Management of patients with non-invasive positive pressure ventilation therapy in intensive care units

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SUMMARY

- Non-invasive positive pressure ventilation (NIPPV) refers to the provision of ventilatory support for a spontaneously breathing patient in the absence of endotracheal intubation.
- NIPPV with a facemask was first introduced in the early 1960s, because endotracheal intubation and ventilation, despite being effective and reliable, were associated with many complications.
- From the early 1980s onwards one of the main factors that contributed to the popularisation of NIPPV was the successful use of continuous positive airway pressure (CPAP) to treat obstructive sleep apnoea.
- CPAP provides continuous positive pressure without the need for mechanical support, and is administered to a patient during inspiration and expiration.
- Another type of non-invasive ventilation is bi-level positive airway pressure (BiBAP), whereby separate pressure adjustments can be made for inspiration and expiration.

INTRODUCTION

Non-invasive positive pressure ventilation (NIPPV) provides assistance to a patient's respiration by delivering pressurised gas to the airway, which increases transpulmonary pressure and inflates the lungs. Exhalation is achieved via the elastic recoil of the lungs and sometimes by active contraction recoil of expiratory muscles. The main difference between invasive ventilation and NIPPV is that gas is given via a mask in NIPPV. Bi-level positive airway pressure (BiPAP) describes a form of NIPPV in which there are separate pressure adjustments for the inspiratory and expiratory phases. Continuous positive airway pressure (CPAP) is the non-invasive application of positive airway pressure through a mask without the provision of ventilatory support. It is therefore not considered to be a form of non-invasive ventilation, but serves to stimulate alveolar ventilation in a spontaneously breathing patient. Due to the similar nature of the associated issues, CPAP is often discussed simultaneously.

This article discusses the indications, applications and complications associated with NIPPV. In addition, an overview of the management of patients receiving this therapy is included.

BACKGROUND

NIPPV with a facemask was first introduced in the early 1960s, because endotracheal intubation and mechanical ventilation, despite being effective and reliable, were associated with many complications. However, underdeveloped mask technology at that time and inappropriate mask sizes limited the success of NIPPV. Thus, the use of invasive mechanical ventilation overtook the use of NIPPV. In 1984, French researchers proposed the use of mask ventilation for Duchenne's muscular dystrophy to decrease or eliminate muscle fatigue during the night. Shortly after, the success of nocturnal nasal ventilation in reducing gas exchange disorders and their symptoms was being reported for various neuro-muscular diseases and chest wall deformities. The last decade has seen a NIPPV revival, chiefly related to improvements in mask technology and ventilation systems.

NIPPV is now frequently the first line treatment in selected groups of patients who require respiratory support (BTS, 2002). Ideally NIPPV is applied to patients whose pH values are below 7.35 and above 7.45, such as those with respiratory acidosis due to hypoxia with CO_2 retention and those with respiratory alkalosis due to ineffective rapid and shallow breathing.

The rationale for initially using NIPPV on these patients is to avoid the invasive procedure of endotracheal intubation, decreasing the likelihood of infection and other complications associated with the use of an artificial airway. In addition, the use of NIPPV may prevent admission to an intensive care unit and shorten the hospitalisation period. It also has the added advantages of simplicity, maintenance of the patient's ability to communicate and swallow and the ease of implementation and discontinuation. For these reasons, the use of NIPPV is becoming more widespread.

However, NIPPV treatment may not be readily accepted by all patients. One of the complications of its use is the prevalence of facial and oral ulceration (Smith et al., 1998; Brigg, 1999; Marshall & Pittard, 1999). For some patients it means admission to an intensive care unit which can lead to them experiencing increased levels of panic, anxiety and agitation due to the disturbing environment. In addition, as a consequence of the need for a tightly fitting face mask, this treatment is also difficult to accept for patients with claustrophobia.

PHYSIOLOGICAL EFFECTS OF NIPPV

The physiological effects of NIPPV include improved oxygenation, less effort needed to breathe, improved ventilation/perfusion (V/Q) matching, decreased fatigue and increased minute ventilation (Meduri, 1996; Hotchkiss & Marini, 1998; Duke & Bersten, 1999). The application of positive pressure to the airways increases alveolar distension, helps prevent alveolar collapse and, as a result, has the potential to increase the transfer of oxygen at the alveolar-capillary membrane. In patients with interstitial oedema, the mechanical effects of alveolar distension help the dispersion of interstitial fluid and potentially increase oxygen transfer to capillary blood. NIPPV may also be effective in providing rest for chronically fatigued muscles (Brochard et al., 1990). In studies of the haemodynamic effects of NIPPV, no significant differences were noted in the pulmonary arterial pressure or in cardiac output, although a significant reduction in pulse rate was identified (Çelikel, 2000; Koç & Yüksel, 2003; Vanpee, 2003).

NIPPV INDICATIONS

Several randomised and non-randomised clinical trials have demonstrated that NIPPV is an effective treatment in the management of acute respiratory failure (Antonelli et al., 2002). The indications of its use can be summarised as:

- ❖ Chronic obstructive pulmonary disease (COPD) with acute respiratory acidosis;
- ❖ Long-term homecare of COPD patients;
- ❖ Obstructive sleep apnoea syndrome;
- ❖ Hypercapnic respiratory failure due to chest wall deformities or neuromuscular disorders;
- ❖ Cardiogenic pulmonary oedema (usually BiPAP and only when the condition remains unresponsive to CPAP);
- ❖ Acute pneumonia;
- ❖ Weaning from mechanical ventilation.

COPD with respiratory acidosis

NIPPV is increasingly the first choice treatment option for patients with exacerbated COPD and accompanying acidosis. A randomised controlled trial demonstrated a reduction in the number of intubations, improvements in dyspnoea scores and more stable vital signs in patients who received NIPPV. In addition, statistically significant differences were noted in mortality, morbidity and hospitalisation periods (Çelikel, 2000). Further studies have demonstrated the benefit of the early use of NIPPV in these patients (Brochard et al., 1995; Kramer, 1995 ; Bardi et al., 2000).

Restrictive pulmonary disease

The British Thoracic Society (BTS, 2002) recommends the use of NIPPV as the first-line treatment for patients with decompensated ventilatory failure due to neuromuscular disease or chest wall deformity. There is a lack of controlled studies in this area and the recommendation is based on their success of NIPPV with COPD patients.

Hypoxaemic respiratory failure

A randomised controlled trail conducted by Antonelli et al. (1998) compared NIPPV with endotracheal intubation and mechanical ventilation in 64 patients with hypoxaemic respiratory failure. The results demonstrated that NIPPV was just as effective as conventional ventilation in improving gas exchange, intubation was avoided in 69% of patients, and the incidence of sepsis and other complications was lower in the NIPPV group.

Pulmonary oedema

CPAP is effective in treating cardiogenic pulmonary oedema (Lin et al., 1995; Mehta et al., 1997). BiPAP may have a role to play if the patient's condition is unresponsive to CPAP (Murray, 2002).

Immune-suppressive patients

Due to the increased tendency to develop infection and more frequent incidences of haemorrhage with invasive mechanical ventilation, NIPPV has become the preferred method for use with immune-suppressive patients who have developed acute respiratory deficiencies (Koç & Yüksel, 2003).

Patients who are not suitable for intubation

NIPPV may be applied to patients with malignancies that have a poor prognosis if they are intubated. It will assist in the reduction of dyspnoea and help them to maintain an acceptable quality of life.

Weaning from mechanical ventilators and facilitating intubation

NIPPV may be used as a tool to support patients being weaned from mechanical ventilation. It has been shown to increase the likelihood of success when weaning, with a decrease in morbidity and mortality (Ferrer et al., 2003; Koç & Yüksel, 2003). Nava et al. (1998) conducted a study comparing the use of standard weaning with the use of NIPPV. Participants were patients with COPD who had been intubated and ventilated, and who had experienced a failed weaning trial using a T-piece. The group who received NIPPV had reduced ventilation time (quicker weaning) and a reduction in the total number of intensive care days. The 60-day survival rate was 93% for the NIPPV group and 72% for the standard weaning group.

Asthma

Randomised controlled studies have been performed to examine the use of NIPPV in patients with asthma and cystic fibrosis. However, no conclusive results have been reported so far (Çelikel, 2000; Kaçmaz, 2002).

COMPLICATIONS OF NIPPV

There are a number of complications associated with the use of NIPPV. The most common ones are linked to masks, airflow and applied positive pressure.

Complications related to masks

Discomfort, irritation in the facial skin, claustrophobia, ulceration (see photo 1) at the nasal bridge (Meduri, 1996) and facial ulceration (Hill, 1993) are commonly seen in patients receiving NIPPV. In such cases, the mask strap may need to be loosened, and artificial support should be placed between the mask and nose or face. A study conducted by Callaghan and Trapp (1998) showed that the application of a Granuflex (ConvaTec Ltd) dressing on the nasal bridge reduces the pressure damage and may minimise air leaks.

Photo 1: Face ulceration caused by CPAP mask pressure

Complications related to airflow and pressure

Nasal congestion, sinus/ear pain (Hotchkiss & Marini, 1998), nasal/oral dehydration (Hayes et al., 1995), increased intraocular pressure (Alvarez-Sala et al., 1992), conjunctivitis (Hotchkiss & Marini, 1998), gastric distension (Meduri, 1996) can all occur as a result of high pressure. Complications appear to be reduced when pressures of less than 25cm H_2O are applied. Facial ulcerations are often related to ill-fitting masks or incorrect placement and irregular facial and oral care.

Major complications can be minimised with proper patient selection and preparation. Patients must be conscious and should be able to respond to verbal stimuli. Vomiting, aspiration and barotrauma appear to be rare complications of NIPPV (Hotchkiss & Marini, 1998).

CONTRAINDICATIONS TO THE USE OF NIPPV

- ❖ Respiratory arrest – NIPPV is dependent on spontaneous respiratory effort;
- ❖ Cardiovascular instability – this is a controversial point. Confalonieri et al. (1994) indicate that the precise definition of instability is lacking in reported studies. Clinical judgement is required based on an individual needs assessment of the patient;
- ❖ Mental status derangement – co-operation of the patient influences the success and outcome of NIPPV. Patients who are confused or who have a lowered conscious level may not be able to tolerate this intervention;
- ❖ Excessive secretions or vomiting – due to the need to repeatedly remove the face mask, the benefits of NIPPV may not be achieved;
- ❖ Facial trauma or surgery – the application of a suitable face mask will be difficult;
- ❖ Recent oesophageal or gastric surgery – pressure in the upper airways may cause pressure on an anastomosis.

OVERVIEW OF THE MANAGEMENT OF PATIENTS RECEIVING NIPPV

The correct application and maintenance of masks are major factors in the success of NIPPV. Masks should suit the patients' facial anatomy. Although adaptation to this therapy is better with nasal masks, the use of face masks that cover the nose and mouth and the use of nasal buffers have been reported to be more effectivein reducing CO_2 (Çelikel, 2000). Also, nasal masks appear to be tolerated more readily by patients who have claustrophobia.

The mask should be held in position using restraining straps to ensure a tight seal is obtained (see photo 2). A mask that is too loose will allow air leaks and one that is too tight may damage the nasal bridge. Attention to oral, facial and eye hygiene is crucial for maintaining the integration of facial tissues and mucosa. Oxygen should be administered and titrated to achieve a SpO_2 greater than 90%.

Photo 2: CPAP mask in place

When beginning the therapy, the mask should initially be applied using handheld pressure and the pressure levels increased slowly. The inspiratory level should be increased to one that the patient can tolerate. As the patient's condition begins to stabilise, the mask can be removed for short periods to allow oral intake.

The patient and the family need to be fully informed about the intervention and what is required of them. Patients will need to cooperate with medical and nursing staff, and the family can offer much-needed support and encouragement. Familiarisation with the equipment is important for initiating the therapy; the patient should be shown the equipment and agreement reached about methods of communication. The restraining straps generally have a quick release mechanism that the patient should be made aware of and its use demonstrated.

Cardiovascular and respiratory monitoring is required. Regular arterial blood gases are used to assess the effectiveness of the therapy. Pulse oximetry monitoring will allow continuous assessment of oxygenation. Continuous electrocardiogram (ECG) and frequent recording of blood pressure are advocated, particularly in the acute stages. The frequency can be reduced once the patient has stabilised. Assessment of the patient's respiratory rate and pattern will give an indication of how the patient is responding to the therapy. A reduction in respiratory rate and use of accessory muscles is expected as the patient's condition improves.

The incidence of gastric distension is reported as being less than 2% (Meduri, 1996; Duke & Bersten, 1999) so the routine placement of a nasogastric tube is not required. If patients have, or subsequently develop, gastric distension a nasogastric tube is indicated.

CONCLUSION

Invasive mechanical ventilation is associated with a number of minor and major complications. NIPPV decreases the need for intubation and ventilation, and patients remain in control of their treatment and can communicate with the healthcare team. The benefits of NIPPV are evident from the literature; a key factor in its success is its early use.

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