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Noninvasive Mechanical Ventilation in Acute Hypoxemic Respiratory Failure

Akut Hipoksemik Solunum Yetmezliğinde Noninvaziv Mekanik Ventilasyon

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ABSTRACT

Noninvasive mechanical ventilation is widely used for acute respiratory failure in a variety of etiologies. The recommended specific conditions were the exacerbation of chronic obstructive pulmonary disease, cardiogenic pulmonary edema, de novo acute hypoxemic respiratory failure, immunocompromized pneumonia, palliation, postoperative period, weaning and postextubation. Pneumonia and acute respiratory distress syndrome are common causes of acute hypoxemic respiratory failure. Noninvasive mechanical ventilation failure is high in this disease group compared to acute hypercapnic respiratory failure. Noninvasive mechanical ventilation can be recommended in patients with mild even in moderate acute respiratory distress syndrome and not in patients with severe acute respiratory distress syndrome. Due to insufficient evidence in patients with pneumonia and acute respiratory distress syndrome, no recommendation can be given for routine use of noninvasive mechanical ventilation. Although some patients benefit from noninvasive mechanical ventilation, they should be used by a team experienced on noninvasive mechanical ventilation in pneumonia and early acute respiratory distress syndrome. A skilled team, proper place, patient and devices can optimize prognosis. There should be a particular attention to shock, multiorgan failure and change of consciousness. Patient selection should be made correctly, considering that mortality can be seen in case of delayed intubation.
Keywords: Community-acquired pneumonia; acute respiratory distress syndrome; non-invasive ventilation.

ÖZ

Noninvaziv mekanik ventilasyon akut solunum yetmezliğinin birçok nedenlerinden dolayı yaygın olarak kullanılmaktadır. Bunlar arasında kronik obstrüktif akciğer hastalığı alevlenmesi, kardiyojenik pulmoner ödem, de novo hipoksemik solunum yetmezliği, immün sistemi baskılanmış hastalar, göğüs travması, palyatif amaçlı, ameliyat sonrası bakım, weaning ve ekstübasyon sonrası alevlenme bulunmaktadır. Pnömoni ve akut solunum sıkıntısı sendromu, akut hipoksemik solunum yetmezliğinin sık karşılaşılan nedenleridir. Noninvaziv mekanik ventilasyon başarısızlığı bu hastalık grubunda, akut hiperkapnik solunum yetmezliğine göre yüksektir. Noninvaziv mekanik ventilasyon orta-ağır akut solunum sıkıntısı sendromu hastalarında değil yalnız hafif akut solunum sıkıntısı sendromu olan hastalarda erken dönem tedavide önerilebilir. Pnömoni ve akut solunum sıkıntısı sendromu hastalarında kanıtların yetersiz olmasından dolayı noninvaziv mekanik ventilasyonun rutin kullanımıyla ilgili öneri verilememektedir. Bazı hastalar noninvaziv mekanik ventilasyondan fayda görse de pnömoni ve erken dönem akut solunum sıkıntısı sendromunda noninvaziv mekanik ventilasyon konusunda deneyimli bir ekip tarafından kullanılmalıdır. Yetenekli bir ekip, uygun yer, hasta ve cihazlar prognozu optimize edebilir. Özellikle şok, multiorgan yetmezliği ve bilinç değişikliği gibi durumlara dikkat edilmelidir. Entübasyonda gecikmeye bağlı mortalite görülebileceği göz önünde bulundurularak hasta seçimi doğru yapılmalıdır.
Anahtar kelimeler: Toplum kökenli pnömoni; akut solunum sıkıntısı sendromu; non-invaziv ventilasyon.

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INTRODUCTION

The use of noninvasive mechanical ventilation (NIV) is strongly recommended as a therapy for chronic obstructive pulmonary disease (COPD) and cardiogenic pulmonary edema (CPE); but weakly for other etiologies of hypoxemic acute respiratory failure (ARF) (1). ARF is the most important cause of hospital emergency department admissions. The major etiologies were mostly pneumonia, neuromuscular diseases, sepsis and CPE, COPD. Most of these patients underwent invasive mechanical ventilation (IMV) while lesser underwent NIV (2-4).

The use of NIV in ARF acute respiratory distress syndrome (ARDS) has been recently investigated mainly in small cohort series (5). Benefits of NIV is still an area of research in community-acquired pneumonia (CAP), asthma, ARDS and immunosuppression due to conflicting results (6-10).

In CAP, the main basis for NIV is to avoid and overcome severe respiratory failure requiring IMV and the intensive care unit (ICU) admission (11,12). However, the use of NIV in CAP is poorly strong regarding to the exacerbation of COPD. Patients with ARF due to CAP treated with NIV frequently have poor prognosis compared to COPD exacerbation and acute CPE (5). The use of NIV has the benefits and the possibility of avoiding IMV having more increased risk of ventilator-associated pneumonia, ventilator-induced lung injury, the need of more sedation, prolonged stay in hospital, upper airways complications and mortality (13-15).

The aim of this brief review is to examine the use of NIV for CAP and ARDS in the light of recent literature.

DEFINITIONS

Hypoxemic respiratory failure means failure with no known respiratory disease and defined as;

- hypoxemia ($PaO_2/FiO_2 \leq 200$),
- respiratory rate over 30/minute
- diagnosis other than COPD (CAP and/or ARDS).

Patients with CPE or with postoperative respiratory failure are not accepted due to their different pathophysiology. The aim of NIV use in these patients is to avoid intubation, improve oxygenation, decrease the work of breathing, facilitate ventilation and reduce the complications associated with IMV (16,17).

NIV IN PNEUMONIA

Pneumonia and ARDS are the common causes of hypoxemic ARF. NIV failure is higher in these patients than acute hypercapnic respiratory failure. The first study on NIV in patients with pneumonia was 56 patients with CAP and ARF separated in two groups. The half of patients with standard medical therapy and the other half with standard medical therapy plus NIV were treated, respectively (18). NIV was significantly effective only in the subgroup of patients with associated COPD. In a different study, although 24 patients with severe CAP but no known chronic lung disease hospitalized to the ICU showed initial improvement in oxygenation and respiratory rate, the intubation rate was high. Similar results with high rates of NIV failure were reported by different authors in the following studies (19). Compared to the Confalonieri et al. (19) trial Ferrer et al. (20) included more severe hypoxemic patients. They concluded that NIV might be better than oxygen alone in more severe patients.

NIV IN ARDS

In ARDS patients, the use of NIV can decrease the work of breathing compared with non-NIV (21). Hypoxemia and work of breathing return immediately upon NIV removed. This may be ameliorated by the use of high-flow nasal oxygen therapy with a specialized nasal cannula delivering heated and humidified high flow oxygen gas between 30 and 60 L/min (22). Also, the recent evidence suggests that the use of a helmet may offer better tolerance over prolonged periods together with the duration of NIV and its tolerance (23). Potential uses of NIV for de novo ARF is to avoid intubation. One pilot study with mild ARDS patients showed avoidance of intubation (24). Some studies on hypoxemic and non-hypercapnic ARF, mainly due to CAP or hospital-acquired pneumonia patients who have no major organ dysfunction, cardiac ischemia or arrhythmias, and with intact clearing secretions get benefits from NIV (25).

NIV may be recommended for early treatment in patients with mild ARDS, but not moderate-severe ARDS. Because of insufficient evidence, no recommendations can be made for the routine use of NIV in patients with pneumonia and ARDS. Although some patients benefit from NIV, pneumonia and early ARDS should be used by an experienced team with caution, especially in situations such as shock, multiorgan failure and altered consciousness. Patient selection should be made correctly, considering mortality due to delay in intubation. Therefore, the evidence from these preliminary data in patients with ARF due to pneumonia and ARDS were less likely to benefit from NIV when compared to ARF due to COPD exacerbation and CPE. However, some patients seemed to show particular benefit from a NIV trial, including subgroups of immunocompromized patients and patients with associated COPD (26).

In two previous reviews (27,28), the authors reported that urgent use of NIV decreased the rate for mortality and intubation. Due to the population heterogeneity among different etiologies, this relation raised several questions regarding results. A recent study looked at available evidence on hypoxemic ARF and reported same results to those presented in David-João PG et al. (29) review. For the CPE/CAP group, one study (20) showed benefits for the use of NIV, especially in the pneumonia group. However, these results were contrary to those in another study (30).

The use of NIV in ARF is weakly recommended for hypoxemic ARF patients according to European Guideline. While strong recommendation for the COPD patients was mentioned as in previous literature (31). Considering the subgroups of immunosuppressed patients and APE/CAP from well-designed randomized studies, the conflicting results from observational studies significantly limited the power of evidence for recommendations in this particular group of patients (32).

A recent systematic review on the effect of NIV in patients with hypoxemic ARF regarding intubation and mortality showed better outcomes and benefits in immunosuppressed and APE/CAP patients. That study

showed that patients had lower intubation and mortality rate with the use of NIV in patients with hypoxemic ARF due to immunosuppression and APE/CAP (29).

HIGH FLOW OXYGEN SYSTEM IN PNEUMONIA AND ARDS

Until recently, NIV for hypoxemic ARF compared it with oronasal oxygen are the most studied clinical entity. Recently, high-flow oxygen (HFO) has been offered several advantages according to NIV, including dead space reduction and better tolerance (33). A new study reported a survival advantage of HFO comparing to oxygen therapy and NIV. But, still the intubation rate was not significantly different (34). Although HFO therapy is not specifically addressed in these recommendations, it may play an important role in the therapy of de novo ARF in the future.

NIV USE IN ARF DUE TO VIRAL PNEUMONIA

NIV use in viral pneumonia leading to severe ARF has been presented in several nonrandomized studies or case reports. Failure rates are changing between 30% and 33% (35). In more recent studies, failure rates are between 13% and 77% when NIV was also applied to influenza A H1N1 infection patients (36,37). Moreover, no randomized control studies recommend NIV in these particular groups of patients.

FACTORS PREDICTIVE OF NIV FAILURE

Potential predictors of NIV success and failure have been recently investigated in a number of studies (Table 1). The main risk of NIV due to hypoxemic ARF is to delay intubation (25). Early predictors of NIV failure include older age, high score, ARDS or pneumonia, no improvement 1 h after treatment. Negative predictors are low pH, high SAPS II score, low PaO_2/FiO_2, lower postNIV-preNIV deltas of PaO_2/FiO_2. PaO_2/FiO_2 was most important parameter for us to decide to intubate patient. In presence of predictors of NIV failure, NIV should be avoided to minimize potential mortality. Therefore, a prompt and accurate evaluation that can predict NIV failure or success may help us to select those that are most likely to respond to NIV and may avoid delay in ETI (39).

WHAT WILL BE A POTENTIAL ALGORHYTM IN CAP OR ARDS

Although the main rationale for selecting NIV in patients with severe ARF due to CAP or ARDS is to avoid the complications due to IMV, Clinicians should keep in mind the predictors regarding NIV failure to prevent delay in ETI (Figure 1). Patients with CAP and severe ARF

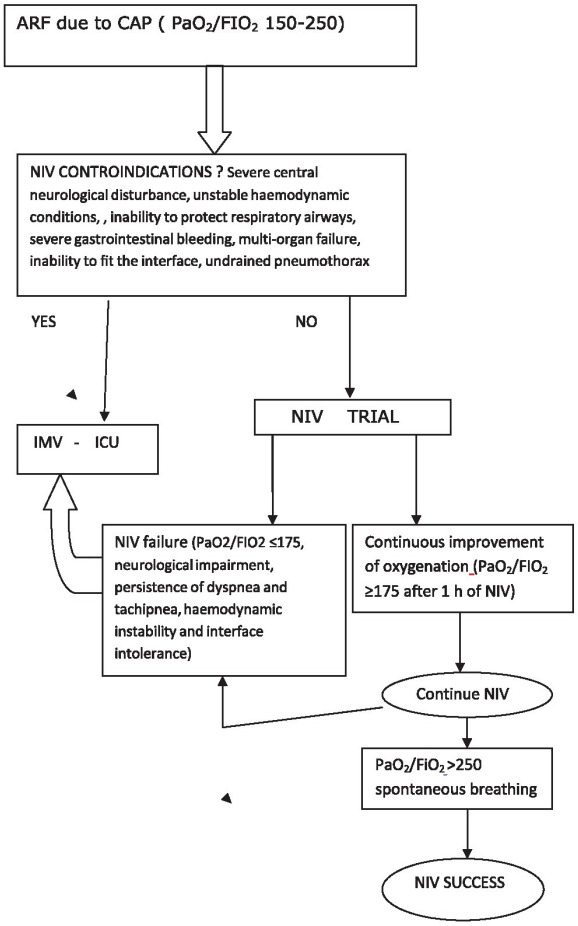

Figure 1. An algorithm for NIV application in CAP and/or ARDS (38)

Table 1. Factors predictive of NIV failure (38)

Carron M, et al. J Crit Care. 2010	Post-NIV to pre-NIV deltas of PaO_2/FiO_2 ratio Post-NIV to pre-NIV deltas of oxygenation index
Carrillo A, et al. Intensive Care Medicine. 2012	Worsening radiologic infiltrate 24 hours after admission Maximum sepsis-related organ failure assessment (SOFA) score Higher heart rate after 1 hour of NIV (compared to pre-NIV) Lower PaO_2/FiO_2 ratio after 1 hour of NIV (compared to pre-NIV) Lower serum bicarbonates after 1 hour of NIV (compared to pre-NIV)
Nicolini A, et al. Clin Respir J. 2014	Extensive chest X-ray involvement on admission Chest X-ray worsening 24 hours after admission Lower PaO_2/FiO_2 ratio after 1 hour of NIV (compared to pre-NIV) Higher A-aDO_2 after 1 hour of NIV (compared to pre-NIV)
Murad A, et al. J Crit Care. 2015	Vasopressor use at 2 hours after NIV initiation

NIV: Non-invasive ventilation, PaO_2/FiO_2: Partial pressure of arterial oxygen, to the fraction of inspired oxygen, A-aDO_2: Alveolar-arteriolar oxygen gradient

evolving into ARDS could safely be treated up to a PaO_2/FiO_2 ratio as low as 150 NIV. The place of application and timing are other two important parameters in the success of NIV. Continuous monitoring must be done to avoid delayed intubation in these patients (40).

CONCLUSIONS

NIV reduces the requirement for ETI and ICU mortality in selected APE/CAP and immunosuppressed patients. Although recent publications are encouraging for NIV application, it is inevitable for us to be careful for proper patient selection in CAP. It is better to limit NIV use in patients with mild and moderate disease (PaO_2/FiO_2 ratio above 150 at presentation, 1 hour after NIV application over >175). In order to early detect NIV failure, close monitoring and management by skilled personnel are needed to avoid ETI delay. There are more randomized controlled studies to understand the limit and indications of NIV in hypoxemic ARF.

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