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Noninvasive Positive-Pressure Ventilation Therapy in Patients with COPD

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1. Introduction

Noninvasive positive pressure ventilation (NPPV) refers to the administration of ventilatory support without using an invasive artificial airway (endotracheal tube or tracheostomy tube). The use of NPPV has markedly increased over the past two decades. Rudimentary devices that provided continuous positive airway pressure were described in the 1930s, but the negative-pressure ventilators were the predominant method of ventilatory support until the polio epidemics overwhelmed their capacity in the 1950s. In the 1980s, increasing experience with positive-pressure ventilation delivered through a mask in patients with obstructive sleep apnea led to this type of ventilatory support, initially in patients with neuromuscular respiratory failure. Success led to its adoption in other conditions, and NPPV became especially promising in the treatment of patients with exacerbations of chronic obstructive pulmonary disease (COPD).

NPPV is defined as ventilatory support delivered by a non-invasive interface such as mask or similar device, acting as an alternative to intubation or tracheostomy. Consequently, by avoiding tracheal intubation, NPPV presents several potential advantages, such as reduction in pulmonary infections, barotrauma and need for sedation (British Thoracic Society Standards of Care Committee 2002). As a result, NPPV should be considered a standard of care to treat COPD exacerbation in selected patients, since it markedly reduces the need for intubation and improves outcome by lowering complication and mortality rates, and shortening hospital stay (Brochard et al. 1995; Kramer et al. 1995; Celikel et al. 1998; Martin et al. 2000; Conti et al. 2002; Squadrone et al. 2004; Lightowler et al. 2003; Nava, Navalesi, & Conti 2006). Weaker evidence indicates that NPPV could allow earlier extubation, avoid re-intubation in patients who fail extubation, and assist do-not-intubate patients, and thus could be beneficial for COPD patients who are suffering respiratory failure precipitated by superimposed pneumonia or postoperative complications, and COPD patients with severe stable disease who have substantial daytime hypercapnia and superimposed nocturnal hypoventilation.

This chapter will examine the evidence pertaining to the use of NPPV for various applications in COPD and make recommendation on patient, ventilation mode and interface selection as well as technical aspects of NPPV application in COPD. The literature review

and consensus processes used to reach the recommendations presented here are the American College of Chest Physicians [ACCP] consensus report on clinical indications for NPPV in CRF due to restrictive lung disease, COPD and nocturnal hypoventilation published in 1999, the British Thoracic Society guidelines published in 2002, the Indian Society of Critical Care Medicine guidelines published in 2006, the guidelines from 12 German Medical Societies published in 2008 and the most recent guideline published in 2011 from Canadian Critical Care Trials Group/Canadian Critical Care Society Noninvasive Ventilation Guidelines Group.

2. Physiologic mechanism of NPPV effect in patients with COPD

Severe COPD places the respiratory muscles at a mechanical disadvantage (Rochester, Braun, & Arora 1979). During COPD exacerbation, this situation becomes catastrophic. Exacerbations of COPD increase the respiratory load in these patients, exceeding their ability to adequately ventilate through a variety of mechanisms, including increasing hyperinflation with decreased diaphragmatic excursion and strength, increasing intrinsic positive end-expiratory pressure (PEEP), changes in respiratory patterns and increased respiratory frequency leading to ineffective or inadequate tidal volume generation. NPPV effectively unloads the respiratory muscles by increasing tidal volume, decreasing the respiratory rate, and decreasing the diaphragmatic work of breathing, which translates into an improvement in oxygenation, a reduction in hypercapnia, and an improvement in dyspnea. NPPV treatment counterbalances auto-PEEP, assists inspiration, reduces transdiaphragmatic pressure, lowers respiratory rate, rests the accessory muscles, increases functional residual capacity, decreases respiratory load and work of breathing and leads to favorable changes in the ventilation/perfusion ratio as well as the respiratory center and the sensivity of chemoreceptors (Mansfield & Naughton 1999; de Miguel et al. 2002). Expiration positive airway pressure (EPAP) counterbalances intrinsic PEEP. Inspiration positive airway pressure (IPAP) is capable of increasing tidal volume and subsequently decreasing the elevated levels of PC02.

3. Indications of NPPV in patients with COPD

3.1 Acute respiratory failure/Exacerbation of COPD

Based upon the overwhelming evidence that NPPV reduces the need for intubation, reduces mortality and complications rates, and shortens the length of stay in both the intensive care unit (ICU) and hospital (Kramer et al. 1995; Brochard et al. 1995; Celikel et al. 1998; Martin et al. 2000; Carlucci et al. 2001; Mehta & Hill 2001) , NPPV should be considered as a standard of care in acute respiratory failure (ARF) due to COPD exacerbations (Keenan et al. 2011). Brochard et al. were the first to show that pressure-support ventilation administered via face mask significantly reduced the need for intubation, duration of mechanical ventilation, and ICU stay in patients with COPD exacerbations (Brochard et al. 1990). The patients with relatively mild COPD exacerbations are not likely to benefit from NPPV, which suggests that NPPV should be applied to selected patients who have moderate-to-severe COPD exacerbations. Though, patients with milder exacerbations appear to demonstrate a more rapid improvement in their level of dyspnea with NPPV treatment, the addition of NPPV to standard therapy for patients with milder exacerbations of COPD is not well tolerated (Keenan, Powers, & McCormack 2005). NPPV should be the first option for ventilatory

support in patients with either a severe exacerbation of COPD or cardiogenic pulmonary edema(Keenan et al. 2011). Furthermore, consensus groups of experts advocate the routine use of NPPV for selected patients with COPD exacerbations (British Thoracic Society Standards of Care Committee 2002). High quality studies have shown that NPPV is an effective treatment for moderate to severe COPD exacerbation (Kramer et al. 1995; Celikel et al. 1998; Martin et al. 2000). In patients with mild to moderate ARF, characterized by pH levels between 7.25 and 7.35, the rate of NPPV failure was ranging from 15% to 20% (Elliott 2002; Lightowler et al. 2003). In more severely ill patients (pH<7.25), the rate of NPPV failure was inversely related to the severity of respiratory acidosis, rising up to 52%-62% (Conti et al. 2002; Squadrone et al. 2004). In patients with ''mild'' exacerbations, not complicated by respiratory acidosis, the use of NPPV was investigated in few studies, including patients in large majority with pH>7.35, which failed to demonstrate a better effectiveness of NPPV than standard medical therapy in preventing the occurrence of ARF (Bardi et al. 2000; Keenan, Powers, & McCormack 2005). Guidelines recommend the use of NPPV in addition to usual care in patients who have a severe exacerbation of COPD (pH<7.35 and relative hypercarbia) (grade 1A recommendation) (Keenan et al. 2011). Based on that evidence, the authors of the meta-analyses and the participants in the consensus groups recommended that NPPV should be used early in the course of a COPD exacerbation, in addition to the standard medical care (Lightowler et al. 2003; Keenan et al. 2003; British Thoracic Society Standards of Care Committee 2002) . NPPV is not appropriate for all COPD patients with ARF and the selection of candidates is important. Most of the indications and contraindications for NPPV in ARF are listed in Table 1 (Brochard et al. 1995). There are no absolute contraindications to NPPV although a number have been suggested (Ambrosino et al. 1995; Soo Hoo, Santiago, & Williams 1994). In part, these contraindications have been determined by the fact that they were exclusion criteria for the controlled trials. It is therefore accurate to state that NPPV is not proven in these circumstances rather than stating that it is contraindicated.

3.2 Severe community-acquired pneumonia in patients with COPD

The presence of pneumonia has been associated with poor outcome in patients treated with NPPV (Ambrosino et al. 1995). However COPD exacerbation is still an appropriate indication for NPPV even when complicated by community-acquired pneumonia (Confalonieri et al. 1999). In one randomized trial with patients suffering severe community-acquired pneumonia, NPPV reduced the need for intubation, and reduced mortality among the COPD subgroup of patients 2 months after hospital discharge (Confalonieri et al. 1999). But it is not clear whether NPPV should be used for severe community-acquired pneumonia in non-COPD patients.

3.3 Adjunct to early liberation

Patients with COPD can be considered for a trial of early extubation to NPPV in centres with extensive experience in the use of NPPV (Keenan et al. 2011). Guidelines suggest that NPPV be used to facilitate early liberation from mechanical ventilation in patients who have COPD, but only in centres that have expertise in this therapy (Grade 2B recommendation) (Keenan et al. 2011). Recent randomized controlled trials (RCTs) suggested benefit from NPPV after extubation in patients who had high risk of deterioration (Ferrer et al. 2006; Ferrer et al. 2009; Nava et al. 2005; Luo, Cheng, & Zhou 2001). The results of the RCTs of

Indications
• Increased dyspnea-moderate to severe • Tachypnea (>25 breaths per minute) • Signs of increased work of breathing, accessory muscle use, pursed lips breathing and abdominal paradox • Acute or chronic ventilatory failure (best indication), PaC02 >45 mmHg, pH <7.35 • Hypoxaemia (use caution), Pa02/Fi02 ratio < 200
Contraindications
Absolute • Cardiac or respiratory arrest • Severe encephalopathy • Unable to fit mask Relative • Severe haemodynamic instability with or without cardiac ischemia or arrhythmia • Severe gastrointestinal bleeding • Agitated, uncooperative state • Upper airway obstruction • Inability to protect the airway and/or high risk of aspiration • Inability to clear secretions • Multiple organ failure • Recent facial, upper airway or upper gastrointestinal surgery

[NPPV= non-invasive positive pressure ventilation; PaC02: arterial partial pressure of carbon dioxide; Pa02: arterial partial pressure of oxygen; Fi02: fraction of inspired oxygen]

Table 1. Indications and contraindications for NPPV in ARF

early extubation in COPD patients with NPPV are controversial, some showing significant benefit and the other showing no important benefit, but no attributable harm in either (Girault et al. 1999; Ferrer et al. 2003). Intubated COPD patients are appropriate candidates for early extubation by NPPV, but clinicians are advised to be cautious when selecting patients. The inability to sustain 5–10 min of unassisted breathing, a prior difficult intubation, multiple co-morbidities, copious secretions, a weakened cough, or the need for high levels of pressure support prior to extubation (>20 cm H2O) should exclude patients from consideration for early extubation (Hill 2004).

3.4 After planned extubation

Extubation failure occurs after 5-20% of planned (Epstein, Ciubotaru, and Wong 1997) and 40-50% of unplanned extubation (Chevron et al. 1998) NPPV may prevent the need for reintubation if applied immediately after planned extubation. NPPV is recommended to be used after planned extubation in patients who are considered to be at high risk of recurrent respiratory failure, but only in centres that have expertise in this type of therapy (Grade 2B recommendation) (Keenan et al. 2011). We should be careful to avoid delays in intubation in the face of deterioration and to select the patients for extubation.

3.5 Postoperative patients

It has been shown that NPPV in post-lung-resection patients with acute respiratory failure results in significantly less need for intubation, shorter ICU stay, and lower mortality rate than conventionally treated controls (Auriant et al. 2001) . The use of NPPV in selected postoperative patients (especially COPD patients) could maintain improved gas exchange and avoid reintubation and its complications.

3.6 Do-not-intubate patients

In the studies of patients in whom endotracheal intubation was contraindicated or postponed, COPD subgroup were supported with NPPV and weaned more successfully than the pneumonia or cancer subgroup of patients (Benhamou et al. 1992; Meduri et al. 1994). Thus, NPPV is indicated in do-not-intubate patients with acutely reversible processes that are known to respond well, including COPD exacerbations. However, if NPPV is to be used in a do-not-intubate patient, the patient and/or the family should be informed that NPPV is being used as a form of life support that may be uncomfortable and can be removed at any time (Hill 2004).

3.7 Overlap syndrome

The term ''overlap syndrome'' was introduced by Flenly to describe the association of obstructive sleep apnea syndrome (OSAS) and COPD (Flenley 1985). Even by chance alone, a patient with one of the disorders has a greater than 10% probability of also having the other disorder. Thus, when seeing a patient with either OSAS or COPD, it is reasonable to screen for the lower and longer nocturnal oxyhemoglobin desaturations, which produces more severe pulmonary hemodynamic complications (Chaouat et al. 1995; Bednarek et al. 2005). Concomitant COPD in patients with severe OSAS so called critical care syndrome is frequently associated with diurnal hypercapnia and acute ventilatory failure (Fletcher et al. 1991). There is an increase in the morbidity and mortality and risk of developing pulmonary hypertension and hypercapnic respiratory failure in patients with overlap syndrome than patients with OSAS alone and patients with usual COPD (Chaouat et al. 1995; Chaouat et al. 1999). NPPV with or without supplemental oxygen is now the treatment of choice for the patients with overlap syndrome (Mayos et al. 2001).

Improvement in daytime hypercapnia and gas exchange has been reported in overlap syndrome with continuous positive airway pressure (CPAP) treatment (Owens & Malhotra. 2010). Mild bronchodilatory effect due to amelioration of chronic irritation and responsiveness of the upper airway and reduction of the chronic airway has also been suggested as the possible mechanisms for the benefits of CPAP. Bilevel positive airway pressure (BPAP) may be preferred if the patient experiences difficulty in exhaling against a fixed pressure or has persistent intermittent hypoxemia despite adequate airflow (Kushida et al. 2006). Supplemental oxygen can be added to NPPV to eliminate persistent intermittent nocturnal hypoxemia (Kakkar & Berry 2007). In a cohort of overlap syndrome patients, CPAP added to long term oxygen treatment as compared to long term oxygen treatment resulted in a survival benefit with 5 years-survival rates of 71% and 26%, respectively (Machado et al. 2010). In another study including COPD and overlap syndrome patients, CPAP therapy eliminated the additional risk of mortality due to OSA in overlap syndrome

patients as compared to COPD- only patients (Marin et al. 2010) . One RCT and another study using a historical cohort showed reduction of mortality in overlap syndrome with NPPV (McEvoy et al. 2009; Windisch et al. 2009). In the study by Windisch et al., intensive pressure settings (average inspiratory pressure 28 cm H2O, average expiratory pressure 5 cm H2O and a high respiratory rate of about 21 breaths/min) were used with inhospital acclimatization and improvement in spirometry and arterial blood gas were reported (Windisch et al. 2009) . Finally, BPAP may be more comfortable and effective than CPAP in lowering CO2 and increasing tidal volume for patients with overlap syndrome, COPD component of which is much more related to moderate to severe hypercapnia and more prominent than the OSAS component.

3.8 Severe stable COPD/Chronic respiratory failure in patients with COPD

Despite the reported benefits of NPPV application in COPD patients with ARF, the role of NPPV in chronic respiratory failure (CRF) remains controversial. COPD patients with both increased hypercapnia and sleep-disordered breathing may be the ones, who are most likely to benefit from NPPV (Hill 2004). However the evidence to support the use of NPPV in CRF in the setting of severe stable COPD has been less consistent. COPD treatment guidelines does not recommend NPPV treatment routinely in end stage stable hypercapnic COPD in addition to conventional treatment (Global Initiative for Chronic Obstructive Lung Disease [GOLD] 2010).

Once hypercapnia develops, 2-year mortality is approximately 30-40% (Foucher et al. 1998). The reported studies show some physiological benefits for the use of NPPV in stable COPD, but clear survival benefit has not yet been demonstrated (Leger et al. 1994; Jones et al. 1998; Tuggey, Plant, & Elliott 2003). All of these and most other studies used a moderately aggressive ventilation to treat stable hypercapnic COPD patients and so an impressive reduction in hypercapnia was not achieved. In contrast, more aggressive form of ventilation with mean IPAP of up to 30 cmH20 or even higher was used in recent studies by Windish et al. and a remarkable reduction of PC02 was achieved (Windisch et al. 2002; Windisch et al. 2005; Windisch et al. 2006). Another RCT also has shown an improvement in survival with the application of nocturnal NPPV in end stage chronic hypercapnic COPD. The authors reported that the use of higher IPAP levels sufficient to be cardioprotective (but not to awake central respiratory drive) may result in greater treatment benefits (McEvoy et al. 2009). High intensity NPPV therefore offers a new and promising therapeutic option in the treatment of patients with CRF. High intensity NPPV is better tolerated in patients with severe chronic hypecapnic COPD and has been shown to be superior to the conventional and widely used form of low intensity NPPV in controlling nocturnal hypoventilation (Dreher et al. 2010). Nevertheless, higher leak volume, side effects and impairments in sleep quality are the main disadvantages of this modality.

NPPV might rest the chronically fatigued muscles and increase the muscle strength during daytime, could improve sleep time and efficiency, and sleep disordered breathing with episodes of hypoventilation. NPPV use in a select proportion of patients with severe stable COPD can improve gas exchange, exercise tolerance, dyspnea, work of breathing, frequency of hospitalisation, health-related quality of life and functional status (Kolodziej et al. 2007). Inconsistency in the effectiveness of all assessed outcomes may be due to the variability in degree of lung hyperinflation and NPPV levels and duration of use. As yet, no study has

provided convincing evidence that survival in COPD is prolonged by NPPV. Further work is also required to evaluate the effect of NPPV on reducing frequency and severity of COPD exacerbation. The general consensus, however, is that there is insufficient evidence to recommend NPPV for routine use in stable hypercapnic COPD (Kolodziej et al. 2007; Wijkstra et al. 2003). Despite the insufficient evidence, the ACCP consensus group opined that a trial of NPPV was justified with a symptomatic but stable and optimally treated patient who has daytime PaCO2 > 55 mm Hg, if OSA had been excluded. For PaCO2 between 50 and 54 mm Hg, , the ACCP consensus group suggested that there should be evidence of worsening hypoventilation during sleep, as suggested by a sustained (> 5 min) desaturation during use of the usual oxygen supplementation. In addition, the need for repeated hospitalizations was deemed a justification for a trial of NPPV (ACCP consensus conference 1999).

The other limitation of NPPV use in patients with stable hypercapnic COPD is poor compliance to NPPV in this group of patients. Criner et al., found that only 50% of COPD patients were still using NPPV after 6 months, compared to 80% for neuromuscular patients (Criner et al. 1999). Reasons for poor adherence are unclear, but probably include the advanced age of COPD patients, frequent occurrence of co morbidities and cognitive defects, lack of motivation and appropriate/inefficient setting of NPPV. Close follow-up is probably helpful to optimize compliance rates.

3.9 Sleep related hypoventilation/Hypoxemia due to COPD

The latest edition of The International Classification of Sleep Disorders: Diagnostic and Coding Manual (ICSD-2) subsumes a broad range of disorders under the heading ''Sleep Related Hypoventilation/hypoxemic Syndromes.'' (American Academy of Sleep Medicine. 2005). Some are quite common, such as COPD with worsening gas exchange during sleep; while some are exceedingly rare, such as congenital central hypoventilation syndrome. The ICSD-2 manual recommended the use of NPPV in addition to optimal treatment of the underlying disorder in selected subgroups of the patients (Casey, Cantillo, & Brown 2007).

In normal subjects, minute ventilation changes little, whereas minute ventilation in COPD patients falls approximately 16% from wakefulness to non REM sleep and almost 32% during REM sleep, compared to wakefulness, largely as a result of decreased tidal volumes. The greater drop in minute ventilation in subjects with COPD may reflect increased dependence on accessory muscles that become hypotonic during sleep, particularly in REM sleep leading to Sleep Related Hypoventilation/hypoxemic Syndrome due to COPD.

NPPV devices are used during sleep to treat patients with Sleep Related Hypoventilation/ hypoxemic syndromes. Compelling evidence exists to support the use of NPPV during sleep in the management of selected Sleep Related Hypoventilation/ hypoxemic syndromes. NPPV has been used in Sleep Related Hypoventilation/ hypoxemic due to central respiratory control disturbances, restrictive thoracic cage disorders, neuromuscular diseases and the obesity hypoventilation syndrome. A select subgroup of COPD patients also appears to have improved sleep after treatment with NPPV but specific characteristics that describe this subgroup well remain to be elucidated. It is unclear whether exclusively nocturnal hypoxemia in these patients will be deleterious and therefore whether isolated sleep-related hypoxemia should be treated. COPD patients with clear evidence of hypoventilation while awake as evidenced by daytime hypercapnia are a reasonable starting target group. Those COPD

patients who also show continued sleep disruption or worsening hypercapnia and nocturnal hypoventilation despite oxygen therapy should be further investigated probably with polysomnography to rule out other sleep related breathing disorders. Finally we need to define optimal NPPV and interface design and settings in hopes of improving compliance of long-term therapy for all types of appropriate patients, who are likely to benefit from NPPV.

3.10 Adjunct to exercise training in pulmonary rehabilitation programs

Another potential application of NPPV in patients with severe stable COPD is to enhance exercise training during rehabilitation. It has been shown that when delivered during cycle ergometry, CPAP, pressure-support ventilation, and proportional-assist ventilation all reduce inspiratory effort and dyspnea in hypercapnic COPD patients (Petrof, Calderini, & Gottfried 1990; Bianchi et al. 1998). Recent studies in patients with severe COPD in a 6-week exercise training program has reported that, NPPV alone was more effective than supplemental oxygen alone as adjunct to physical exercise in improving submaximal exercise tolerance and health related quality of life (HRQOL) (Borghi-Silva et al. 2010). These studies demonstrated that NPPV can be used to increase or prolong the intensity of exercise training sessions in patients with severe COPD.

4. Where to administer NPPV?

Any patient on NPPV is classified as receiving Critical Care Level 2 care, defined as ''Patients requiring more detailed observation or intervention including support for a single failed organ system''. This suggest NPPV should be administered in an intensive care unit (ICU) or high dependency unit (HDU) setting, but it has been widely recognised that NPPV can be successfully used outside the ICU and HDU with dedicated NPPV team able to provide 24/7 care. This is however only feasible in large units with many trained staff (Manuel, Russell, & Jones. 2010). NPPV is more frequently used outside the ICU, in HDU, respiratory wards and emergency departments (EDs) (Brochard, Mancebo, & Elliott 2002; Hill 2004). It has been suggested that each hospital should have a specific designed area with experienced staff, where patients requiring NPPV can be transferred with the minimum delay (British Thoracic Society Standards of Care Committee 2002).

5. Selection of optimal ventilator and mode of NPPV

NPPV is broadly classified into volume preset and pressure preset devices, early studies of long-term domiciliary NPPV mainly concern patients on volume preset ventilators, whereas in the last 5-10 years pressure preset machines, particularly bilevel pressure support equipment has become more prominent.

Volume preset machines gives the adjusted tidal volume regardless of mechanics of respiratory system (i.e. compliance, resistance and active inspiration) and if there is a leak from mask or mouth, patient cannot deliver the adjusted tidal volume.

On the contrary **pressure preset** machines gives the adjusted pressure according to respiratory system mechanics by changing the flow and compensates the mask leaks. However pressure preset machines may not to be sufficient in patients who need high inspiratory pressure. Pressure support ventilators on a first line basis, especially with pressure support mode, is easier to adjust and to synchronise with the patient. CPAP and BPAP are the pressure support

ventilators. CPAP as the name implies, requires the airway pressure not to change between inspiration and expiration. However BPAP therapy was originally conceived with the idea of varying the administered pressure between the inspiratory and expiratory cycles. BPAP is the commonly used pressure preset method. BPAP devices deliver separately adjustable inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP). The IPAP and EPAP levels are adjusted to maintain upper airway patency, and the pressure support (PS=IPAP-EPAP), which augments ventilation.

Three modes of NPPV were also defined according to principles of cycling of inspiration. NPPV devices can be used in the 1) **spontaneous mode** (the patient cycles the device from EPAP to IPAP), 2) the **spontaneous timed (ST)**/assisted-controlled (AC) mode (a backup rate is available to deliver IPAP for the set inspiratory time if the patient does not trigger an IPAP/EPAP cycle within a set time window otherwise patient the device from EPAP to IPAP), 3) the **timed (T)** /pressure controlled (PC) mode (patient cannot trigger and cycle the inspiration- inspiratory time and respiratory rate are fixed).

Volume assured pressure support / volume target BPAP (VT-BPAP) which is a hybrid mode of volume preset and pressure support ventilation was available by the end of the 1990s. Release of dual portable ventilators providing either pressure support ventilation or volume preset ventilation opened the way for new potent turbine pressure support ventilators able to deliver real volume ventilation with the average volume assured pressure support ventilation mode which represents a flexible way for managing the most difficult patients (Storre et al. 2006). Patient delivers the target tidal volume by the support of adjusted pressure support range. VT-BPAP has been developed in which the IPAP-EPAP difference is automatically adjusted to deliver a target tidal volume (Storre et al. 2006; Ambrogio et al. 2009; Janssens, Metzger, & Sforza 2009; Jaye et al. 2009)

Proportional Assist Ventilation is another mode still under investigation. It provides a level of ventilatory assistance which is proportional to the patient's respiratory effort throughout the respiratory cycle. Some studies reported better comfort and tolerance with proportional assist ventilation but found no differences in rates of mortality or intubation (Fernandez-Vivas et al. 2003; Gay, Hess, & Hill 2001). Guidelines make no recommendation about the use of proportional assist ventilation versus pressure support ventilation in patients who are receiving NPPV for ARF, due to lack of sufficient evidence.

6. Selection of interface

Interfaces connect the patient's airway to the NPPV tubing. The main six interfaces for NPPV are nasal mask, full face or oronasal mask, total face mask, helmet mask, nasal pillow or plugs and mouthpieces. Usually made of silicone, masks need to be carefully fitted to the individual to obtain optimum results. Variations include the bubble-type mask, and gel masks. Mask fit can be enhanced using mask cushions and seal/support rings which are supplied with the mask.

Nasal mask: Nasal mask covers nose and does not cover mouth so allows speaking, drinking and cough also reduces the risk of vomiting and asphyxia. Disadvantages of nasal masks are air leaks if mouth opens, possible nasal skin damage and the need for patent nasal passages.

Oronasal /Full face mask: Oronasal mask cover the nose and mouth and can prove valuable in patients with nasal airway blockage or acute confusional state. Oronasal mask is

recommended rather than nasal mask in patients who have ARF. Although there was no difference in endotracheal intubation or mortality rates, the oronasal mask was better tolerated (Keenan et al. 2011). The use of an oronasal mask seem a logical solution to maximize the NPPV efficacy, presumably due to lower leakage with oronasal mask compared to nasal mask in dyspneic patients who are mostly mouth-breathers (Carrey, Gottfried, & Levy 1990). However during long-term use the face mask can be poorly tolerated, thus causing a premature NPPV interruption (Carlucci et al. 2001).

Total face mask: Total face mask covers mouth, nose and eyes. Advantages of this type of masks are minor air leaks, little cooperation required and easy fitting application. Risks of asphyxia, claustrophobia, speaking difficulty are the main disadvantages.

Helmet: Helmet mask covers whole head and all or part of the neck without a contact with face. Advantages of this type of masks are minor air leaks, little cooperation required and absence of nasal or facial skin damage. The risk of vomiting, worsening of C02 clearance due to rebreathing, asynchrony with pressure support ventilation and discomfort of axillae are the disadvantages of the helmet.

Nasal pillow or plugs: These masks are inserted into the nostrils. This type of the mask may be suitable for claustrophobic patients with chronic stable COPD who do not need high pressures. Nasal irritation is the main disadvantage.

Mouthpieces: They are placed between lips and held in place by lip seal. Mouthpieces can be applied with other interfaces. The risk of vomiting and salivation, possible air leaks, gastric distension and speaking difficulty are the disadvantages of the mouthpieces. Mouthpiece ventilation is mainly used in patients with neuromuscular disease.

7. Application, setting and adjustments of NPPV

The first hours of NPPV are associated with an increased workload for health care personnel that requires a specific management protocol, including monitoring mask ventilation and monitoring the patient (Nava and Hill 2009). Recommended application, setting and adjustments of NPPV in the ICU, HDU, respiratory wards and emergency departments (EDs) are summarised as in the following:

1. Explain technique to patient (if competent).
2. Choose correct interfaces and size.
3. Set pressure starting from low levels (minimum starting IPAP and EPAP should be 8 cm H_20 and 4 cm H_20, respectively).
4. Place mask gently over face, holding it in place and start ventilation.
5. When patient is tolerant, tighten straps just enough to avoid major leaks, but not keep it too tight.
6. Set Fi02 on ventilator or add low-flow oxygen into the circuit, aiming for S02>90%.
7. Set alarms-low pressure alarm should be above PEEP level.
8. Be mindful of and try to optimise patient's comfort.
9. Reset pressures (pressure support increased to obtain inspired tidal volume 6mL/kg or higher, achieving a respiratory rate <25 breaths/min, PaC02 <45 mmHg and also raise EPAP to obtain S02 of 90% or higher). The recommended maximum IPAP should be 30 cm H_20 for patients ≥ 12 years. The recommended minimum and maximum levels of PS

are 4 cm H_20 and 20 cm H_20, respectively. PS should be increased in order to optimize CO2 removal and control of auto-positive end expiratory pressure (PEEP), according to the patient's tolerance. A backup rate (ST mode) should be used in all patients with low respiratory rate, in patients who unreliably trigger IPAP/EPAP cycle due to muscle weakness and in patients who do not achieve adequate ventilation or respiratory muscle rest with the maximum tolerated PS in the spontaneous mode. The inspiratory duration should be as short as possible.

10. Protect site of skin pressure from the interface.
11. Consider use of mild sedation if the patient is agitated.
12. Monitor comfort, respiratory rate, oxygen saturation and dyspnea every 30 minute for 6-12 hours and then hourly.
13. Measure arterial blood gases at baseline and within 1 hour from the start.
14. Humidification is advised for longer application.

Predictors of NPPV failure are no improvement or a fall in pH and PC02, no change or a rise in breathing frequency after 1-2 hours and lack of cooperation. Delays in intubation of these patients run the risk of unanticipated respiratory or cardiac arrest with attended morbidity and mortality. NPPV failure occurs more frequently in the first hours of ventilation, and was reported to be predicted by the following clinical factors: severe acidosis, high severity score, severe impairment of consciousness, presence of co-morbidities and lack of improvement of arterial blood gases after 1-2 hours of initial ventilation (Ambrosino et al. 1995; Elliott 2002; Nava & Ceriana 2004)

8. Complications of NPPV

Complications of NPPV therapy are minor and preventable. Major complications of NPPV such as pneumothorax and pneumocephalus are so rare (Grunstein 2005). The most common complications effecting almost half of the patients who are administered NPPV are due to mask leak and/or mask pressure injury (Pepin et al. 1999; Hoffstein et al. 1992; Abisheganaden et al. 1998; Lojander, Brander, & Ammala 1999; Sanders, Gruendl, & Rogers 1986). The main complications of NPPV therapy are listed in Table 2.

Due to Mask	**Due to Device**
Facial and nasal pressure injury/ ulcerations / pain	Rhinitis, Rhinorrhea
Mask allergy	Sinusitis
Conjunctivitis	Tinnitus
Dermatitis	Otitis /ear pain
Claustrophobia	Epistaxis
General	Gastric distension
Anxiety	Dry mucous membranes and thick secretions
Insomnia	Aspiration of gastric contents
Chest pain	Barotrauma (pneumothorax, pneumocephalus)
Headache	Central Sleep Apnea
Periodic Legs Movement Syndrome	Hypotension related to positive intrathoracic pressure

Table 2. Complications of NPPV Therapy

9. Conclusion

For COPD exacerbations NPPV should now be considered as a standard of care in properly selected patients, used in preference to invasive mechanical ventilation. Available evidence and experience have indicated that NPPV has an important role in managing COPD exacerbations, markedly by reducing the need for intubation and improving outcomes, including lowering complication and mortality rates, as well as shortening the hospital stay. NPPV can also be used in certain other situations in COPD patients: in respiratory failure precipitated by a superimposed pneumonia, in postoperative respiratory failure, in intubated patients to facilitate extubation with the aim of reducing the complications of prolonged intubation, in patients with postextubation failure to avoid reintubation, and in do-not-intubate patients; although the evidence to support these applications is not as strong as for NPPV in typical COPD exacerbations. For patients with severe stable COPD, currently available evidence suggests that NPPV can improve daytime and nocturnal gas exchange, prolong sleep duration, improve quality-of-life scores, and possibly reduce the need for hospitalization. However, the findings among studies have not been consistent on these benefits, partly related to numerous methodological shortcomings in most studies performed to date. Despite the weakness of the evidence base, however, some of the consensus and guidelines agree that COPD patients with substantial daytime carbon dioxide retention and evidence of superimposed nocturnal hypoventilation are the ones most likely to benefit (ACCP consensus conference 1999). Achieving desired NPPV adherence by COPD patients will remain still a challenge. Identification of eligible patients, establishment of the appropriate settings and close monitoring of the patients with trained staff are the key points of success of NPPV therapy. Technological improvement of NPPV devices and masks besides new guidelines on the selection of patient, ventilation mode and interface may achieve better NPPV adherence in patients with COPD in the future.

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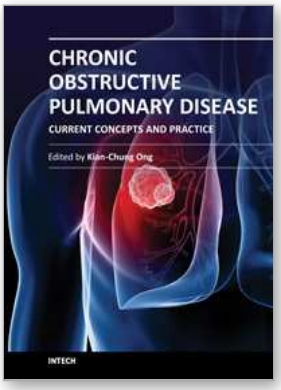

Chronic Obstructive Pulmonary Disease - Current Concepts and Practice

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A decade or so ago, many clinicians were described as having an unnecessarily 'nihilistic' view of COPD. This has certainly changed over the years... This open access book on COPD provides a platform for scientists and clinicians from around the world to present their knowledge of the disease and up-to-date scientific findings, and avails the reader to a multitude of topics: from recent discoveries in the basic sciences to state-of-the-art interventions on COPD. Management of patients with COPD challenges the whole gamut of Respiratory Medicine - necessarily pushing frontiers in pulmonary function (and exercise) testing, radiologic imaging, pharmaceuticals, chest physiotherapy, intensive care with respiratory therapy, bronchology and thoracic surgery. In addition, multi-disciplinary inputs from other specialty fields such as cardiology, neuro-psychiatry, geriatric medicine and palliative care are often necessary for the comprehensive management of COPD. The recent progress and a multi-disciplinary approach in dealing with COPD certainly bode well for the future. Nonetheless, the final goal and ultimate outcome is in improving the health status and survival of patients with COPD.

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