ERJ Express. Published on February 24, 2011 as doi: 10.1183/09031936.00192810

Unusual applications of non-invasive ventilation

Nicolino Ambrosino[1,3], Fabio Guarracino[2]

[1] Pulmonary and Respiratory Intensive Care Unit, [2] Intensive Care Unit, Cardio-Thoracic Department, University Hospital Pisa, Italy, [3] Weaning and Pulmonary Rehabilitation Unit, Auxilium Vitae, Volterra, Italy.

Correspondance:

Nicolino Ambrosino, MD

U.O. Pneumologia, Dipartimento Cardio-Toracico, Azienda Ospedaliero-Universitaria Pisana.

Via Paradisa 2, Cisanello, 56124 Pisa, Italy

Tel +39 050996786

Fax +39 050996779

e.mail n.ambrosino@ao-pisa.toscana.it

Summary.

The use of non invasive mechanical ventilation (NIV) in acute hypercapnic respiratory failure, cardiogenic pulmonary oedema, acute lung injury/acute respiratory distress syndrome (ARDS), community-acquired pneumonia, weaning/post-extubation failure is considered common in clinical practice. We review the use of NIV in unusual conditions.

Evidence supports the use of NIV during fiberoptic bronchoscopy especially with high risks of endotracheal intubation (ETI), such as in immunocompromised patients. During trans-esophageal echocardiography as well as in interventional cardiology and pulmonology, NIV can reduce the need of deep sedation or general anaesthesia and prevent respiratory depression induced by deep sedation. NIV may be useful in postsurgery including cardiac surgery, and with lower level of evidence in patients with pulmonary contusion. NIV should not be considered as an alternative to ETI in severe communicable airborne infections likely to progress to ARDS. NIV is being used increasingly as an alternative to ETI in end-stage symptomatic patients, especially to relief dyspnoea. The role of assisted ventilation during exercise training in COPD patients is still controversial.

NIV should be applied under close monitoring and ETI should be promptly available in the case of failure. A trained team, careful patient selection and optimal choice of devices, can optimise outcome of NIV.

Keywords: Endoscopy, endo-tracheal intubation, hemodynamics, cardiac surgery, palliative care, exercise, interventional cardiology, interventional pulmonology.

Non invasive mechanical ventilation (NIV) is one of the most important developments in respiratory medicine over the past 15 years [1,2] and is increasingly being used in many countries, with a highly variable frequency of use [3]. A literature research since 1966 to December 2010 (key word: Noninvasive ventilation; Source PubMed) shows 3550 (678 reviews) references. A recent study describing current mechanical ventilation practices found that, compared with 1998, in 2004 the use of NIV increased (11.1 versus 4.4%) in 349 intensive care units (ICU) in 23 countries [4]. Although continuous positive airway pressure (CPAP) is not considered as a form of ventilation since no inspiratory aid is applied, according to the International Consensus Conference 2001 [5], NIV is defined as any form of ventilatory support applied without endotracheal intubation (ETI). Strong evidence supports the use of NIV for acute respiratory failure (ARF) to prevent ETI as well as to facilitate extubation in patients with acute exacerbations of chronic obstructive pulmonary disease (COPD) and to avoid ETI in acute cardiogenic pulmonary oedema, and in immunocompromised patients. Weaker evidence supports the use of NIV for patients with ARF due to asthma exacerbations, with postoperative or postextubation ARF, pneumonia, acute lung injury (ALI), acute respiratory distress syndrome (ARDS) [1,2]. A recent survey [3] asked physicians about only four “common” case scenarios of their own clinical experience with NIV: acute hypercapnic respiratory failure, cardiogenic pulmonary oedema, ALI/ARDS/community-acquired pneumonia/post surgical (de novo respiratory failure); weaning/post-extubation failure. Nevertheless many other potential applications are undergoing investigation. This review will focus on recent developments on potential “unusual” application of NIV.

Diagnostic Maneouvres

Fiberoptic Bronchoscopy. In hypoxaemic patients to be investigated for respiratory diseases, a bronchoscopy, may be mandatory, but potentially risky. 10–15% of the normal tracheal lumen may be occupied by the bronchoscope, potentially resulting in increased work of breathing (WOB), oxygen desaturation, respiratory complications and cardiac arrhythmias [6,7]. Hypoxaemia is worsened by local anesthetics or saline solution into the lower airways and even more by performing bronchoalveolar lavage (BAL) [8]. Hypoxaemia associated cardiac arrhythmias (observed in 11–40% of patients undergoing bronchoscopy) are seldom clinically important. It has been reported that BAL performed in the ICU does not significantly increase ETI requirements in critically ill cancer patients with ARF, compared to non invasive diagnostic testing for identifying the cause of ARF in these patients [9]. Nevertheless the American Thoracic Society (ATS), recommends avoiding flexible bronchoscopy and BAL in patients with arterial oxygen tension (PaO_2) levels that cannot be corrected to at least 75 mm Hg or to an arterial oxygen saturation (SaO_2) of > 90% with supplemental oxygen [10]. In these higher-risk patients when non-invasive diagnostic tests are not conclusive, avoidance of bronchoscopy, means to be compelled to empirical treatment. As a consequence, when bronchoscopy is mandatory only ETI and mechanical ventilation can assure adequate ventilation during the maneouvre. Invasive mechanical ventilation is not risk free. Most of the complications of invasive mechanical ventilation (**Table1**) are related to the ETI, to baro- or volu-trauma and to the loss of airway defence mechanisms; some others may follow the extubation [11]. Non-invasive mechanical ventilation may avoid most of these complications, especially ventilator acquired pneumonia, ensuring at the same time a similar level of ventilatory efficacy [1,2,12].

Confirming a preliminary study [13], in a randomised controlled trial (RCT) mask CPAP reduced the risk of ARF following bronchoscopy in severe hypoxaemic patients [14]. Another RCT

[15] in hypoxaemic patients, showed that NIV increased the PaO_2 to oxygen inspiratory fraction (PaO_2/FiO_2) ratio whereas the patients randomised to conventional oxygen therapy suffered from a worsening in oxygenation during bronchoscopy. NIV –assisted bronchoscopy has also been reported to be useful in hypercapnic COPD patients with pneumonia [16]. Flexible bronchoscopy in spontaneously breathing young children was associated with significant decreases in tidal volume and respiratory flow which were reversed by CPAP [17]. In patients with acute exacerbation of COPD due to community acquired pneumonia, candidates for ETI because of hypercapnic encephalopathy and inability to clear copious secretions, NIV with early therapeutic bronchoscopy performed by an experienced team was considered as a feasible, safe and effective strategy [18].

From these observations the use of NIV during fiberoptic bronchoscopy is supported by evidence and should be considered for use, especially when risks of ETI are high, such as in immunocompromised patients. However, an expert team besides competences in endoscopy and in NIV use should be offered the availability of emergent intervention [1]. Non invasive ventilation during bronchoscopy may be performed by means of commercial or modified oro-nasal or full face masks [19]. (**Figure 1**)

Trans- Esophageal Echocardiography (TEE). In orthopnoeic cardiac patients needing TEE, NIV can reduce the need of deep sedation or general anaesthesia. We have recently reported the use of NIV-aided TEE under sedation in severely orthopnoeic patients with severe aortic valve stenosis [20]. Non invasive ventilation and continuous TEE were performed with the TEE probe passed through a modified face-mask, (**Figure. 2**) throughout percutaneous aortic valve implantation and aortic valvuloplasty procedures without technical problems or respiratory or haemodynamic complications. Non invasive ventilation allowed to perform continuous TEE examination in lightly sedated patients, so avoiding ETI and general anaesthesia.

Major Surgery

Abdominal and thoracic surgery. Major abdominal and thoracic surgery may be fatally complicated early after surgery by ARF. Anaesthesia, site of surgery (e.g. the upper abdomen surgery, approaching the diaphragm) and pain may induce atelectasis and diaphragm dysfunction. Pulmonary atelectasis after major surgery is frequent in the dependent parts of the lungs of most anesthetised patients (even more frequently in morbid obese patients) [21] and may predispose patients to pneumonia. Atelectasis is associated with reduction in lung compliance, hypoxaemia, increased pulmonary vascular resistance, and possibly lung injury potentially resulting in life threatening ARF, or at least delaying patient recovery. Maintenance of adequate oxygenation in the postoperative period is therefore mandatory [22]. Non invasive ventilation may be an important tool to prevent (*prophylactic* treatment) or to treat ARF (*curative* treatment) avoiding ETI [23,24]. The aims of NIV in postsurgery are i- to reduce the WOB; ii- to improve alveolar recruitment resulting in better gas exchange and iii- to reduce left ventricular after load increasing cardiac output and improving haemodynamics [23,24]. Evidence suggests that NIV, as a prophylactic or curative treatment, may be effective to reduce ETI rates, nosocomial infections, ICU and hospital lengths of stay, morbidity and mortality in postoperative patients [23,24]. Both mask CPAP and positive pressure ventilation (PPV) have been successfully used in the postoperative period [25,26].

Compared with standard treatment, non invasive CPAP after major abdominal or thoracoabdominal aneurysm surgery improved hypoxaemia and reduced complications such as pneumonia, atelectasis, and the need of ETI [27,28]. Non invasive ventilation substantially improved gas exchange and pulmonary function after gastrosplasty in obese patients [29] and was also effective in patients with ARF and/or massive atelectasis after liver resection [30]. A case-control study reported that NIV for the treatment of post-oesophagectomy ARF may decrease the incidence of ETI and related complications, without increasing the risk of anastomotic leakage [31]. Preventive NIV use before [32] or immediately after thoracic,[33] cardiac [34] or vascular [28] surgery may reduce atelectasis. A prospective study [35] evaluated early NIV use for ARF after lung resection during a 4-year period in the setting of a medical and a surgical ICU of a university hospital. Among 690 patients at risk of severe complications following lung resection, 16.3% experienced ARF, which was initially supported by NIV in 78.7%, including 59 patients with hypoxaemic (66.3%) and 30 with hypercapnic ARF (33.7%). The overall NIV success rate was 85.3%, in-ICU mortality was 6.7% whereas mortality rate following NIV failure was 46.1%. Predictive factors of NIV failure were age, previous cardiac comorbidities, postoperative pneumonia, admission in the surgical ICU, no initial response to NIV and occurrence of non infectious complications. Only two independent factors were significantly associated with NIV failure: cardiac comorbidities (odds ratio, 11.5; 95%) and no initial response to NIV (odds ratio, 117). Furthermore, NIV to treat early ARF after lung resection improved survival in one randomised study [36]. Current evidence shows that NIV associated with physiotherapy is safe and effective in reducing postoperative complications and in improving patient recovery, thus enhancing the choice of available medical care and improving outcome in lung resection surgery [37,38]. Although NIV has been successfully used after thoracic surgery, NIV fails in about 20% of patients. In a study aimed to assess possible risk factors for NIV failure in this condition, 20.3% of patients undergoing lung resection or pulmonary thrombo-endoarterectomy needed ICU admission and 29.6% of 135 patients undergoing NIV, needed ETI [39]. Four independent variables were associated with NIV failure during the first 48h: increased respiratory rate, increased Sequential Organ Failure Assessment (SOFA) score, number of fiberoptic bronchoscopies performed, and number of hours spent on NIV. Nosocomial pneumonia was the leading cause of respiratory complications and occurred more in patients with NIV failure. Patients in the failure group had also a higher mortality rate [39]. Non invasive ventilation can play an important role to prevent postoperative pulmonary complications also in high-risk chronic ventilators users as a consequence of a restrictive lung pathology [40]. Other studies show that NIV has a role also in ARF after solid organ transplantation (liver, lung, renal) [41,42].

Despite few studies have examined different techniques to treat or prevent complications following various surgeries, NIV should be considered among the recommended options for post-surgical patients [1].

Cardiac-Surgery. Non invasive ventilation has been used postoperatively also in cardio-surgery patients. In 96 patients undergoing coronary artery revascularization with mammary arteries [34], different modalities of NIV in the first two days after surgery were compared to the effect on lung function tests of conventional physiotherapy using incentive spirometry [38]. Patients were randomised to receive either non invasive inspiratory pressure support (IPS) or CPAP for one every three hours. A third group underwent incentive spirometry for 20 min every 2 hours. The use of CPAP and NIV was effective in decreasing the negative effect of coronary surgery on pulmonary function, as shown by significant reduction of venous admixture and improved vital capacity (VC), FEV_1 and PaO_2. In a randomised study in 150 patients after cardiac surgery [43] the non invasive application of external positive end-expiratory pressure (PEEP) 5 cm H_2O plus IPS 10 cm H_2O for 30 min was superior to CPAP 5 cm H_2O in improving pulmonary atelectasis, but did not confer any additional clinical benefit in terms of oxygenation, pulmonary function tests, or ICU length of stay. In 2009 a prospective randomised study in 500 patients [44] investigated the efficacy of prophylactic nasal 10 cm H_2O CPAP for at least 6 hours/day in preventing pulmonary complications after elective cardiac surgery in comparison with standard treatment. In the study group, CPAP improved arterial oxygenation, reduced pulmonary complications including pneumonia and reintubation rate, and reduced readmission rate to ICU or intermediate intensive care unit. More recently [45] 35% of 2261 spontaneously breathing post cardiac surgical patients after primarily successful extubation, were diagnosed with ARF. Only 7% of patients did not tolerate NIV, whereas in 93% NIV was performed. In patients with ARF, ejection fraction was lower, combined cardiac surgical procedures were more frequent, postoperative mechanical ventilation time was longer, and the severity of illness score was higher. The duration of catecholamine support was longer, and the transfusion rate was higher in the NIV group. Furthermore, mortality did not differ between patients with ARF treated by NIV and patients without ARF. Reintubation after cardiac operations should be avoided since non invasive CPAP and PPV are safe and effectively improve arterial oxygenation in the majority of patients with non hypercapnic oxygenation failure. However, it is of great importance to pay special care to sternal wound complications [46].

With negative-pressure ventilators through *"cuirass", "ponchowrap"* applicators or *"iron lung"* the chest wall is exposed to subatmospheric pressure during inspiration, resulting in airflow into the lungs through the mouth and nose. When the pressure around the chest wall returns to atmospheric, expiration occurs passively owing to the elastic recoil of the lungs and chest wall. At the present time there are five modes for delivering negative pressure ventilation: intermittent negative pressure ventilation (INPV), negative/positive pressure, continuous negative pressure (CNEP), negative pressure/CNEP, external high frequency oscillation [47]. Modalities of negative pressure ventilation have been used either alone or in addition to PPV in cardiac surgery patients. A pilot study showed that CNEP attenuates the negative effects of PPV on cardiac output of these patients [48]. Prophylactic application of CNEP immediately after extubation decreased right ventricular load and improved arterial oxygenation in 16 infants and children managed in a paediatric ICU after surgery for congenital heart defects [1, 49].

Thoracic trauma

Pulmonary parenchimal contusion is the most frequent lesion, whereas flail chest is a rare finding in multiple trauma patients [50]. Since eighties' CPAP was used to treat thoracic trauma. Nevertheless ETI and mechanical ventilation are the choice treatment of blunt chest trauma, a frequent picture in multiple trauma patients [51], prolonged mechanical ventilation being mainly associated with bilateral chest injuries, increased age, and severity of neurological damage [52].

Non invasive CPAP and bilevel positive airway pressure have been increasingly applied in clinical practice of trauma patients. With the contribution of appropriate pain management protocols, there has been a decrease in the incidence of ETI in blunt thoracic trauma [53]. In an uncontrolled study 33 trauma hypoxaemic but not hypercapnic patients were treated with CPAP via a snug-fitting face mask. All patients had demonstrated prolonged hypoxaemia despite supplemental oxygen before CPAP. The therapeutic goal of PaO_2/FIO_2 ratio greater than 300 was achieved in 32 of 33 patients. Only 2 patients (6%) required ETI, but neither for hypercapnia [54].

In another study NIV was evaluated in the treatment of multiple rib fractures [55] in 69 patients randomly allocated to one of the following two treatments: (1) a CPAP mask combined with regional analgesia; or (2) ETI and mechanical ventilation with PEEP. Clinical outcome was as follows: the mean duration of treatment, ICU and hospital length of stay, and complications were lower for the group with CPAP. Infections caused the difference in complications, primarily pneumonias, which occurred in 14% of the group with CPAP but in 48% of the ETI group [55].

On the basis of non randomised studies [56,57] guidelines for NIV recommend (although with low level of evidence) CPAP in patients with thoracic trauma who remain hypoxic despite regional anaesthesia [2,58]. More recently in a single-center RCT patients with PaO_2/FiO_2 ratio <200 for longer than 8 hours under high-flow oxygen within the first 48 hours after thoracic trauma, were randomised to remain on high-flow oxygen mask or to receive NIV. The interface was selected on the basis of the associated injuries. Thoracic anaesthesia was universally supplied unless contraindicated. After 25 patients were enrolled in each group, the trial was prematurely stopped for efficacy because the ETI rate was much higher in controls than in NIV patients. Non invasive ventilation was considered as the only variable independently related to ETI. Furthermore hospital length of stay was shorter in NIV patients [59]. Although with low level of evidence these studies indicate that NIV may represent a valuable alternative to ETI in patients with pulmonary contusion [60].

<u>Minimally invasive interventional techniques</u>

Interventional Cardiology. Recent advances in interventional techniques have made it possible to offer minimally invasive treatment of aortic valve stenosis to elderly patients who cannot undergo standard surgical treatment due to a compromised overall health status or severe comorbidities, as pulmonary disease. In this condition orthopnoea prevents a prolonged supine position. We have recently reported our initial experience with NIV in interventional cardiology [61] to support patients with severe pulmonary disease, undergoing percutaneous implantation of an aortic bioprothesis for severe valve stenosis. Non invasive ventilation was delivered in IPS + PEEP modality under conscious sedation through an adult oro-nasal mask. **(Figure 2)** Non invasive ventilation is started in the sitting position and maintained for 10 min to allow the patient to adapt to both the mask and the ventilatory modality. Thereafter, the patient is placed in the supine position under NIV, which is performed throughout the procedure and continued in the ICU. In our experience NIV allowed to avoid general anaesthesia, to alleviate orthopnoea and to prevent ARF [61].

Interventional Pulmonology. Vitacca et al. [62] found that INPV by a poncho-wrap may be useful in reducing apnoeas during laser therapy under general anaesthesia, thus reducing hypercapnia, related acidosis and need for oxygen supplementation and related hazard of combustion. In a following study [63], as compared to spontaneous ventilation, INPV in paralysed patients during interventional rigid bronchoscopy reduced administration of opioids, shortened recovery time, prevented respiratory acidosis, excluded the need for manually assisted ventilation, reduced oxygen need and afforded optimal surgical conditions [63,64].

Video-assisted thoracoscopic surgery (VATS) is a minimally invasive technique allowing for intrathoracic surgery without formal thoracotomy and its accompanying complications [65]. This technique requires the exclusion of a lung from ventilation. In order to support one-lung spontaneous ventilation in a high-risk patient, we successfully used facemask IPS [66] associated to regional anesthesia. Although these patients pose substantial challenges to the anaesthetist, based on this preliminary experience, we think that critically ill patients scheduled for palliative surgery can be successfully managed with the combination of minimally invasive surgical techniques, neuraxial block and NIV.Our unpublished experience combined with evidence from published case reports of the combination of NIV and regional anaesthesia techniques [67–71] suggests that even critically ill patients may successfully undergo major abdominal and thoracic surgery in this manner.

Pandemics.

In the fifthies of the last century the INPV by iron lung increased the survival during the polio epidemic [72] nevertheless, during the following decades INPV played only a minor role. Use of NIV for severe acute respiratory syndrome (SARS) and other airborne diseases leading to ARF has been debated. Indeed there is concerning whether NIV be considered a high-risk procedure in infectious diseases like TB or recent pandemics [73]. On the basis of a previous experience [74] with SARS, in which some caregivers were contaminated when a patient underwent ETI after NIV failure, use of this technique was discouraged for patients with this disease. A study observed a greater risk of developing SARS for physicians and nurses performing ETI (relative risk [RR], 13.29) and NIV (RR, 2.33 : that is lower than for ETI), whereas nurses caring for patients receiving high-frequency oscillatory ventilation did not appear at an increased risk (RR, 0.74) compared with their respective reference cohorts [75]. However, subsequent studies [76-78] from China reported no evidence of viral spread to caregivers under appropriate precautions.

During the more recent H1N1 influenza pandemic, although adverse effects were not reported [79,80] NIV success rate was highly variable [81,82]. A document endorsed by the European Respiratory Society (ERS) and the European Society of Intensive Care Medicine (ESICM) stated that NIV should not be considered as an alternative to ETI in ARF secondary to H1N1 infection that is likely to progress to ARDS [82]. According to this document NIV might be considered to prevent further deterioration and need for ETI in patients with mild to moderate hypercapnic or hypoxaemic ARF, and/or distress due to cardiogenic pulmonary oedema, **in the absence** of pneumonia, multiple organ failure, and refractory hypoxaemia. It can be also used to prevent post-extubation respiratory failure in patients with resolving ARDS secondary to H1N1 infection, preferentially when the patient is no longer contaminated [83].

Indeed some clinicians consider this technique contra indicated in ARF due to communicable respiratory airborne diseases unless used inside a negative-pressure isolation room with strict precautions. Recent reports have demonstrated that the use of different facial masks for NIV may be associated with a substantial exposure to exhaled air which occurs within a one meter region, from patients, with differences according to the type of mask, and enhanced with increased leakage from face masks, and with higher inspiratory pressures [84,85]. Another study showed that NIV and chest physiotherapy are droplet-generating procedures, producing droplets of > 10 µm in size. Due to their large mass, most fall out on to local surfaces within 1 m. These findings confirm that health-care workers providing NIV and chest physiotherapy, working within 1 m of an infected patient should have a higher level of respiratory protection, but that infection control measures designed to limit aerosol spread may have less relevance for these procedures

[86]. World Health Organization has included NIV among aerosol-generating procedures in which the risk of pathogen transmission is possible [87]. However, as the procedure of ETI processes a higher risk of disease transmission and associated complications, the use of NIV as initial ventilator support for ARF in the presence of highly transmissible diseases is a reasonable option under strict infection-control measures.

Technical issues should be considered in cases of ARF induced by contagious infectious diseases. Ventilators equipped with a double-line circuit without an expiratory port (i.e. whisper, plateau exhalation valve, anti-rebreathing valve etc) should be preferred. This choice avoids the dispersion of expiratory air containing infected particle through the intentional leaks of a single-line circuit. Full-face or total-face mask should be preferred to nasal mask in order to prevent the potential spreading of the contaminated exhaled air particles though the non-intentional mouth air leaks. Under this perspective, the choice of the brand and of the size that best fit the anatomy of the patient's face profile together with the delivery of adequate levels of pressures is crucial to minimise non-intentional air leaks around the interface. Healthcare workers should be aware of the potential risks of caring for contagious patients during NIV application, and should take appropriate contact and droplet precaution. Specifically, clinicians should care special attention during the phases of disconnection of the patient from the NIV: it's advisable to quickly switch the ventilators off as soon as the circuit is taken away from the mask to prevent the dispersion of the all expiratory flow nearby the healthcare workers. In general, prudent isolation of the patient coupled to protective measures for care providers and other patients are the keys to limit disease transmission **(Table 2)** [83].

Palliative and end of life care

As reported in a recent survey, using a specifically designed questionnaire on the families' attitudes regarding end-of-life care in the last 3 months of life of patients on home mechanical ventilation, the majority of patients complained respiratory symptoms [88]. Symptom burden and palliative care needs of breathless patients with severe COPD are considerable and as high as among patients with advanced primary and secondary lung cancer although patients with COPD have a longer survival [89]. The goal of palliative care is to prevent and relieve suffering and to support the best possible quality of life for patients and their families, regardless of the stage of disease or the need for other therapies. Using these definitions, palliative care includes end-of-life care, but is broader and also includes care focused on improving quality of life and minimising symptoms like dyspnoea [90]. Patients with COPD are at risk for ARF and recent advances in NIV use raise questions about the use of this technology in the palliative care setting [90,91]. Despite some previous guidelines did not mention [92] NIV is being used increasingly as an alternative to ETI in end-stage symptomatic patients, especially to relief dyspnoea [93-97]. Therefore more recent guidelines have incorporated such notion with limitation that "As relief of dyspnoea with NIV may not relate to changes in arterial blood gases, it is appropriate to reassess the breathlessness experienced by patients receiving such ventilatory support at frequent intervals" [98]. A recent European survey in respiratory intermediate care units has shown that NIV was used as the ceiling of ventilatory care in almost a third of the patients [99]. A self administered, postal survey of all practicing intensivists, pulmonologists, and respiratory therapists at 20 North American centers between 2003 and 2005 showed that for patients with do-not-intubate (DNI) orders, many physicians used NIV, and many respiratory therapists were asked to initiate NIV, most often to treat COPD and cardiogenic pulmonary oedema [100]. Observational as well as clinical trials have recently underlined and confirmed [101-103] the role of NIV as an effective alternative to ETI in those patients with chronic disease and poor life expectancy (with or without COPD) showing that this ventilatory technique may favourably reduce dyspnoea shortly after initiation even without an associated episode of hypercapnic ARF. It was demonstrated that about half of the patients survived the episode of respiratory distress and were discharged from the hospital.

The Society of Critical Care Medicine has recently charged a Task Force with developing an approach for considering NIV use for patients who choose to forego ETI. The use of NIV for patients with ARF could be classified into three categories: 1) NIV as life support with no preset limitations on life-sustaining treatments, 2) NIV as life support when patients and families have decided to forego ETI, and 3) NIV as a palliative measure when patients and families have chosen to forego all life support, receiving comfort measures only. The Task Force suggested an approach to use NIV for patients and families who choose to forego ETI. NIV should be applied after careful discussion of the goals of care, with explicit parameters for success and failure, by experienced personnel, and in appropriate healthcare settings [1,104,105].

The use of NIV in these extreme circumstances should keep into account ethical, legal and religious issues. A Spanish study concluded that the use of NIV offers very low expectations in medium-term survival in DNI patients. The main reason may be that, in a country with little experience in advanced directives, the DNI statement coincides with the final stages of disease progression [106].

Rehabilitation

In the most compromised COPD patients extreme breathlessness and muscle fatigue limit training at the highest levels of exercise intensity prescribed in pulmonary rehabilitation programs. Increased WOB also contributes to dyspnoea and exercise limitation [107]. In COPD patients NIV during exercise, reduces dyspnoea and increases exercise tolerance [108,109], without relevant hemodynamic effects [110]. Inspiratory support provides symptomatic benefit by unloading the ventilatory muscles [111] and CPAP counterbalances the intrinsic PEEP [112,113]. Nevertheless, the role of assisted ventilation during exercise training in COPD patients is still controversial [114-118]. More evidence is required to better define the role of ventilatory support in routine training sessions in COPD [119]. Furthermore it has been reported that in chronic hypercapnic COPD under long term ventilatory support, NIV can also be administered during walking, resulting in improved oxygenation, decreased dyspnoea and increased walking distance. Therefore NIV during walking could prevent hypoxia-induced complications [120,121]. Nocturnal NIV has been suggested as an addition to diurnal pulmonary rehabilitation in COPD patients [122,123]. Non invasive ventilation has been used as an aid to exercise also in patients with restrictive ventilatory pattern [124,125].

In **conclusion** although NIV is a consolidated therapeutical tool in several respiratory conditions [1,2], its potential usefulness is far from being completely elucidated. More RCT are needed to confirm the promising results in the reviewed “unusual” and other conditions.

References.

1. Ambrosino N, Vagheggini G. Noninvasive positive pressure ventilation in the acute care setting: where are we?. Eur Respir J 2008; 31: 874-886.
2. Nava S, Hill N. Non-invasive ventilation in acute respiratory failure. Lancet 2009; 374: 250-259.
3. Crimi C, Noto A, Princi P, Esquinas A, Nava S. A European survey of noninvasive ventilation practices. Eur Respir J 2010; 36: 362-369.
4. Esteban A, Ferguson ND, Meade MO, Frutos-Vivar F, Apezteguia C, Brochard L, Raymondos K, Nin N, Hurtado J, Tomicic V, et al. Evolution of mechanical ventilation in response to clinical research. Am J Respir Crit Care Med 2008; 177: 170–177.
5. International Consensus Conference in Intensive Care Medicine: non-invasive positive pressure ventilation in acute respiratory failure. Am J Respir Crit Care Med 2001; 163: 283-291.
6. Murgu SD, Pecson J, Colt HG. Bronchoscopy during noninvasive ventilation: Indications and technique. Respir Care 2010; 55: 595– 600.
7. Payne CB Jr, Goyal PC, Gupta SC. Effects of transoral and transnasal fiberoptic bronchoscopy on oxygenation and cardiac rhythm. Endoscopy 1986; 18: 1-3.
8. Katz AS, Michelson EL, Stawicki J, Holford FD. Cardiac arrhythmias, frequency during fiberoptic bronchoscopy and correlation with hypoxemia. Arch Intern Med 1981; 141: 603-606.
9. Azoulay E, Mokart D, Lambert J, Lemiale V, Rabbat A, Kouatchet A, Vincent F, Gruson D, Bruneel F, Epinette-Branche G, et al. Diagnostic strategy for hematology and oncology patients with acute respiratory failure: randomized controlled trial. Am J Respir Crit Care Med. 2010; 182: 1038-1046.

10. Goldstein RA, Rohatgi PK, Bergofsky EH, Block ER, Daniele RP, Dantzker DR, Davis GS, Hunninghake GW, King TE Jr, Metzger WJ, et al. Clinical role of bronchoalveolar lavage in adults with pulmonary disease. Am Rev Respir Dis 1990; 142: 481-486.

11. Epstein SK. Complications associated with mechanical ventilation. In: Tobin MJ (ed): Principles & practice of mechanical ventilation. 2nd Edn. 2006. McGraw-Hill, New York; pp. 877-902.

12. Girou E, Schortgen F, Delclaux C, Brun-Buisson C, Blot F, Lefort Y, Lemaire F, Brochard L. Association of noninvasive ventilation with nosocomial infections and survival in critically ill patients. JAMA 2000; 284: 2361-2367.

13. Antonelli M, Conti G, Riccioni L, Meduri GU. Noninvasive positive-pressure ventilation via face mask during bronchoscopy with BAL in high-risk hypoxemic patients. Chest 1996; 110: 724-728.

14. Maitre B, Jaber S, Maggiore SM, Bergot E, Richard JC, Bakthiari H, Housset B, Boussignac G, Brochard L. Continuous positive airway pressure during fiberoptic bronchoscopy in hypoxaemic patients. A randomized double-blind study using a new device. Am J Respir Crit Care Med 2000; 162:1063–1067.

15. Antonelli M, Conti G, Rocco M, Arcangeli A, Cavaliere F, Proietti R, Meduri GU. Noninvasive positive-pressure ventilation vs. conventional oxygen supplementation in hypoxemic patients undergoing diagnostic bronchoscopy. Chest 2002; 121:1149–1154.

16. Da Conceicao M, Genco G, Favier JC, Bidallier I, Pitti R. Fiberoptic bronchoscopy during non-invasive positive-pressure ventilation in patients with chronic obstructive lung disease with hypoxemia and hypercapnea. Ann Fr Anesth Reanim 2000; 19: 231–236.

17. Trachsel D, Erb TO, Frei FJ, Hammer J, on behalf of the Swiss Paediatric Respiratory Research Group. Use of continuous positive airway pressure during flexible bronchoscopy in young children. Eur Respir J 2005; 26: 773–777.

18. Scala R, Naldi M, Maccari U. Early fiberoptic bronchoscopy during non-invasive ventilation in patients with decompensated chronic obstructive pulmonary disease due to community-acquired-pneumonia. Critical Care 2010, 14: R80.

19. Heunks LMA, Charlotte, de Bruin CJR, van der Hoeven JG, van der Heijden HFM. Non-invasive mechanical ventilation for diagnostic bronchoscopy using a new face mask: an observational feasibility study. Intensive Care Med 2010; 36:143–147.

20. Guarracino F, Cabrini L, Baldassarri R, Cariello C, Covello RD, Landoni G, Petronio S, Ambrosino N. Non-invasive ventilation aided transoesophageal echocardiography in high risk patients: a pilot study. Eur J Echocard 2010; 11: 554-556.

21. Eichenberger AS, Proietti S, Wicky S, Frascarolo P, Suter M, Spahn DR, Magnusson L. Morbid obesity and postoperative pulmonary atelectasis: an underestimated problem. Anesth Analg 2002; 95: 1788 –1792.

22. Duggan M, Kavanagh BP. Pulmonary atelectasis a pathogenic perioperative entity. Anesthesiology 2005; 102: 838–854.

23. Jaber S, Michelet P, Chanques G. Role of non-invasive ventilation (NIV) in the perioperative period. Best Pract Res Clin Anaesthesiol. 2010; 24: 253-265.

24. Jaber S, Chanques G, Jung B. Postoperative noninvasive ventilation. Anesthesiology 2010; 112:453– 461.

25. Jaber S, Delay JM, Chanques G, Sebbane M, Souche EJB, Perrigault PF, Eledjam JJ. Outcomes of patients with acute respiratory failure after abdominal surgery treated with noninvasive positive pressure ventilation. Chest 2005; 128: 2688-2695.

26. Ferreyra GP, Baussano I, Squadrone V, Richiardi L, Marchiaro G, Del Sorbo L, Mascia L, Merletti F, Ranieri VM. Continuous positive airway pressure for treatment of respiratory complications after abdominal surgery: A systematic review and meta-analysis. Ann Surg 2008; 247:617–626.

27. Squadrone V, Coha M, Cerutti E, Schellino MM, Biolino P, Occella P, Belloni G, Vilianis G, Fiore G, Cavallo F, Ranieri VM. Continuous positive airway pressure for treatment of postoperative hypoxemia. JAMA 2005; 293: 589–595.

28. Kindgen-Milles D, Muller E, Buhl R, Bohner H, Ritter D, Sandmann W, Tarnow J. Nasal continuous positive airway pressure reduces pulmonary morbidity and length of stay following thoracoabdominal aortic surgery. Chest 2005; 128: 821–828.

29. Joris JL, Sottiaux TM, Chiche JD, Desaive CJ, Lamy ML. Effect of bi-level positive airway pressure nasal ventilation on the postoperative pulmonary restrictive syndrome in obese patients undergoing gastroplasty. Chest 1997; 111**:** 665–670.

30. Narita M, Tanizawa K, Chin K, Ikai I, Handa T, Oga T, Niimi A, Tsuboi T, Mishima M, Uemoto S, Hatano E. Noninvasive ventilation improves the outcome of pulmonary complications after liver resection. Intern Med 2010; 49: 1501-1507.

31. Michelet P, D'Journo XB, Seinaye F, Forel JM, Papazian L, Thomas P. Non-invasive ventilation for treatment of postoperative respiratory failure after oesophagectomy. Br J Surg 2009; 96:54-60.

32. Perrin C, Jullien V, Venissac N, Berthier F, Padovani B, Guillot F, Coussement A, Mouroux J. Prophylactic use of noninvasive ventilation in patients undergoing lung resectional surgery. Respir Med 2007; 101**:** 1572–1578.

33. Aguilo R, Togores B, Pons S, Rubí M, Barbé F, Agustí AG. Noninvasive ventilatory support after lung resectional surgery. Chest 1997; 112**:** 117–121.

34. Matte P, Jacquet L, Van Dick M, Goenen M. Effects of conventional physiotherapy, continuous positive airway pressure and non-invasive ventilatory support with bilevel positive airway pressure after coronary artery bypass grafting. Acta Anaesthesiol Scand 2000; 44**:** 75–81.

35. Lefebvre A, Lorut C, Alifano M, Dermine H, Roche N, Gauzit R, Regnard JF, Huchon G, Rabbat A. Noninvasive ventilation for acute respiratory failure after lung resection: an observational study. Intensive Care Med 2009;35: 663-70.

36. Auriant I, Jallot A, Hervé P, Cerrina J, Le Roy Ladurie F, Fournier JL, Lescot B, Parquin F. Noninvasive ventilation reduces mortality in acute respiratory failure following lung resection. Am J Respir Crit Care Med 2001; 164: 1231-1235.

37. Freynet A, Falcoz PE. Does non-invasive ventilation associated with chest physiotherapy improve outcome after lung resection? Interact CardioVasc Thor Surg 2008; 7: 1152–1154.

38. Ambrosino N**,** Gabbrielli L**.** Physiotherapy in the peri-operative period. Best Pract Res Clin Anaesthesiol 2010 ; 24: 283–289.

39. Riviere S, Monconduit J, Zarka V, Massabie P, Boulet S, Dartevelle P, Stéphan F. Failure of noninvasive ventilation after lung surgery: a comprehensive analysis of incidence and possible risk factors. Eur J Cardiothorac Surg 2010; Sep 16. [Epub ahead of print]

40. Lumbierres M, Prats E, Farrero E, Monasterio C, Gracia T, Manresa F, Escarrabill J. Noninvasive positive pressure ventilation prevents postoperative pulmonary complications in chronic ventilators users. Respir Med 2007; 101, 62–68.

41. Antonelli M, Conti G, Bufi M, Costa MG, Lappa A, Rocco M, Gasparetto A, Meduri GU. Noninvasive ventilation for treatment of acute respiratory failure in patients undergoing solid organ transplantation: a randomized trial. JAMA 2000; 283: 235-241.

42. Feltracco P, Serra E, Barbieri S, Milevoj M, Furnari M, Rizzi S, Rea F, Marulli G, Ori C. Noninvasive Ventilation in Postoperative Care of Lung Transplant Recipients Transplant Proc 2009; 41: 1339–1344.

43. Pasquina P, Merlani P, Granier J, Ricou B. Continuous positive airway pressure *versus* noninvasive pressure support ventilation to treat atelectasis after cardiac surgery. Anesth Analg 2004; 99:1001– 1008.

44. Zarbock A, Mueller E, Netzer S, Gabriel A, Feindt P, Kindgen-Milles D. Prophylactic nasal continuous positive airway pressure following cardiac surgery protects from postoperative pulmonary complications: A prospective, randomized, controlled trial in 500 patients. Chest 2009; 135: 1252–1259.

45. Kilger E, Möhnle P, Nassau K, Beiras-Fernandez A, Lamm P, Frey L, Briegel J, Zwissler B, Weis F. Noninvasive mechanical ventilation in patients with acute respiratory failure after cardiac surgery. Heart Surg Forum 2010; 13: E91-E95.

46. Boeken U, Schurr P, Kurt M, Feindt P, Lichtenberg A. Early reintubation after cardiac operations: impact of nasal continuous positive airway pressure (nCPAP) and noninvasive positive pressure ventilation (NPPV). Thorac Cardiovasc Surg 2010; 7: 398-402.

47. Corrado A, Gorini M. Negative pressure ventilation, in Tobin MJ (ed): Principles and practice of mechanical ventilation, 2d ed. New York, McGraw-Hill, 2006, pp 403-419.

48. Chaturvedi RK, Zidulka AA, Goldberg P, deVarennes B, Iqbal S, Rahme E, Lachapelle K. Use of negative extrathoracic pressure to improve hemodynamics after cardiac surgery. Ann Thorac Surg 2008; 85: 1355-1360.

49. Shime N, Toida C, Itoi T, Hashimoto S. Continuous negative extrathoracic pressure in children after congenital heart surgery. Crit Care Resusc 2006; 8: 297-301.

50. Lucangelo U, Ferluga M. Trauma. In Elliott M, Nava S, Schonhofer B eds. Non-invasive ventilation and weaning : principles and practice. Hodder Arnold pub, London 2010, pp 454-458.

51. Cohn SM. Pulmonary contusion. J Trauma 1997; 42: 973-979.

52. Dimopoulou I, Anthi A, Lignos M, Boukouvalas E, Evangelou E, Routsi C, Mandragos K, Roussos C. Prediction of prolonged ventilatory support in blunt thoracic trauma patients. Intensive Care Med 2003;29:1101–1105.

53. Papadakos PJ, Karcz M, Lachmann B. Mechanical ventilation in trauma. Curr Opin Anaesthesiol. 2010; 23: 228-232.

54. Hurst JM, DeHaven CB, Branson RD. Use of CPAP mask as the sole mode of ventilatory support in trauma patients with mild to moderate respiratory insufficiency. J Trauma 1985; 25: 1065-1068.

55. Bolliger CT, Van Eeden SF. Treatment of multiple rib fractures. Randomized controlled trial comparing ventilatory with non ventilatory management. Chest 1990; 97:943–948.

56. Gregoretti C, Beltrame F, Lucangelo U, Burbi L, Conti G, Turello M, Gregori D. Physiologic evaluation of non-invasive pressare-support ventilation in trauma patients with acute respiratory failure. Intensive Care Med 1998; 24: 785-790.

57. Beltrame F, Lucangelo U, Gregori D, Gregoretti C. Noninvasive positive pressare ventilation in trauma patientswith acute respiratory failure. Monadi Arch Chest Dis 1999; 54: 109-114.

58. British Thoracic Society Standards of Care Committee. Non-invasive ventilation in acute respiratory failure. Thorax 2002; 57**:** 192–211.

59. Hernandez G, Fernandez R, Lopez-Reina P, Cuena R, Pedrosa A, Ortiz R, Hiradier P. Noninvasive ventilation reduces intubation in chest trauma-related hypoxemia: a randomized clinical trial. Chest 2010;137:74-80.

60. keenan SP, Mehta S. Non invasive ventilation for patients presenting with acute respiratory failure: the randomised controlled trials. Resp Care 2009; 54: 116-124.

61. Guarracino F, Cabrini L, Baldassarri R, Petronio AS, De Carlo M, Covello RD, Landoni G, Gabbrielli L, Ambrosino N. Non-invasive ventilation for awake percutaneous aortic valve implantation in high-risk respiratory patients: a preliminary study. J Cardiothorac Vasc Anesth 2010, Sep 7. [Epub ahead of print].

62. Vitacca M, Natalini G, Cavaliere S, Clini E, Candiani A, Ambrosino N. Breathing pattern and arterial blood gases during Nd-YAG laser photoresection of endobronchial lesions under general anesthesia: Use of negative pressure ventilation. A preliminary study. Chest 1997; 111: 1466–1473.

63. Natalini G, Cavaliere S, Vitacca M, Amicucci G, Ambrosino N, Candiani A. Negative pressure ventilation vs spontaneous assisted ventilation during rigid bronchoscopy. A controlled randomized trial. Acta Anaesthesiol Scand 1998; 42: 1063–1069.

64. Natalini G, Cavaliere S, Seramondi V, Foccoli P, Vitacca M, Ambrosino N, Candiani A. Negative pressure ventilation vs external high frequency oscillation during rigid bronchoscopy. A controlled randomized trial. Chest 2000; 118; 18-23.

65. Georghiou GP, Stamler A, Sharoni E, Fichman-Horn S, Berman M, Vidne BA, Saute M.. Video-assisted thoracoscopic pericardial window for diagnosis and management of pericardial effusions. Annals of Thoracic Surgery 2005; 80: 607–610.

66. Guarracino F, Gemignani R, Pratesi G, Melfi F, Ambrosino N**.** Awake palliative thoracic surgery in a high-risk patient: one-lung, non-invasive ventilation combined with epidural blockade. Anaesthesia 2008; 63: 761-763.

67. Ferrandière M, Hazouard E, Ayoub J, Laffon M, Gage J, Mercier C, Fusciardi J. Non-invasive ventilation corrects alveolar hypoventilation during spinal anesthesia. Can J Anaest 2006; 53: 404–408.

68. Iwama H. Application of nasal bi-level positive airway pressure to respiratory support during combined epidural propofol anaesthesia. J Clin Anaesthesiol 2002; 14: 24–33.

69. Duque-Gonzales P, Ferrando A, Garutti I, Pineiro P, Garcia-Sancho J, Diaz-Reganon G. Noninvasive positive pressure ventilation during surgery in a patient with exacerbated chronic obstructive pulmonary disease. Rev Esp Anesthesiol Rean 2004; 51: 290–291.

70. Warren J, Sharma SK. Ventilatory support during neuraxial blockade using bilevel positive airway pressure in a patient with severe respiratory compromise. Anesth Analg 2006; 102: 910–911.

71. Bapat PP, Anderson JA, Bapat S, Sule A. Use of continuous positive airway pressure during spinal anaesthesia in a patient with severe chronic obstructive pulmonary disease. Anaesthesia 2006; 61: 1001–1003.

72. Hodes HL. Treatment of respiratory difficulty in poliomyelitis. In poliomyelitis: papers and discussion presented at the third international poliomyelitis conference. Philadelphia 1955.

73. McCracken J. Should noninvasive ventilation be considered a high-risk procedure during an epidemic? CMAJ 2009; 181: 663-664.

74. Poutanen SM, Low DE, Henry B, Finkelstein S, Rose D, Green K, Tellier R, Draker R, Adachi D, Ayers M, et al. Identification of severe acute respiratory syndrome in Canada. N Engl J Med 2003; 348: 1195–2005.

75. Fowler RA, Guest CB, Lapinsky SE, Sibbald WJ, Louie M, Tang P, Simor AE, Stewart TE. Transmission of Severe Acute Respiratory Syndrome during intubation and mechanical ventilation. Am J Respir Crit Care Med 2004; 169: 1198–1202,

76. Cheung, TMT, Yam LYC, So LKY, Lau ACW, Poon E, Kong BMH, Yung RWH, Effectiveness of noninvasive positive pressure ventilation in the treatment of acute respiratory failure in severe acute respiratory syndrome. Chest 2004; 126: 845–850.

77. Zhao Z, Zhang F, Xu M, Huang K, Zhong W, Cai W, Yin Z, Huang S, Deng Z, Wei M, Xiong J, Hawkey PM. Description and clinical treatment of an early outbreak of severe acute respiratory syndrome (SARS) in Guangzhou, PR China. J Med Microbiol 2003; 52: 715–720.

78. Yam LYC, Chan AYF, Cheung TMT, Tsui ELH, Chan JCK, Wong VCW. Non invasive versus invasive mechanical ventilation for respiratory failure in severe acute respiratory syndrome. Chin Med J 2005;118:1413-1421.

79. Djibre´ M, Berkane, Salengro A, Ferrand E, Denis M, Chalumeau-Lemoine L, Parrot A, Mayaud C, Fartoukh M. Non-invasive management of acute respiratory distress syndrome related to Influenza A (H1N1) virus pneumonia in a pregnant woman. Intensive Care Med 2010: 36:373-374.

80. Winck JC, Marinho A. Non-invasive ventilation in acute respiratory failure related to 2009 pandemic Infl uenza A/H1N1 virus infection. Crit Care 2010, 14:408

81. Bai L, Gu L, Cao B, Zhai XL, Lu M, Lu Y, Liang LR, Zhang L, Gao ZF, Huang KW, Liu YM, Song SF, Wu L, Yin YD, Wang C. Clinical Features of Pneumonia Caused by Influenza A (H1N1) Virus in Beijing, China. Chest 2010; Sep 23. [Epub ahead of print]

82. Nin N, Soto L, Hurtado J, Lorente JA, Buroni M, Arancibia F, Ugarte S, Bagnulo H, Cardinal P, Bugedo G, Echevarría E, et al. Clinical characteristics and outcomes of patients with

2009 influenza A (H1N1) virus infection with respiratory failure requiring mechanical ventilation. J Crit Care 2010 Aug 3 [Epub ahead of print]

83. Conti G, Larrsson A, Nava S, Navalesi P. On the role of non-invasive (NIV) to treat patients during the H1N1 influenza pandemic. [http://dev.ersnet.org/uploads/Document/63/WEB_CHEMIN_5410_1258624143.pdf].

84. Hui DS, Hall SD, Chan MTV, Chow BK, Tsou JY, Joynt GM, Sullivan CE, Sung JJY. Noninvasive positive-pressure ventilation. An experimental model to assess air and particle dispersion Chest 2006; 130: 730–740.

85. Hui DS, Chow BK, Ng SS, Chu LCY, Hall SD, Gin T, Sung JJY, Chan MTV. Exhaled air dispersion distances during noninvasive ventilation via different Respironics face masks. Chest 2009;136: 998-1005.

86. Simonds AK, Hanak A, Chatwin M, Morrell M, Hall A, Parker KH, Siggers JH, Dickinson RJ. Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebuliser treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections. Health Technol Assess 2010 ; 14: 131-172.

87. World Health Organization. Infection prevention and control during health care for confirmed, probable, or suspected cases of pandemic (H1N1) 2009 virus infection and influenza like illnesses, 16 December, 2009. http://www.who.int/csr/resources/publications/cp150_2009_1612_ipc_interim_guidance_h1n1.pdf

88. Vitacca M, Grassi M, Barbano L, Galavotti G, Sturani C, Vianello A, Zanotti E, Ballerin L, Potena A, Scala R, et al. Last 3 months of life in home-ventilated patients: the family perception. Eur Respir J 2010; 35: 1064-1071

89. Bausewein C, Booth S, Gysels M, Kühnbach R, Haberland B, Higginson IJ. Understanding breathlessness: cross-sectional comparison of symptom burden and palliative care needs in chronic obstructive pulmonary disease and cancer. J Palliat Med 2010; 13: 1109-1118.
90. Curtis JR. Palliative and end-of-life care for patients with severe COPD. Eur Respir J 2008; 32: 796–803.
91. Clarke DE, Vaughan L, Raffin TA. Noninvasive positive pressure ventilation for patients with terminal respiratory failure: the ethical and economic cost of delaying the inevitable are too great. Am J Crit Care 1994; 3: 4–5.
92. Selecky PA, Eliasson CA, Hall RI, Schneider RF, Varkey B, McCaffree DR. Palliative and end-of-life care for patients with cardiopulmonary diseases: American College of Chest Physicians position statement. Chest. 2005; 128: 3599-3610.
93. Azoulay E, Alberti C, Bornstain C, Leleu G, Moreau D, Recher C, Chevret S, Le Gall JR, Brochard L, Schlemmer B. Improved survival in cancer patients requiring mechanical ventilatory support: Impact of noninvasive mechanical ventilatory support. Crit Care Med 2001; 29: 519 –525.
94. Levy M, Tanios MA, Nelson D, Short K, Senechia A, Vespia J, Hill NS. Outcomes of patients with do-not-intubate orders treated with noninvasive ventilation. Crit Care Med 2004; 32: 2002-2007.
95. Schettino G, Altobelli N, Kacmarek RM. Noninvasive positive pressure ventilation reverses acute respiratory failure in selected “do-not-intubate” patients. Crit Care Med 2005; 33:1976-1982.
96. Ambrosino N, Simonds A. The clinical management in extremely severe COPD. Respir Med 2007; 101: 1613-1624.

97. Clini EM, Ambrosino N. Nonpharmacological treatment and relief of symptoms in COPD. Eur Respir J 2008; 32: 218-228.
98. Mahler DA, Selecky PA, Harrod CG, Benditt JO, Carrieri-Kohlman V, Curtis JR, Manning HL, Mularski RA, Varkey B, Campbell M, et al. American College of Chest Physicians consensus statement on the management of dyspnea in patients with advanced lung or heart disease. Chest 2010;137; 674-691.
99. Nava S, Sturani C, Hartl S , Magni G, Ciontu M, Corrado A, Simonds A, on behalf of the European Respiratory Society Task Force on Ethics and decision-making in end stage lung disease. End-of-life decision-making in respiratory intermediate care units: a European survey. Eur Respir J 2007; 30: 1442–1450.
100. Sinuff T, Cook DJ, Keenan SP, Burns KEA, Adhikari NKJ, Rocker GM, Mehta S, Kacmarek R, Eva K, Hill NS. Noninvasive ventilation for acute respiratory failure near the end of life. Crit Care Med 2008; 36:789–794.
101. Bulow HH, Thorsager B. Non-invasive ventilation in do-not-intubate patients: five-year follow-up on a two-year prospective, consecutive cohort study Acta Anaesthesiol Scand 2009; 53: 1153-1157.
102. Chu C-M, Chan VL, Wong IWY, Leung W, Lin AWN, Cheung K-F. Noninvasive ventilation in patients with acute hypercapnic exacerbation of chronic obstructive pulmonary disease who refused endotracheal intubation. Crit Care Med 2004; 32: 372–377.
103. Cuomo A, Delmastro M, Ceriana P, Nava S, Conti G, Antonelli M, Iacobone E. Noninvasive mechanical ventilation as a palliative treatment of acute respiratory failure in patients with end-stage solid cancer. Pall Med 2004; 18: 602-610.
104. Curtis JR, Cook DJ, Sinuff T, White DB, Hill N, Keenan SP, Benditt JO, Kacmarek R, Kirchhoff KT, Levy MM. Society of critical care medicine palliative noninvasive positive ventilation

task force. Noninvasive positive pressure ventilation in critical and palliative care settings: understanding the goals of therapy . Crit Care Med 2007; 35: 932-939.

105. Truog RD, Campbell ML, Curtis JR, Haas CE, Luce JM, Rubenfeld GD, Hylton Rushton C, Kaufman DC. Recommendations for end-of-life care in the intensive care unit: A consensus statement by the American College of Critical Care Medicine. Crit Care Med 2008; 36: 953–963.

106. Fernandez R, Baigorri F, Artigas A. Noninvasive ventilation in patients with “do-not-intubate” orders: medium-term efficacy depends critically on patient selection Intensive Care Med 2007; 33: 350–354.

107. O'Donnell DE, Sanii R, Younes M. Improvement in exercise endurance in patients with chronic airflow limitation using continuous positive airway pressure. Am Rev Respir Dis 1988; 138: 1510–1514.

108. Keilty SE, Ponte J, Fleming TA, Moxham J. Effect of inspiratory pressure support on exercise tolerance and breathlessness in patients with severe stable chronic obstructive pulmonary disease. Thorax 1994; 49: 990–996.

109. Bianchi L, Foglio K, Pagani M, Vitacca M, Rossi A, Ambrosino N. Effects of proportional assist ventilation on exercise tolerance in COPD patients with chronic hypercapnia. Eur Resp J 1998; 11: 422-427.

110. Carrascossa CR, Oliveira CC, Borghi-Silva A, Ferreira EM, Maya J, Queiroga F Jr, Berton DC, Nery LE, Neder JA. Haemodynamic effects of proportional assist ventilation during high-intensity exercise in patients with chronic obstructive pulmonary disease. Respirology 2010;15:1185-1191.

111. Borghi-Silva A, Oliveira CC, Carrascosa C, Maia J, Berton DC, Queiroga F Jr, Ferreira EM, Almeida DR, Nery LE, Neder JA. Respiratory muscle unloading improves leg muscle oxygenation during exercise in patients with COPD. Thorax 2008; 63: 910-915.

112. Ambrosino N, Strambi S. New strategies to improve exercise tolerance in COPD. Eur Resp J 2004: 24: 313-322.

113. Ambrosino N**,** Palmiero G, Strambi S. New approaches in pulmonary rehabilitation. Clin Chest Med 2007; 28 : 629–638.

114. Bianchi L, Foglio K, Porta R, Baiardi R, Vitacca M, Ambrosino N. Lack of additional effect of adjunct of assisted ventilation to pulmonary rehabilitation in mild COPD patients. Respir Med 2002; 96: 359–367.

115. Hawkins P, Johnson LC, Nikoletou D, Hamnegård CH, Sherwood R, Polkey MI, Moxham J. Proportional assist ventilation as an aid to exercise training in severe chronic obstructive pulmonary disease. Thorax 2002; 57: 853–859.

116. Van t'Hul A, Gosselink R, Hollander P, Postmus P, Kwakkel G. Training with inspiratory pressure support in patients with severe COPD. Eur Respir J 2006; 27: 65-72.

117. Borghi-Silva A, Goncalves Mendes R, Toledo AC, Malosa´ Sampaio LM, da Silva PT, Kunikushita LN, Dutra de Souza HC, Salvini TF, Costa D. Adjuncts to physical training of patients with severe COPD: oxygen or noninvasive Ventilation? Respir Care 2010; 55: 885–894.

118. Menadue C, Alison JA, Piper AJ, Flunt D, Ellis ER. Bilevel ventilation during exercise in acute on chronic respiratory failure: a preliminary study. Respir Med 2010; 104: 219-227.

119. Ambrosino N. Assisted ventilation as an aid to exercise training: a mechanical doping? Eur Respir J 2006; 27: 3-5.

120. Dreher M, Storre JH, Windisch W. Noninvasive ventilation during walking in patients with severe COPD: a randomised cross-over trial. Eur Respir J 2007; 29: 930–936.

121. Menadue C, Alison JA, Piper AJ, Flunt D, Ellis ER. Non-invasive ventilation during arm exercise and ground walking in patients with chronic hypercapnic respiratory failure. Respirology 2009; 14: 251-259.

122. Garrod R, Mikelsons C, Paul EA, Wedzicha JA. Randomized controlled trial of domiciliary non-invasive positive pressure ventilation and physical training in severe chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2000; 162: 1335–1341.

123. Duiverman ML, Wempe JB, Bladder G, Jansen DF, Kerstjens HAM, Zijlstra JG, Wijkstra PJ. Nocturnal non-invasive ventilation in addition to rehabilitation in hypercapnic patients with COPD. Thorax 2008; 63:1052-1057.

124. Vila B, Servera E, Marín J, Díaz J, Giménez M, Komaroff E, Bach J. Noninvasive ventilatory assistance during exercise for patients with kyphoscoliosis: a pilot study. Am J Phys Med Rehabil. 2007; 86: 672-677

125. Borel JC, Wuyam B, Chouri-Pontarollo N, Deschaux C, Levy P, Pépin JL. During exercise non-invasive ventilation in chronic restrictive respiratory failure. Respir Med 2008; 102: 711-719.

Legends

Figure 1. Use of NIV during Bronchoscopy and BAL. Bronchoscope is introduced through a handmade hole in the mask.

Figure 2. Non invasive ventilation and continuous TEE performed with the TEE probe passed through a modified face-mask, throughout percutaneous aortic valve implantation.