Weaning from Mechanical Ventilation and Post-Extubation Failure

Mekanik Ventilatörden Ayırma ve Ekstübasyon Sonrası Başarısızlık

Paola Pierucci, Annalisa Carlucci, Annia Schreiber, Stefano Nava

Pulmonary and Critical Care Sant'Orsola and Malpighi Hospital, Bologna, Italy

ABSTRACT

In the event of acute respiratory failure, invasive mechanical ventilation (IMV) is a required practice to support gas exchanges and to unload respiratory muscles. It is important to optimise the timing of effective need of IMV. Weaning is defined as the process of gradual removal of mechanical ventilation support toward spontaneous ventilation. Non-invasive ventilation (NIV) efficacy have been proved only in a selected population of patients such as people with acute-on-chronic respiratory failure (COPD exacerbation) to shorten the length of invasive mechanical ventilation, the intensive care unit (ICU) stay and to avoid intubation related complications such as VAP. The role of NIV in all the other conditions (i.e. hypoxic patients, post-surgical patients) remains unclear. In the event of unplanned extubations during the weaning period, NIV could be considered as a good option to prevent re-intubation.
(Tur Toraks Der 2011; 12: 27-31)

Key words: Respiratory failure, noninvasive ventilation, invasive mechanical ventilation, weaning

Received: 06.10.2010 *Accepted: 07.10.2010*

ÖZET

Akut solunum yetmezliği durumlarında, solunum kaslarının yükünü azaltmak ve gaz değişiminin sağlanması için invaziv mekanik ventilasyon (İMV) yapılması gereken bir işlemdir. İMV'un yararlı olabilmesi için en uygun zamanlama önemlidir. Mekanik ventilatörden ayırma (weaning) işlemi mekanik ventilasyon desteğinden spontan solunuma aşamalı olarak geçme işlemidir. Noninvaziv ventilasyonun etkinliği, kronik solunum yetmezliği üzerine eklenmiş akut solunum yetmezliği gibi (örn. KOAH alevlenmesi) seçilmiş hasta gruplarında, invaziv mekanik ventilasyonda ve yoğun bakım ünitesinde kalma süresinde kısalma, ventilatörle ilişkili pnömoni (VİP) gibi entübasyonla ilişkili komplikasyonlardan korunmada etkili olduğu gösterilmiştir. Ancak NİV'un başka patolojilerdeki (örn. hipoksik hastalar, cerrahi sonrası hastalar) rolü net değildir. Weaning sırasında planlanmamış ekstübasyonlarda, yeniden entübasyonu önlemek için NİV iyi bir seçenek olarak düşünülebilir. *(Tur Toraks Der 2011; 12: 27-31)*

Anahtar sözcükler: Solunum yetmezliği, noninvaziv ventilasyon, invaziv mekanik ventilasyon, weaning

Geliş Tarihi: 06.10.2010 *Kabul Tarihi: 07.10.2010*

INTRODUCTION

In the event of acute respiratory failure, Invasive Mechanical Ventilation (IMV) is a required practice to support gas exchanges and to unload respiratory muscles. Even if it is a life-saving procedure, it is not free from complications such as ventilator associated pneumonia (VAP) [1] gastro-intestinal haemorrhages [2] and generalized myopathy [3]. For these reasons it is important to optimise the timing of effective need of IMV, guaranteeing a safe and lasting extubation [4]. Weaning is defined as the process of gradual removal of mechanical ventilation support toward spontaneous ventilation. There are no differences between the two most popular weaning methods, either the gradual progressive reduction of Pressure support level or T piece breathing. In fact, they have been shown to be equally effective and the operator confidence with one or the other technique should be the criteria of choice [5].

WEANING with NIV

One third of IMV time is devoted to weaning [6] and it becomes close to 50% in patients affected by COPD, cardiac failure and neurological problems. When the weaning fails, it is usually associated with an increased risk of death, prolonged ICU stay, and transfer to long-term facilities [7].

Many investigators examined the possibility of weaning from IMV using Non Invasive Ventilation (NIV) to shorten the intubation time and to avoid intubation related complications such as ventilation associated pneumonia. Udwadia et al. [8] in 1992 published the first report describing the use of NIV to facilitate liberation from IMV and after this several studies, trials and meta-analysis have followed [9 -15].

From a physiological point of view, NIV is similar to IMV, in fact, it reduces the breathing work and frequency, decreases the negative deflections of intrathoracic

Address for Correspondence / Yazışma Adresi: Stefano Nava, Respiratory and Critical Care Unit Sant'Orsola and Malpighi Hospital via Massarenti n:9 40138 Bologna, Italy Phone: 051 6363253 Fax: 051 6364019 E-mail: stefano.nava@aosp.bo.it

doi:10.5152/ttd.2011.06

pressure, improves gas exchange, and rests respiratory muscles [16]. Indeed, both invasive and non-invasive pressure support, are equally effective and NIV may be used as a "full alternative" for invasive ventilation.

NIV may also facilitate the weaning process in "difficult to wean patients". A randomised-controlled study [12] performed in severe COPD patients showed that the likelihood of weaning success increases while the ICU stay and duration of mechanical ventilation decrease, using NIV as a weaning technique compared to the above mentioned weaning protocols. A French study [18], conducted on patients intubated for acute respiratory failure due to COPD or restrictive diseases confirmed the finding of a shorter duration of invasive mechanical ventilation using NIV versus traditional weaning. However, no differences in terms of ICU and hospital length of stay, as well as 3-months survival were found between the two techniques.

Burns et al. [19] conducted a meta-analysis of five studies [12,18, 20-22] considering "difficult to wean" patients (i.e. clinical stable patients who failed a weaning trial) randomly assigned from IMV to either continued IMV, or to prompt extubation followed by NIV as a weaning strategy. Although respiratory failure requiring IMV was the unifying enrolment criteria, severe COPD was identified as the responsible pathology among most patients enrolled.

Trevisan and his group in Brasil [23], obtained similar results in a more recent randomized controlled trial. An heterogeneous group of patients treated with IMV for more than 48 hours who failed a SBT, were randomly assigned to the NIV group or the IMV group. Comparison between the two groups showed that the percentage of complications was lower in the NIV group (28.6% vs 75.5%). Patients in the NIV group had a shorter length of stay in the ICU and a shorter duration of mechanical ventilation, but these results were not statistically significant. Blood gases showed no differences between the two groups.

On the other hand, Prasad and co-workers in India conducted a similar randomized-controlled trial [24], evaluating NIV for weaning from IMV of COPD patients with acute-on-chronic hypercapnic respiratory failure. Patients after a SBT failure were randomized into two groups to receive either NIV or continued weaning with IMV in pressure support mode. However, in this study no statistically significant differences were found between the two groups in terms of duration of MV, hours of weaning, ICU stay, incidence of VAP and number of deaths at discharge from the ICU and at 30 days. A possible explanation for these results could be related to the small number of patients recruited in the trial.

Girault et al. [25] recently completed a randomized controlled trial with a large number of patients in 17 centers in France. Inclusion criteria were the same as reported in the previous study. Patients were randomized into 3 groups either to continue intubation in IMV, to start NIV or to receive standard medical therapy after extubation. There were no differences in weaning failure, complications, ICU or hospital stay, or hospital survival. Interestingly, NIV was used effectively as rescue therapy in patients weaned invasively and also in patients extubated with oxygen alone. Further larger studies will be needed in order to assess the real impact of NIV on heterogeneous population of ICU patients.

Ferrer et al. [20] in a randomized controlled trial compared NIV with conventional weaning strategy in patients with "persistent" weaning failure defined as a failure of a SBT for 3 consecutive days. They showed a significant reduction in duration of mechanical ventilation, ICU and hospital stay using NIV, but no difference in the incidence of reintubation between the two techniques. However, patients treated with NIV had a minor incidence of serious complications and a better ICU and 90 days survival.

Some small, nonrandomised trials have been performed using NIV for weaning trauma patients with hypoxemic respiratory failure [26] and non-COPD patients with persistent acute respiratory failure after early extubation [27]. However, based on these studies, we cannot recommend NIV as a weaning strategy in severe hypoxic patients.

Through all these studies, strong support for NIV as a weaning strategy in the subgroup of COPD patients who experienced a failure of a SBT was provided, with the effect of reducing mortality, minimizing ventilator-associated pneumonia, and shortening the length of hospital stay.

The poor tolerance of facial interfaces and the possible difficulties in fitting masks, has been considered as possible causes for failure of NIV in the weaning process [28]. Lately, the helmet has been considered as a potential alternative for NIV. In a recent case report Klein et al. [29] described the possibility to rapidly wean a COPD patients intubated for an acute respiratory failure by using the helmet during NIV. They showed good patient compliance, lower costs and nurse workload and mostly, fewer complications related to sedation and infections compared to invasive ventilation. Further studies will be needed to assess the role of routine helmet NIV in IMV weaning.

NIV and POST-EXTUBATION FAILURE

Prevention

Post-extubation failure is a major clinical problem in intensive care units (ICU) [30]. Extubation attempts may fail in as many as 23.5% of patients and the in-hospital mortality of these patients may reach 30-40%. The cause of extubation failure and the time elapsed before re-intubation are independent predictors of outcome [31,32].

Few studies have evaluated the use of NIV as a means to prevent, rather than treat post-extubation respiratory failure. Jiang et al. [33] conducted a prospec-

tive study on 93 patients randomised to receive NIV or oxygen therapy after planned or unplanned extubation. They found no difference in the re-intubation rate between the two groups. Epstein et al. [32] showed that there is a certain subset of patients whose clinical characteristics at the time of extubation may predict re-intubation. Two randomised trials from Nava and Ferrer [34, 35] were therefore performed to assess whether NIV is effective in preventing the occurrence of post-extubation failure in patients at "highest risk" when compared to standard medical treatment. Both studies showed that the groups treated with NIV had a lower re-intubation rate and a lower ICU mortality than the groups treated with standard therapy. Furthermore, one study [36] found a better 90-days survival in a subgroup of hypercapnic patients treated with NIV. To confirm the result found in this subgroup of patients, Ferrer and colleagues [36] performed a multi-centre randomized controlled trial specifically designed for patients who developed hypercapnia during an SBT. They were randomly divided in order to receive NIV or conventional oxygen therapy after a successful SBT. The primary end point was to avoid respiratory failure within 72 h after extubation. They found that respiratory failure was less frequent in the NIV arm than in the other (15% vs 25%). NIV was also independently associated with a lower risk of respiratory failure after extubation and NIV as a rescue therapy, avoided re-intubation in patients with respiratory failure. The overall 90 days mortality was significantly lower in the group of NIV (11% vs 31%).

Obesity represents another important risk factor of post extubation respiratory failure. El Sohl and colleagues [37] evaluated NIV immediately after extubation in morbidly obese patients who had been ventilated for more than 48 hours. Compared to matched control patients treated with conventional medical therapy, they found a 16% absolute risk reduction of post extubation respiratory failure and a lower need for re-intubation in the NIV group (10 in the NIV group versus 26% in controls). A shorter length of ICU stay and a reduced mortality was found only in the sub-group of hypercapnic patients treated by NIV. In summary, routine use of NIV immediately after extubation is not recommended, except for patients at high risk for extubation failure.

Treatment

The use of NIV has been suggested in an attempt to avoid re-intubation in patients that show signs of "incipient" or overt respiratory failure following extubation.

Hilbert and co-workers [38] demonstrated that NIV improved the outcome of patients with COPD and post-extubation hypercapnic respiratory failure when compared to conventional treatment of matched subjects, by reducing the need for endotracheal intubation, the mean duration of ventilatory assistance and the duration of ICU stay.

In a randomised controlled trial [39], patients developing Acute Respiratory Failure (ARF) within 48 hours after extubation were randomised to receive standard medical therapy alone or NIV. The authors did not find any difference in re-intubation rate, hospital mortality rate, ICU and hospital stay, despite a trend of a shorter duration of hospital stay in the NIV group. It is therefore important to underline a few comments concerning the present study. Patients were considered eligible for the study when developing respiratory distress was defined, in the present study, as a respiratory rate greater than 30/min, presence of increased respiratory rate greater than 50% from baseline rate, use of respiratory accessory muscles or abdominal paradox. These criteria could be not necessarily related to apost extubation failure. Moreover, after the first year, patients with an acute exacerbation of COPD were excluded from this study even if the randomised trial, strongly supported the use of NIV for this class of patients. Esteban et al. [40] conducted a large multicenter, randomised trial to evaluate the effect of NIV on the mortality of patients who had respiratory failure. Within the subsequent 48 hours of IMV, they were randomly assigned to either NIV or standard medical therapy. The study was stopped prematurely during an interim analysis because the authors found a higher mortality rate in the NIV group compared to the standard therapy (25% vs 14% respectively, p=0.048). However the dissimilarity appeared to be due to differences in the rate of death among the patients who required reintubation (38% in NIV group vs 22% in SMT group, p=0.06). This could correlate with the result of a longer interval between the onset of ARF and reintubation in the NIV group (p=0.02). This study was performed in an unselected group of patients, consequently the authors concluded there was the potential that selected patients (i.e. those with COPD) may still benefit from NIV, but the sample was too small to allow meaningful conclusions. As a result, the authors concluded that NIV does not improve survival and may in fact be harmful. Although selected patients in specialized centres may benefit from this therapy, specific hypothesis need to be tested prospectively. What remains unclear is a result not discussed in the paper. Of the 114 patients assigned to SMT, 28 received NIV as rescue therapy; only 7 (25%) were subsequently intubated and 3 (11%) died. This means that patients who are treated with NIV as rescue therapy had a lower rate of failure and a lower rate of death than patients treated with NIV as a first attempt (failure rate=48%, rate of death=25%). In summary, up to the present, the literature does not support the routine use of NIV to treat an incipient post-extubation respiratory failure.

CONCLUSIONS

The weaning process is crucial and a recent review by Epstein et al. [41] underline that the majority of studies which focused on this topic, found NIV superior to IMV. Until now, if the weaning criteria are met, confirmed evidences of real NIV efficacy have been proved only in a selected population of patients such as people with

acute-on-chronic respiratory failure (COPD exacerbation) to shorten the length of invasive mechanical ventilation, the ICU stay and to avoid intubation related complications such as VAP. The role of NIV in all the other conditions (i.e. hypoxic patients, post-surgical patients) remains unclear. Randomised controlled studies have demonstrated that it may even be harmful to treat an over episode of post-extubation respiratory failure with NIV, while promising results were obtained using NIV to prevent reintubation in patients considered at risk. In the event of unplanned extubations, during the weaning period, NIV could also be considered as a good option to prevent re-intubation.

Conflict of Interest

No conflict of interest is declared by the authors.

REFERENCES

1. Kollef Mh, Levy Nt, Ahrens Ts Et Al. The Use Of Continuous Iv Sedation Is Associated With Prolongation Of Mechanical Ventilation. Chest 1998; 114: 541-8. [CrossRef]
2. Mutlu GM, Mutlu EA, Factor P. GI Complications in patients receiving mechanical ventilation. Chest 2001; 119: 1222-41. [CrossRef]
3. Berek K, Margreiter J, Willeit J, Berek A, Schmutzhard E, Mutz NJ. Polyneuropathies in critically ill patients: a prospective evaluation. Intensive Care Med 1996; 22: 849-55. [CrossRef]
4. Kollef MH, Shapiro SD, Silver P et al. A randomized, controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation. Crit.Care Med 1997; 25: 567-74. [CrossRef]
5. Esteban A, Alía I, Ibañez J, Benito S, Tobin MJ. Modes of mechanical ventilation and weaning: a national survey of Spanish hospitals. Chest 1994; 106: 1188-93. [CrossRef]
6. Ely EW. Challenges encountered in changing physicians' practice styles: the ventilator weaning experience. Intensive Care Med 1998; 24: 539-41. [CrossRef]
7. Epstein SK, Ciubataru RL, Wong JB. Effect of failed extubation on the outcome of mechanical ventilation. Chest 1997; 112: 186-92. [CrossRef]
8. Udwadia ZF, Santis GK, Steven MH, Simonds AK. Nasal ventilation to facilitate weaning in patients with chronic respiratory insufficiency. Thorax 1992; 47: 715-8. [CrossRef]
9. Goodenberger DM, Couser JI Jr, May JJ. Successful discontinuation of ventilation via tracheostomy by substitution of nasal positive pressure ventilation. Chest 1992; 102: 1277-9. [CrossRef]
10. Restrick LJ, Scott AD, Ward EM et al. Nasal intermittent positive-pressure ventilation in weaning intubated patients with chronic respiratory disease from assisted intermittent positive pressure ventilation. Respir Med 1993; 87: 199-204. [CrossRef]
11. Gregoretti C, Beltrame F, Lucangelo U et al. Physiologic evaluation of non-invasive pressure support ventilation in trauma patients with acute respiratory failure. Intensive Care Med 1998; 24: 785-90. [CrossRef]
12. Nava S, Ambrosino N, Clini E et al. Noninvasive mechanical ventilation in the weaning of patients with respiratory failure due to chronic obstructive pulmonary disease. A randomized, controlled trial. Ann Intern Med 1998; 128: 721-8.
13. Kilger E, Briegel J, HallerM et al. Effects of noninvasive positive pressure ventilatory support in non-COPD patients with acute respiratory insufficiency after extubation. Intensive Care Med 1999; 25: 1374-80. [CrossRef]
14. Burns KE, Adhikari NK, Keenan SP, Meade M. Use of non-invasive ventilation to wean critically ill adults off invasive ventilation: meta-analysis and systematic review. BMJ 2009; 338: b1574. [CrossRef]
15. Burns KEA, Adhikari NKJ, Meade MO. Non-invasive positive pressure ventilation as a weaning strategy for intubated adults with respiratory failure. Cochrane Database Syst Rev 2003; CD004127.
16. Vitacca M, Ambrosino N, Clini E et al. Physiological response to pressure support ventilation delivered before and after extubation in patients not capable of totally spontaneous autonomous breathing. Am J Respir Crit Care Med 2001; 164: 638-41.
17. Nava S, Ambrosino N, Rubini F et al. Effects of nasal pressure support ventilation and external PEEP on diaphragmatic activity in patients with severe stable COPD. Chest 1993; 103: 143-50. [CrossRef]
18. Girault C, Daudenthun I, Chevron V, Tamion F, Leroy J, Bonmarchand G. Noninvasive ventilation as a systematic extubation and weaning technique in acute-on-chronic respiratory failure. A prospective, randomized controlled study. Am J Respir Crit Care Med 1999; 160: 86-92.
19. Burns KE, Adhikari NK, Meade MO. A meta-analysis of non-invasive weaning to facilitate liberation from mechanical ventilation. Can J Anesth 2006;53:305-15.
20. Ferrer M, Esqinas A, Arancibia F et al. Non invasive ventilation during persistent weaning failure. Am J Respir Crit Care Med 2003; 168: 70-6.
21. Chen J, Qiu D, Tao D. Time for extubation and sequential noninvasive mechanical ventilation in COPD patients with exacerbated respiratory failure who recei¬ved invasive ventilation. Zhonghua Jie He He Hu Xi Za Zhi 2001; 24: 99-100.
22. Hill NS, Lin D, Levy M et al. Noninvasive positive pressure ventilation (NVVP) to facilitate extubation after acute respiratory failure: a feasibility study. Am J Respir Crit Care Med 2000; 161: 263 (abstract).
23. Trevisan CE, Vieira SR; Research Group in Mechanical Ventilation Weaning. Noninvasive mechanical ventilation may be useful in treating patients who fail weaning from invasive mechanical ventilation: a randomized clinical trial. Crit Care 2008; 12: R51. Epub 2008 Apr 17. [CrossRef]
24. Prasad SB, Chaudhry D, Khanna R. Role of noninvasive ventilation in weaning from mechanical ventilation in patients of chronic obstructive pulmonary disease: an Indian experience. Indian J Crit Care Med 2009; 13: 207-12. [CrossRef]
25. Girault C, Bubenheim M, Benichou J, Bonmarchand G. Non invasive ventilation and weaning from mechanical ventilation in crhonic respiratory failure patients: the VENISE study: preliminary results (abstract). Proc Am Thorax Soc 2009; A2165.
26. Gregoretti C, Beltrame F, Lucangelo U et al. Physiologic evaluation of non-invasive pressure support ventilation in trauma patients with acute respiratory failure. Intensive Care Med 1998; 24: 785-90. [CrossRef]
27. Kilger E, Briegel J, Haller M et al. Effects of noninvasive positive pressure ventilatory support in non-COPD patients with acute respiratory insufficienzy after early extubation. Intensive Care Med 1999; 25: 1374-80. [CrossRef]
28. Carlucci A, Richard JC, Wysocki M, Lepage E, Brochard L; SRLF Collaborative Group on Mechanical Ventilation. Noninvasive versus conventional mechanical ventilation. An

pidemiologic survey. Am J Respir Crit Care Med 2001; 163: 874-80.
29. Klein M, Weksler N, Bartal C, Gurman GM. Helmet noninvasive ventilation for weaning from mechanical ventilation. Respir Care 2004; 49: 1035-7.
30. Torres A, Gatell JM, Aznar E et al. Re-intubation increases the risk of nosocomial pneumonia in patients needing mechanical ventilation. Am J Respir Crit Care Med 1995; 152: 137-41.
31. Epstein SK, Ciubataru RL, Wong JB. Effect of failed extubation on the outcome of mechanical ventilation. Chest 1997; 112: 186-92. [CrossRef]
32. Espstein SK, Ciubotaru RL. Independent effects of etiology of failure and time to reintubation on outcome for patients failing extubation. Am J Respir Crit Care Med 1998; 158: 489-93.
33. Jiang JS, Kao SJ, Wang SN. Effect of early application of biphasic positive airway pressure on the outcome of extubation in ventilator weaning. Respirology 1999; 4: 161-5. [CrossRef]
34. Nava S, Gregoretti C, Fanfulla F et al. Noninvasive ventilation to prevent respiratory failure after extubation in high-risk patients. Crit Care Med 2005; 33: 2465-70.
35. Ferrer M, Valencia M, Nicolas JM, Bernadich O, Badia JR, Torres A. Early noninvasive ventilation averts extubation failure in patients at risk: a randomized trial. Am J Respir Crit Care Med. 2006; 173: 164-70
36. Ferrer M, Sellarés J, Valencia M et al. Non-invasive ventilation after extubation in hypercapnic patients with chronic respiratory disorders: randomised controlled trial. Lancet 2009; 374: 1082-8. Epub 2009 Aug 12. [CrossRef]
37. El-Solh AA, Aquilina A, Pineda L, Dhanvantri V, Grant B, Bouquin P. Non invasive ventilation for prevention of post-extubation respiratory failure in obese patients. Eur Respir J 2006; 28: 588-95.
38. Hilbert G, Gruson D, Portel L, Gbikpi-Benissan G, Cardinaud JP. Noninvasive pressure support ventilation in COPD patients with postextubation hypercapnic respiratory insufficiency. Eur Respir J 1998; 11: 1349-53. [CrossRef]
39. Keenan SP, Powers C, McCormack DG, Block G. Noninvasive positive-pressure ventilation for postextubation respiratory distress. JAMA 2002; 287: 3238-44. [CrossRef]
40. Esteban A, Frutos-Vivar F, Ferguson ND, et al. Non-invasive positive pressure ventilation for respiratory failure after extubation. NEJM 2004; 350: 2460-2. [CrossRef]
41. Epstein SK, Durbin CG Jr. Should a patient be extubated and placed on noninvasive ventilation after failing a spontaneous breathing trial? Jr. Respir Care 2010; 55: 198-206; discussion 207-8.