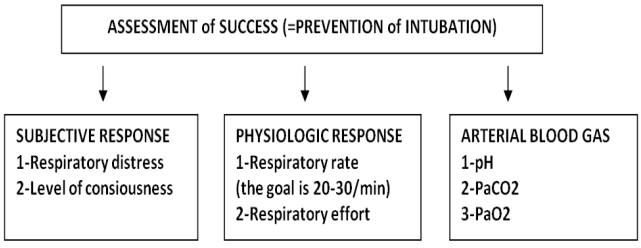

Figure 4. Assessment of success.

Table II. Clinical pictures and level of evidences that are successfully treated by NIMV (change from 2)

STRONG EVIDENCE
-Exacerbation of COPD
-Acute cardiogenic pulmonary edema
-Immunosupression
-Weaning period of COPD patient
MODERATE EVIDENCE
-Asthma
-Cystic fibrosis
-Postoperative respiratory failure
-Do not Intubate(DNI) patient
-Extubation failure
WEAK EVIDENCE
-Upper airway obstruction
-ARDS
-Trauma
-Obstructive Sleep Apnea Syndrome, Obesity Hypoventilation Syndrome

Complications and treatments

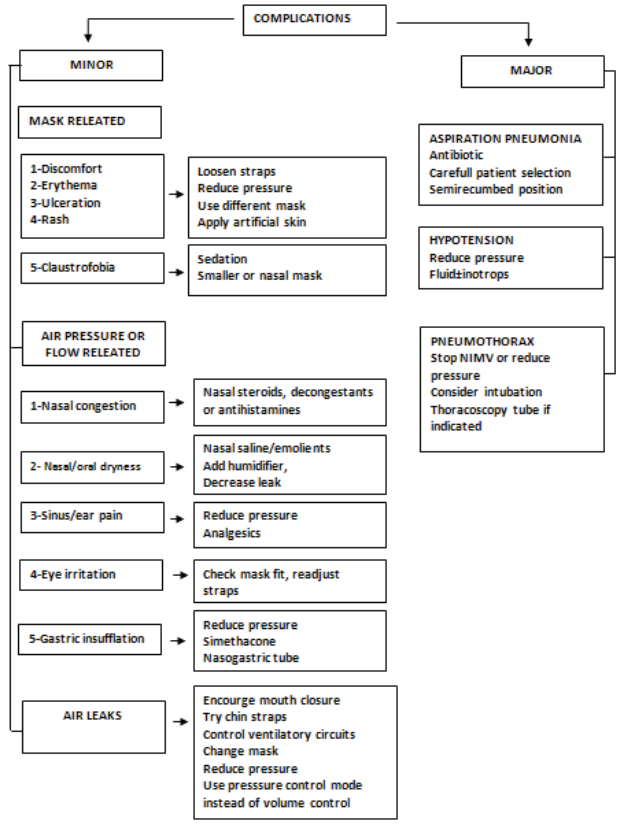

Figure 5. Complications of NIMV and treatments

Follow up: If the patient has criteria indicating NIMV failure, the patient should be admitted to ICU. Close monitoring is necessary for these patients.

NIMV vs. High-flow oxygen therapy (HFOT)

HFOT through a nasal cannula is a technique whereby heated and humidified oxygen is delivered to the nose at high flow rates. These high flow rates generate low levels of positive pressure (approximately 1 cm H2O for every 10L/min flow) in the upper airways [1-5]. The high flow rates may also decrease physiological dead space by flushing expired carbon dioxide from the upper airway, decrease in the work of breathing is observed.

HFOT serve as an important alternative to NIMV especially in the management the patients with hypoxemic respiratory failure. The rate of treatment failure with NIMV is as high as 50% in patients who have contraindication of NIMV such as facial surgery, impaired swallowing and

cough. In HFOT a special nasal cannula is used, thus HFOT does not interfere with eating and speaking.

HFOT is not suitable in patients with hypercapnic respiratory failure.

If the patient receives FiO2 of greater than 60% and more than 48 hours, the patient may be at the risk of oxygen toxicity. Positive pressure ventilation improves oxygenation and CO2 removal by alveolar recruitment, increasing alveolar volume and redistribution of extracellular lung water. So it is reasonable to implement positive pressure ventilation in patients on high O2 like this level [6].

Mechanical ventilation vs. Extracorporeal membrane oxygenation (ECMO)/ Extra corporeal CO2 removal (ECCOR)

Venoarterial ECMO is preferred if cardiac function is depressed and cardiac support is also required. Patients with severe respiratory failure and secondary cardiac failure may improve on venovenous ECMO support alone. ECCOR is provided to remove CO2 and, unlike ECMO, does not provide significant oxygenation. In contrast to ECMO, where the need for oxygenation requires high blood flow rates, ECCOR allows much lower blood flow rates (500-1000mL/min) and needs smaller access cannulas. So, ECCOR promises to improve safety and ease of use. If the patient has sufficient arterial pressure (arteriovenous pressure gradient ≥ 60 mm Hg), a pumpless system can be used in ECCOR. Otherwise, a mechanical pump should be used [7].

ECCOR provide prevention of ventilator induced lung injury associated with ultra-protective ventilation (3-4mL/kg VT) during severe ARDS treatment, end-stage COPD respiratory failure and as a bridge to lung transplant [8].

NIMV compared to IMV has been demonstrated to reduce mortality by approximately 50% respiratory failure in COPD patients [9]. However, approximately 25% of these patients will fail NIMV and require IMV [10]. It has been reported that COPD patients who require IMV have high mortality rate and were also at increased risk of weaning failure and prolonged ventilation. ECCOR has been utilized to avoid intubation, to facilitate weaning and to reduce length of IMV in COPD patients. It is possible that in patients suffering from COPD exacerbations with NIVM failure, it could be possible to avoid intubation with the implementation of ECCOR in order to correct respiratory acidosis and hypercapnia until recovery of gas exchange and an improvement in the dynamic hyperinflation [8].

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