NONINVASIVE MECHANICAL VENTILATION

Şermin Börekçi, Bülent Tutluoğlu
Istanbul University, Istanbul, Turkey

НЕИНВАЗИВНАЯ ИСКУССТВЕННАЯ ВЕНТИЛЯЦИЯ ЛЕГКИХ

Шермин Борокчи, Тутлоуглу Буллент
Стамбульский Университет, Стамбул, Турция

Summary. Noninvasive mechanical ventilation (NIMV) refers to the provision of ventilatory support through a noninvasive interface (nasal mask, oronasalmask, facemask, helmet or nasal plugs), rather than an invasive interface (endotracheal tube, tracheostomy). It's use has become more common as its benefits are increasingly recognized. NIMV must be applied for appropriate patients in an appropriate clinical area by trained staff about using the optimal ventilator mode, settings. NIMV can be set up and successfully used on intensive care unit, high dependence units, respiratory wards, general wards and on imergency rooms.

Key words: noninvasive mechanical ventilation.

Резюме. Неинвазивная искусственная вентиляция легких (НИВЛ) обеспечивает вспомогательное дыхание при помощи неинвазивных устройств (маска для рта и носа, маска для лица, шлем-маска или носовые затычки), без использования инвазивных (интубационная трубка, трахеостомия). Использование НИВЛ набирает все большую популярность, так как ее преимущества широко признаются. НИВЛ должна применяться к определенным пациентам в соответствующей клинической сфере деятельности, осуществляться при помощи специально обученного персонала, ознакомленного с оптимальным режимом вентилятора и прочими настройками. Аппарат НИВЛ может быть установлен и успешно использоваться в палатах интенсивной терапии, послеоперационных палатах, респираторных палатах, общих палатах, а также в палатах оказания первой помощи

Ключевые слова: **.** неинвазивная искусственная вентиляция легких.

Introduction. Noninvasive mechanical ventilation (NIMV) refers to the provision of ventilatory support through a noninvasive interface (nasal mask, oronasalmask, facemask, helmet or nasal plugs), rather than an invasive interface (endotracheal tube, tracheostomy). It's use has become more common as its benefits are increasingly recognized. NIMV must be applied for appropriate patients in an appropriate clinical area by trained staff about using the optimal ventilator mode, settings. NIMV can be set up and successfully used on intensive care unit, high dependence units, respiratory wards, general wards and on imergency rooms [1,2].

Mode of Noninvasive Mechanical Ventilation. There are much more confusing terminology to describe mode of NIMV, also there is no standardization between manifacturers, sometimes same mode may be called by different names.The main modes are [1]:

- **Bi-level pressure support:** Ventilation is produced by the inspiratory positive airway pressure (IPAP), while the expiratory positive airway pressure (EPAP) recruits underventilated lung.
- **Continuous positive airway pressure**: The same pressure applied all throughout the inspiration and expiration to keep the airways and alveoli open and not fully deplated.
- **Controlled mechanical ventilation:** In the mandatory controlled mechanical ventilation (CMV) mode, full ventilatory support is provided and no patient effort is required.
- **Assist/control ventilation:** In assist/control mode (ACV) a preset number of mandatory breaths per minute will be delivered in the absence of patient effort.
- **Assisted spontaneous breathing (pressure support)**: In assisted spontaneous breathing (ASB) the patient's respiratory effort triggers the ventilator both on and off. Respiratory frequency and the timing of each breath are therefore determined by the patient.

Proportional assist ventilation (PAV): PAV is a spontaneous breathing mode that offers assistance

to the patient in proportion to the patient's effort. This mode is an alternative technique in which both flow-to counter resistance-and volüme-to counter compliance-are independently adjusted. It may improve patient comfort and so improve success and compliance with acute NIMV [3].
NIMV is not suitable for all patients with respiratory failure, the most important thing is chosing the apropriate patients to NIMV.

Contraindications to Noninvasive Mechanical Ventilation [1,4]

Life-threatening hypoxaemia

- Severe co-morbidity
- Confusion/agitation/severe cognitive impairment
- Facial burns/trauma/recent facial or upper airway surgery
- Vomiting
- Fixed upper airway obstruction
- Undrained pneumothorax
- Upper gastrointestinal surgery
- Inability to protect the airway
- Copious respiratory secretions
- Haemodynamically unstable requiring inotropes/pressors (unless in a critical care unit)
- Bowel obstruction

Indications to Noninvasive Mechanical Ventilation. NIMV should be initiated as soon as possible if one of these conditions is present [2]:

- Poor alveolar gas exchange (PaO2/FiO2<200)
- Ventilatory pump failure with hypercapnia and respiratory acidosis (PaCO2>45mmHg and pH<735)
- Severe dyspnea accompanied by use of accessory respiratory muscles
- Tachypnea (with respiratory rate>24 breaths/ min)

The some of main conditions that NIMV may be used are mentioned below.

Hypercapnic respiratory failure and chronic obstructive pumonary disease. In the literatüre, there are several studies shown that NIMV added to standard medical treatment reducing mortality, avoiding intubation, improving dyspnea and reducing hospital length of stay in chronic obstructive pulmonary disease (COPD) patients with acute respiratory failure compared to medical management and oxygen therapy alone [4-6]. A multicentre randomised controlled trial of NIMV in acute exacerbations of COPD on general respiratory wards reported that; NIMV was applied by the usual ward staff according to a simple protocol, and need for intubation defined by a priori criteria, was reduced from 27% to 15% by NIMV ($p<0.05$). In-hospital mortality was also reduced from 20% to 10% ($p<0.05$). Subgroup analysis suggested that the outcome in patients with pH <7.30 (H+ >50 nmol/l) after initial treatment was inferior to that in the studies performed in the intensive care unit; these patients are probably best managed in a higher dependency setting with individually tailored ventilation. Staff training and support are crucial wherever NIMV is performed, and operator expertise more than any other factor is likely to determine the success or otherwise of NIMV [7]. These data point to the need for an early and accurate differentiation between patient subgroups, in order to promptly address them to the most effective treatment. On the other hand, recently Roberts et al. conducted a study in-patients with COPD exacerbation and acute respiratory failure managed in general clinical practice showed an overall mortality of 25% in patients receiving NIMV, significantly higher than the ratios reported in the previous studies [8]. There are much more factors that effect the results, such as; selection of appropriate patients, the use of NIMV as a ceiling of treatment in patients with very severe disease, or substantial delays in initiating the NIMV. The British Thoracic Society guidelines stated that, NIMV should be considered in patients with an acute exacerbation of COPD in whom a respiratory acidosis (pH <7.35, H+ >45 nmol/l) persists despite maximum medical treatment on controlled oxygen therapy (level of evidence A) [1,4].

Cardiogenic pulmonary edema. There are several studies have showing that CPAP treatment is improving survival rate and decrease the need for intubation in patient with cardiogenic

pulmonary edema [9-13]. In addition, Nava and his collegues reported that; compared with standard medical therapy, early use of noninvasive pressure support ventilation (NPSV= Bi-level pressure support ventilation) in emergency departments for treatment of acute respiratory failure due to cardiogenic pulmonary edema produces faster gas exchange, and dyspnea score and respiratory rate improvements, but does not affect the overall clinical outcome. and they said that both NPSV and CPAP may be used in the treatment of cardiogenic pulmonary edema [14]. In another multicenter randomized study, Nouira and his collegues showed that; During cardiogenic pulmonary edema, NPSV accelerates the improvement of respiratory failure compared to CPAP but does not affect primary clinical outcome either in overall population or in subgroups of patients with hypercapnia or those with high B-type natriuretic peptide [15]. The British Thoracic Society guidelines stated that CPAP has been shown to be effective in patients with cardiogenic pulmonary oedema who remain hypoxic despite maximal medical treatment. NPSV should be reserved for patients in whom CPAP is unsuccessful [level of evidence B] [1].

Chest wall deformity/neuromuscular disease. NIMV may also used for patients with chronic ventilatory failure due to chest wall deformity and neuromuscular disease-for example in myasthenia gravis and Guillain-Barré syndrome. Simonds et al, reported that; the long term outcome of NIMV in patients with chronic respiratory failure due to scoliosis, previous poliomyelitis, chest wall and progressive neuromuscular disorders have benefits [16]. In a recent study, Adıgüzel and her collegues has shown that kyphoscoliosis patients with respiratory failure due to pump failure have a mainly good response to NIMV and pulmonary performance improved with NIMV during long term follow up. Because of these results, outhors mentioned that they strongly discourage the use of NIMV in the case of septic shock in intensive care unit (ICU) kyphoscoliosis patients with acute respiratory failure [17]. The British Thoracic Society guidelines stated that NIMV is indicated in acute or acute-on-chronic hypercapnic respiratory failure due to chest wall deformity or neuromuscular disease [level of evidence C] [1].

Asthma. There is limited number of studies about using NIMV to treat patient with asthma. Meduri and his colleagues reported that; In asthmatic patients with acute respiratory failure (Mean pH was 7.25), NIMV via a face mask appears highly effective in correcting gas exchange abnormalities using a low inspiratory pressure (<25 cm H20) (18). There is not enough data to recommend to use NIMV for asthma patients. So that, the British Thoracic Society guidelines stated that; NIV should not be used routinely in acute asthma [level of evidence C] [1].

Cystic fibrosis/bronchiectasis. Similar to asthma, in these group of patients also there is no enough data to recommend the use of NIMV. Secretions are the important problem that limit the using NIMV. Hodson and his collegues in their study said that; NIMV appears to be a useful bridge to transplantation when a patient suddenly deteriorates. It gives them a chance of survival for a few more days or even weeks during which time an urgent search for donor organs can be made. This is also a very cost effective method of ventilation and does not encroach on conventional intensive care unit facilities (19). Because of these limited data, The British Thoracic Society guidelines stated that; A trial of NIMV may be undertaken in patients with a respiratory acidosis (pH<7.35) secondary to an acute exacerbation of bronchiectasis, but excessive secretions are likely to limit its effectiveness and it should not be used routinely in bronchiectasis [level of evidence C] [1].

Pneumonia. NIMV may be usefull for some selected patients with respiratory failure due to pneumonia. Confalonieri and his collegues reported that in selected patients with acute respiratory failure caused by severe community-acquired pneumonia, NIMV was associated with a significant reduction in the rate of endotracheal intubation and duration of ICU stay (20). Brett et al. have shown that CPAP improves oxygenation, reduces respiratory rate, and decrease the dyspnoea in patients with severe community acquired pneumonia [21]. The British Thoracic Society guidelines stated that; CPAP improves oxygenation in patients with diffuse pneumonia who remain hypoxic despite maximum medical treatment. NPSV can be used as an alternative if the patient becomes hypercapnic [level of evidence C] [1].

Weaning and postextubation failure. Recently, Burns et al, reported that, NIMV may be used in the ICU to shorten the weaning process in stable patients recovering from hypercapnic

respiratory failure who had previously failed a spontaneous breathing trial [22]. Similar to Burns's result, Girault and his collegues showed that; NIMV decreases the intubation duration and may improve the weaning results in difficult-to-wean chronic hypercapnic respiratory failure patients by reducing the risk of postextubation acute respiratory failure [23]. The British Thoracic Society guidelines stated that; NIMV has been used successfully to wean patients from invasive ventilation and should be used when conventional weaning strategies fail [level of evidence B] [1].

Respiratory failure in immunocompromised patients. Immunocompromised patients, can potentially benefit significantly from NIMV. There are several studies that support the use of NIMV for these group of patients [24-30]. Same advise as pneumonia is valid for these froup of patients; CPAP improves oxygenation in patients with diffuse pneumonia who remain hypoxic despite maximum medical treatment. NPSVcan be used as an alternative if the patient becomes hypercapnic [level of evidence C], [level of evidence D] [1].

Other conditions. NIV has been used in a variety of other conditions (such as acute respiratory distress syndrome, postoperative or post-transplantation respiratory failure) with reduced intubation rates, ICU stay, and mortality [level of evidence D] [1].

Treatment failure. Treatment failure is accepted when [1]:

• Deterioration in patient's condition
• Failure to improve or deterioration in arterial blood gas tensions
• Development of new symptoms or complications such as pneumothorax, sputum retention, nasal bridge erosion
• Intolerance or failure of coordination with the ventilator
• Failure to alleviate symptoms
• Deteriorating conscious level
• Patient and carer wish to withdraw treatment

References

1. British Thoracic Society Standards of Care Committee. Non-invasive ventilation in acute respiratory failure. Thorax. 2002 Mar;57(3):192-211.
2. Boldrini R, Fasano L, Nava S. Noninvasive mechanical ventilation. Curr Opin Crit Care. 2012 Feb;18(1):48-53. doi: 10.1097/MCC.0b013e32834ebd71.
3. Younes M. Proportional assist ventilation: a new approach to ventilatory support. Am Rev Respir Dis 1992;145:114–20.
4. BTS Guidelines, Non-invasive ventilation in chronic obstructive pulmonary disease: management of acute type 2 respiratory failure. http://www.brit-thoracic.org.uk/Guidelines/NIPPV-NIV-in-Acute-Respiratory-Failure-Guideline.aspx. Reached at 30 October 2013.
5. Meduri GU, Conoscenti CC, Menashe P, Nair S. Noninvasive face mask ventilation in patients with acute respiratory failure. Chest 1989; 95:865-870.
6. Bott J, Carrol MP, Conway JH, et al. Randomised controlled trial of nasal ventilation in acute ventilatory failure due to chronic obstructive airways disease. Lancet 1993; 341:1555–1557.
7. Plant PK, Owen JL, Elliott MW. Early use of non-invasive ventilation for acute exacerbations of chronic obstructive pulmonary disease on general respiratory wards: a multicentre randomised controlled trial. Lancet 2000;355:1931–5.
8. Roberts CM, Stone RA, Buckingham RJ, et al. Acidosis, noninvasive ventilation and mortality in hospitalised COPD exacerbations. Thorax 2011; 66:43-48.
9. Bersten AD, Holt AW, Vedig AE, et al. Treatment of severe cardiogenic pulmonary edema with continuous positive airway pressure delivered by face mask. N Engl J Med 1991;325:1825-30.
10. Lin M, Yang YF, Chiang HT, et al. Reappraisal of continuous positive airway pressure therapy in acute cardiogenic pulmonary edema. Short-term results and long-term follow-up. Chest 1995;107:1379–86.

11. Rasanen J, Heikkila J, Downs J, et al. Continuous positive airway pressure by face mask in acute cardiogenic pulmonary edema. Am J Cardiol 1985;55:296-300.
12. Pang D, Keenan SP, Cook DJ, et al. The effect of positive pressure airway support on mortality and the need for intubation in cardiogenic pulmonary edema: a systematic review. Chest 1998;114:1185–92.
13. Peter JV, Moran JL, Phillips-Hughes J, et al. Effect of noninvasive positive pressure ventilation on mortality in patients with acute cardiogenic pulmonary oedema: a meta-analysis. Lancet 2006; 367:1155–1163.
14. Nava S, Carbone G, Dibattista N, et al. Noninvasive ventilation in cardiogenic pulmonary edema: a multicenter, randomized trial. Am J Respir Crit Care Med 2003; 168:1432–1437.
15. Nouira S, Boukef R, Bouida W, et al. Noninvasive pressure support ventilation and CPAP in cardiogenic pulmonary edema: amulticenter randomized study in the emergency department. Intensive Care Med 2011; 37:249- 256.
16. Simonds AK, Elliott MW. Outcome of domiciliary nasal intermittent positive pressure ventilation in restrictive and obstructive disorders. Thorax 1995;50:604-9.
17. Adıgüzel N, Karakurt Z, Güngör G, Moçin O, Balcı M, Saltürk C, Kargın F, Takır HB, Güven A, Yarkın T. Management of kyphoscoliosis patients with respiratory failure in the intensive care unit and during long term follow up. Multidiscip Respir Med. 2012 Sep 21;7(1):30. doi: 10.1186/2049-6958-7-30.
18. Meduri GU, Cook TR, Turner RE, et al. Noninvasive positive pressure ventilation in status asthmaticus. Chest 1996;110:767-74.
19. Hodson ME, Madden BP, Steven MH, et al. Non-invasive mechanical ventilation for cystic fibrosis patients–a potential bridge to transplantation. Eur Respir J 1991;4:524-7.
20. Confalonieri M, Potena A, Carbone G, et al. Acute respiratory failure in patients with severe community-acquired pneumonia. A prospective randomized evaluation of noninvasive ventilation. Am J Respir Crit Care Med 1999;160:1585-91.
21. Brett A, Sinclair DG. Use of continuous positive airway pressure in the management of community acquired pneumonia. Thorax 1993;48:1280-1.
22. Burns KE, Adhikari NK, Keenan SP, Meade M. Use of noninvasive ventilation to wean critically ill adults off invasive ventilation: meta-analysis and systematic review. Br Med J 2009; 338:1574.
23. Girault C, Bubenheim M, Abroug F, et al. Noninvasive ventilation and weaning in chronic hypercapnic respiratory failure patients: a randomized multicenter trial. Am J Respir Crit Care Med. 2011 Sep 15;184(6):672-9. doi: 10.1164/rccm.201101-0035OC.
24. Gristina GR, Antonelli M, Conti G, et al. Noninvasive versus invasive ventilation for acute respiratory failure in patients with hematologic malignancies: a 5-year multicenter observational survey. Crit Care Med. 2011 Oct;39(10):2232-9. doi: 10.1097/CCM.0b013e3182227a27.
25. Prevedoros HP, Lee RP, Marriot D. CPAP, effective respiratory support in patients with AIDS-related Pneumocystis carinii pneumonia. Anaesth Intensive Care 1991;19:561-6.
26. Gregg RW, Friedman BC, Williams JF, et al. Continuous positive airway pressure by face mask in Pneumocystis carinii pneumonia. Crit Care Med 1990;18:21-4.
27. Kesten S, Rebuck AS. Nasal continuous positive airway pressure in Pneumocystis carinii pneumonia. Lancet 1988;ii:1414-5.
28. Gachot B, Clair B, Wolff M, et al. Continuous positive airway pressure by face mask or mechanical ventilation in patients with human immunodeficiency virus infection and severe Pneumocystis carinii pneumonia. Intensive Care Med 1992;18:155-9.
29. Miller RF, Semple SJ. Continuous positive airway pressure ventilation for respiratory failure associated with Pneumocystis carinii pneumonia. Respir Med 1991;85:133–8.

30. Cowan MJ, Shelhamer JH, Levine SJ. Acute respiratory failure in the HIV-seropositive patient. Crit Care Clin 1997;13:523-52.