

Nursing care plan: Non-invasive ventilation in thoracic surgery patients

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ABSTRACT

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During recent years the application of non invasive ventilation (NIV) has emerged as a central component of respiratory failure management, acute and chronic. Although the use of NIV in acute respiratory failure was initially meant to be given in critical care units, it is nowadays natural to provide it in other settings as well, provided that there are the necessary resources and expertise. NIV represents a viable alternative to endotracheal ventilation and despite most data refer to patients with chronic obstructive pulmonary disease; its indications are continuously expanding to cover more clinical scenarios. Randomized controlled studies are needed in order to provide sound evidence regarding optimal patient-ventilator interface, NIV duration and ventilation parameters in thoracic surgery patients.

INTRODUCTION

Following lung resection surgery, gas exchange deteriorates due to loss of lung parenchyma, decrease in respiratory drive due to 'opioids' suspending effect and raised work of

breathing due to postoperative pain and closure of distal airways¹⁻³. Prior to the introduction of NIV in intensive care units (ICU) during the 90s, most patients with acute respiratory failure (ARF) required endotracheal intubation and invasive mechanical ventilation, often complicated by airway injury, barotrauma, ventilation induced acute lung injury

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and ventilator associated pneumonia^{4,5}. ARF following lung resection, when treated with invasive endotracheal ventilation, is fatal in up to 80% of cases⁶. More recently, however, new non-invasive ventilation (NIV) techniques have been devised that utilize patient-ventilator interfaces to improve gas exchange. NIV has a unique set of advantages, e.g., the patient does not need to be sedated, and be communicative and the ventilation can be applied intermittently.

The most common types of NIV include continuous positive airway pressure (CPAP) and positive pressure ventilation (NPPV). CPAP is a method of applying a positive airway pressure during both the inspiration and expiration phase in spontaneously breathing patients. Although CPAP is not actively assisting breathing, it is regarded as a mode of NIV⁷. On the other hand, NPPV delivers two levels of positive pressure: positive inspiratory pressure and positive end-expiratory pressure (PEEP). The rationale behind NIV is to improve gas exchange, reduce the work of breathing and improve haemodynamics³. In this context, NIV may be used as a means to either prevent ARF (prophylactic use) or to treat it (curative use) once the respiratory failure has been established, avoiding intubation and invasive mechanical ventilation.

Indications and Contraindications

NIV's efficacy was initially demonstrated for the treatment of patients with acute exacerbations of chronic obstructive pulmonary disease (COPD), but the spectrum of its uses appears to increase substantially over the last years^{5,8-10}. Despite its widespread use, though, most of the studies refer to COPD patients.

The clinical indications for NIV include acute exacerbation of COPD¹⁰, immunosuppression with ARF^{11,12}, weaning from mechanical ventilation^{13,14}, ARF following lung resection surgery and palliation for symptom relief in patient with dyspnea in combination with opioids¹⁵. Use of NIV only in patients with COPD and ARF is supported by strong evidence. For instance, in patients with asthma, pneumonia or acute respiratory distress syndrome (ARDS), evidence from randomized controlled trials is lacking or does not suggest benefit^{16,17}.

Contraindications for NIV include untreated pneumothorax¹⁴, severe hypoxemia¹⁸, life-threatening arrhythmias and hemodynamic instability^{2,3,19,20}, abundant respiratory secretions^{2,3,7,21-23}, uncontrolled vomiting³ or high risk for aspiration^{20,23}, severe agitation^{10,23}, facial traumas³ or upper airway surgery^{14,23}. Such patients need to be intubated promptly as any delay may lead to increased morbidity and mortality²³. Also, patient lack of cooperation and deteriorating

mental status are relative contraindications for the use of NIV³.

Surgical Patients

Postoperative complications following cardiac and vascular surgery are common and they may lead to compromised hospital survival and length of hospitalisation²⁴. Similarly, ARDS after pulmonary resections constitute a major cause of mortality²⁵, despite the improvements in surgical, anesthetic and critical care techniques of the last years.

The short term effects of NIV on gas exchange and hemodynamics in patients with elective lung resection have been studied¹. There has been concern that NIV may cause some undesired effects in respiratory physiology, such as pleura air leaks or reduction of cardiac output due to decrease of venous return, but such fears have not been confirmed¹. For instance, in an observational study, Rocco et al used NIV in 21 patients with bilateral lung transplantation who developed ARF and tolerance of NIV in this patient cohort was good²⁶. Risk factors for NIV failure in thoracic surgery patients include cardiac comorbidities and no initial response to NIV^{2,21}.

In thoracic surgery patients, data on efficacy of NIV in postoperative ARDS are sparse. A single-center randomized trial found that in patients with ARF after a lung resection surgery, NIV decreased the need to intubate and subsequently decreased the associated mortality⁶.

Contrariwise, a more recent randomized trial failed to demonstrate an effect of prophylactic postoperative NIV in COPD patients undergoing lung resection surgery, but it reduced the number of re-intubation rates²⁷. Thus, NIV may have a role as a preventive intervention in selected patients at severe risk^{28,29}.

On a similar note, a trial by Kindgen-Milles et al demonstrated that prophylactic use of CPAP after extubation for 12-24 hours after thoracoabdominal aortic aneurysm surgery reduced pulmonary complications and resulted in improved oxygenation and shorter hospital stay³⁰. In the aforementioned study, authors suggested nasal CPAP to avert postoperative atelectasis on the grounds that it is a simple method for pulmonary function improvement and relatively well tolerated by the patient. Therefore, the preventive role of NIV is further strengthened.

A meta analysis from Olper et al showed that NIV appears to be effective in reducing reintubation rates after cardiothoracic surgery²⁹. Also, the benefits arising from NIV are more pronounced in patients with acute respiratory failure and those at high risk for postoperative pulmonary complications. Perrin et al showed that prophylactic use of NIV in a pre- and post-operative manner significantly reduced pulmonary dysfunction following lung resection surgery³¹. In their randomized trial, patients were given NIV for 7 days before sur-

gery and 3 days post surgery. These results are challenged by a more recent randomized trial from Liao et al where prophylactic NIV in post-thoracic surgery patients improved lung re-expansion but failed to affect postoperative pulmonary complications and lung functions³². These seemingly conflicting results may be reconciled within the context of different surgery types. In Perrin's trial all patients underwent posterolateral open thoracotomy as opposed to Liao's study where patients underwent video-assisted thoracoscopic surgery³³. Finally, Zarbock et al randomized 500 patients scheduled for elective cardiac surgery. Following extubation they were given either standard treatment with intermittent 10 min nCPAP every 4h or prophylactic nCPAP for at least 6h. The long-term application of prophylactic nCPAP improved arterial oxygenation, reduced pulmonary complications such as pneumonia and need for reintubation and re-admission to ICU³⁴.

Location Care

The optimal location regarding NIV delivery in acute care patients has been a matter of debate, yet relatively few studies tried to answer this question³⁵. Although the use of NIV in acute respiratory failure is meant to be given in critical care units, given the paucity of ICU beds, many hospitals are forced to deliver NIV to relatively stable patients in general wards³⁵⁻³⁷. In two meta-analyses of NIV in COPD pa-

tients with acute exacerbations no significant difference in outcomes with respect to location care (ICU vs wards) could be demonstrated^{38,39}.

Longitudinal studies have showed that the accumulated experience with NIV allows the treatment of more severely ill patients with the same rate of success⁴⁰. Therefore, it could be argued that patients with mild to moderate respiratory acidosis and single organ failure could be managed in a ward area, as long as there are the necessary resources. In COPD case series severe acidosis has been an independent adverse prognostic factor for early NIV failure⁴¹⁻⁴³. The tolerance of NIV and the change in arterial blood gas, more importantly pH, and respiratory rate in the early hours are valid predictors of the subsequent outcome^{43,44}.

Patient-Ventilator Interface

For a successful application of NIV and patient compliance the choice of a suitable interface is very important⁴⁵. These include: nasal mask, oro-nasal mask, mouthpiece, total face mask and helmet. There are several factors that may contribute to mask intolerance, such as discomfort, claustrophobia (especially in the presence of increased respiratory drive and difficulty in breathing)³, excessive air leak, skin breakdown (e.g. on the bridge under the nose)^{10,46}, oronasal dryness and patient-ventilator asynchrony.

To the best of our knowledge there is no evidence to support the use of a particular mask in patients receiving NIV^{20,47} and specifically in thoracic surgical patients. Although, by far the most commonly used interface appears to be the oronasal mask^{21,48}, helmet use is better tolerated with fewer complication rates in abdominal surgery patients⁴⁹. NIV via helmet shows some favorable traits, such as low distensibility, absence of contact with the face (which makes the use more comfortable for the patient and reduces skin pressure wounds), minimum air leaks and the ability to be used in edentulous patients or patients with face traumas^{7,50}. On the other hand, the high internal volume may result in CO₂ rebreathing and increase patient-ventilator asynchrony²³. Full-face masks improve efficacy by reducing leaks and are perhaps more appropriate for use in the setting of severe hypoxemic ARF²⁰. In any case, it is recommended that a wide array of interfaces be available for immediate use, in order to initiate NIV in all clinical scenarios^{20,45}. High-flow nasal cannula oxygen (HFNC) is a relatively new therapeutic innovation being used in adults with respiratory failure but more studies are needed to compare HFNC with NIV⁴⁶.

Nursing Care Plan

Although there exist international guidelines, there is a lack of specific recommendations to guide the selection of modes or interfaces of

NIV, due to absence of empirical evidence^{14,20,47}. Perhaps this explains why NIV success depends so strongly on the skill and expertise of the attending medical and nursing staff⁵². A summary of nursing care actions is shown in table 1.

Table 1. Summary of nursing care actions

Prior to the initiation of NIV, patients are to be assessed for their anticipated degree of compliance with the interface, their capacity to manage their respiratory secretions and their capacity to protect their airway²². If these requirements cannot be met, then alternate methods of respiratory support should be undertaken. Also, patient consent should be sought whenever a patient is able to provide one.

Explaining the NIV method to the patient is considered a major key for success^{10,53}. Moreover, patient comfort, breathing synchrony and enhanced compliance are significant outcome determinants^{7,45,54}.

As much preparation as possible needs to be carried out away from patient's bedside in order to prevent patient distress. Patient is positioned at an elevated angle so as to facilitate chest wall expansion⁴⁵. In obese patients or pregnant side lying to remove pressure from a pendulous abdomen may be considered²². NIV method needs to be explained to the patient in a positive and calm manner, encouraging him or her to hold the mask and breathe through it for a few seconds before connecting it to the ventilator.

Ventilation pressures start low and are gradually increased as tolerated provided there are no major leaks^{45,54}. Peak inspiratory pressure should be kept as low as possible, (e.g. < 30 cm H₂O) to avoid risking barotrauma, air leaks

- Assess patients for anticipated degree of compliance with the interface, their capacity to manage their respiratory secretions and to protect their airway.
- Explain the NIV method to the patient and seek patient consent whenever he or she is able to provide one.
- Prepare as much possible away from patient's bedside.
- Position patient at an elevated angle and encourage him or her to hold the mask and breathe through it for a few seconds before connecting it to the ventilator.
- Start with low ventilation pressures and gradually increase as tolerated.
- Peak inspiratory pressure should be kept as low as possible, e.g. < 30 cm H₂O.
- Check for air leaks, readjust straps (but not too much) or decrease pressure if there are major leaks.
- Add heated humidifier, e.g. 100% relative humidity at about 30°C. Be cautious with heat/moisture exchangers.
- Monitor vital signs, arterial blood gases, level of consciousness, patient-ventilator synchrony and assess response to treatment.
- If NIV fails, re-intubation should not be delayed.
- Perform a full body skin integrity at least daily, particularly around nose, face and neck.
- Be vigilant for NIV-related complications, e.g. wound pressures, aspiration, barotrauma and hemodynamic compromise.

and gastric insufflation²³. The nurse needs to check for air leaks, readjust straps (but not too

much) or decrease pressure if there are major leaks.

The need for humidification of NIV gas is controversial⁵⁵. Still, humidification and warming of the air may be required during NIV, since inadequate humidification may cause patient distress due to the effects of cool, dry gases on the tracheobronchial epithelium⁵⁶. Adding heated humidifier, e.g. 100% relative humidity at about 30°C is usually sufficient¹⁰. Regarding heat/moisture exchangers (HMEs) extra caution should be exercised as they may increase dead space and negatively affect the effectiveness of NIV^{10,56}.

It is prudent to monitor vital signs, arterial blood gases, level of consciousness, patient-ventilator synchrony and assess response to treatment^{22,47}. If NIV fails, re-intubation should not be delayed as this may increase morbidity and mortality^{23,44}. In acutely ill patients monitoring should be performed every 15 minutes in the first hour, every 30 minutes in the 1-4 hour period and then hourly²².

A full body skin integrity at least daily, particularly around nose, face and neck to prevent pressure injury by the interface is mandated. The ideal method of handling pressure wounds is to prevent them altogether by not strapping the mask too tight. Should they occur though, one could consider using a different interface¹⁰. Applying hydrocolloids may prevent nosebridge or axillary skin pressure

sores⁴⁵. A full body wash on a daily basis is recommended based on patient's diaphoresis and level of tolerance²².

Oral feeding may be initiated as long as the patient is able to tolerate small periods off NIV. On the contrary, if patient has a decreased level of consciousness or is in respiratory distress with increased work of breathing, intravenous fluids should be commenced.

Complications

There are certain complications that may arise from the application of NIV and require nurse vigilance. Some of them are merely uncomfortable adverse effects while others could potentially escalate to life-threatening severe complications^{23,46}.

Major complications include pneumonia due to inhalation of foreign materials, e.g. condensed fluid in the ventilator circuit, or aspiration of gastric contents and secretions²³. This could be largely avoided by carefully selecting patients for NIV. As mentioned earlier, patients with copious secretions that are unable to protect their airway, have decreased level of consciousness or need to be sedated, should be excluded from receiving NIV. Other major complications include barotrauma and negative hemodynamic effects and could be minimized by carefully selecting ventilation parameters and close monitoring^{23,46}.

Minor complications include ocular complications due to increased gas flows that may dry

the cornea, poor oral hygiene due to the inability to tolerate withdraw from NIV, facial skin lesions due to mask interface or pressure wounds on dependant areas because the patient is reluctant to move due to breathlessness and abdominal distension due to gastric insufflation^{22,23}.

CONCLUSION

In order to optimally apply NIV in everyday clinical practice, there is a necessary learning curve. It is very important to be able to identify those patients most likely to benefit from NIV as opposed to those that will likely not and recognize signs of early NIV failure in order to escalate respiratory support. There are still major questions for which we lack high quality data, such as optimal patient selection, duration of NIV, patient-ventilator interface and ventilator parameters.

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Author Disclosures:

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