Noninvasive Mechanical Ventilation in Acute Hypoxemic Respiratory Failure

Akut Hipoksemik Solunum Yetmezliğinde Noninvaziv Mekanik Ventilasyon

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


Anahtar kelimeler: Toplum kökenli pnömoni; akut solunum sıkıntısı sendromu; non-invaziv ventilasyon.
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 (PaO2/FIO2 ≤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 PaO2/FiO2, lower postNIV-preNIV deltas of PaO2/FiO2. PaO2/FiO2 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).

Table 1. Factors predictive of NIV failure (38)

<table>
<thead>
<tr>
<th>Study</th>
<th>Factors Predictive of NIV Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Post-NIV to pre-NIV deltas of oxygenation index</td>
</tr>
<tr>
<td></td>
<td>Worsening radiologic infiltrate 24 hours after admission</td>
</tr>
<tr>
<td></td>
<td>Maximum sepsis-related organ failure assessment (SOFA) score</td>
</tr>
<tr>
<td>Carrillo A, et al. Intensive Care Medicine. 2012</td>
<td>Higher heart rate after 1 hour of NIV (compared to pre-NIV)</td>
</tr>
<tr>
<td></td>
<td>Lower PaO2/FiO2 ratio after 1 hour of NIV (compared to pre-NIV)</td>
</tr>
<tr>
<td></td>
<td>Lower serum bicarbonates after 1 hour of NIV (compared to pre-NIV)</td>
</tr>
<tr>
<td></td>
<td>Chest X-ray worsening 24 hours after admission</td>
</tr>
<tr>
<td></td>
<td>Lower PaO2/FiO2 ratio after 1 hour of NIV (compared to pre-NIV)</td>
</tr>
<tr>
<td></td>
<td>Higher A-aDO2 after 1 hour of NIV (compared to pre-NIV)</td>
</tr>
</tbody>
</table>

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)](image-url)
evolving into ARDS could safely be treated up to a PaO\textsubscript{2}/FiO\textsubscript{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\textsubscript{2}/FiO\textsubscript{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 hypoxicem ARF.

**REFERENCES**