Non-invasive ventilation (NIV) via nasal or full face mask can be applied in respiratory failure due to chronic obstructive pulmonary disease (COPD) both in the acute and long-term settings. In acute exacerbation of COPD with respiratory failure it may be considered as a standard treatment. There is strong evidence that NIV might reduce intubation, complication, and mortality rate in patients with acute hypercapnia (PaCO$_2$ >45 mmHg). The method is cost effective and reduces hospital stay. NIV might be also useful in the weaning of COPD patients from invasive ventilation. On the other hand, for severe stable disease the data concerning a positive effect of NIV are less convincing. Preliminary evidence suggests that NIV improves gas exchange, sleep quality and quality of life and might reduce the need for hospitalization. Especially, COPD patients with substantial chronic hypercapnia (PaCO$_2$ >55 mmHg) and/or nocturnal hypoventilation, and those with repeated exacerbations may profit from NIV. In any case, NIV is a very valuable and effective tool in the non-pharmacological treatment of COPD. Every clinician who is involved in the management of COPD patients with respiratory insufficiency should be able to apply this technique.

**Key words:** COPD, respiratory failure, non-invasive ventilation

The respiratory system consists of two main parts: the lung for gas exchange and the respiratory pump for ventilation of the lungs. Disturbances of gas exchange are treated by oxygen and impairment of ventilation is treated by ventilatory support. Mechanical ventilation is the most often used supportive technique in severe respiratory failure. Several forms of ventilatory support have been described in the last decades to assist or substitute the failing respiratory pump. More recently, new non-invasive ventilatory techniques have been
inaugurated, which use nasal or facial masks as an interface instead of tracheal tubes. This technique is called non-invasive ventilation (NIV) (1, 2). NIV can be used in the case of respiratory failure in chronic obstructive pulmonary disease (COPD). Such a failure might result from mechanical disturbances (due to hyperinflation or airway obstruction), central depression (due to extensive hypercapnia) or muscle fatigue (3). There are three important points in time for the use of NIV in COPD:

1. Acute exacerbation of COPD
2. Weaning process of invasively ventilated patients
3. Stable disease

Effects and indications for the use of NIV in COPD in these three situations shall be summarized.

Table 1. Intubation rate of patients with COPD and acute respiratory failure. Comparison of patients treated with standard therapy (controls) with those treated additionally with non-invasive ventilation (NIV).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Control (n)</th>
<th>NIV (n)</th>
<th>Intubation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bott et al. 1993</td>
<td>30</td>
<td>30</td>
<td>30 % vs. 4 %*</td>
</tr>
<tr>
<td>Kramer et al. 1995</td>
<td>12</td>
<td>11</td>
<td>73 % vs. 9 %*</td>
</tr>
<tr>
<td>Brochard et al. 1995</td>
<td>42</td>
<td>43</td>
<td>74 % vs. 26 %*</td>
</tr>
<tr>
<td>Barbè et al. 1996</td>
<td>10</td>
<td>14</td>
<td>0 % vs. 0 %</td>
</tr>
<tr>
<td>Celikel et al. 1998</td>
<td>15</td>
<td>15</td>
<td>40 % vs. 7 %*</td>
</tr>
<tr>
<td>Martin et al. 2000</td>
<td>11</td>
<td>12</td>
<td>45 % vs. 25 %*</td>
</tr>
<tr>
<td>Plant et al. 2000</td>
<td>118</td>
<td>118</td>
<td>27 % vs. 15 %*</td>
</tr>
</tbody>
</table>

*P<0.05

Table 2. In-hospital mortality rate of patients with COPD and acute respiratory failure. Comparison of patients treated with standard therapy (controls) with those treated additionally with non-invasive ventilation (NIV).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Control (n)</th>
<th>NIV (n)</th>
<th>Mortality rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bott et al. 1993</td>
<td>30</td>
<td>30</td>
<td>30 % vs. 10 %*</td>
</tr>
<tr>
<td>Kramer et al. 1995</td>
<td>12</td>
<td>11</td>
<td>13 % vs. 6 %</td>
</tr>
<tr>
<td>Brochard et al. 1995</td>
<td>42</td>
<td>43</td>
<td>29 % vs. 9 %*</td>
</tr>
<tr>
<td>Barbè et al. 1996</td>
<td>10</td>
<td>14</td>
<td>0 % vs. 0 %</td>
</tr>
<tr>
<td>Martin et al. 2000</td>
<td>11</td>
<td>12</td>
<td>9 % vs. 8 %*</td>
</tr>
<tr>
<td>Plant et al. 2000</td>
<td>118</td>
<td>118</td>
<td>20 % vs. 10 %*</td>
</tr>
</tbody>
</table>

*P<0.05
Acute exacerbation of COPD

Using matched controls, Brochard et al. (4) were the first to show that NIV reduces the need for intubation, duration of mechanical ventilation, and intensive care unit stay in patients with acute exacerbation of COPD in comparison to conventional therapy. These findings were confirmed by several randomized and controlled studies of the last decade (5, 6, 7, 8, 9, 10, 11). A recent Cochrane Analysis confirmed that in acute exacerbation of COPD NIV results in a lower mortality (relative risk 0.42) and a lower need for intubation (relative risk 0.42), if using this method in addition to standard therapy (12). The studies are summarized in Table 1 and Table 2. In two of these studies the stay in the intensive care unit (ICU) or in the hospital could also be reduced significantly (7, 8). However, the latter result was not consistent in all studies (Table 3). NIV is a highly cost effective treatment that reduces mortality, even if it is used outside the ICU. Referring to the data of the United Kingdom, the incremental cost effectiveness ratio per death avoided is £ 955, - (13). Indications and contraindications for the use of NIV in acute exacerbation of COPD are summarized in Table 4.

**Table 3.** ICU/Hospital stays of patients with COPD and acute respiratory failure. Comparison of patients treated with standard therapy (controls) with those treated additionally with non-invasive ventilation (NIV).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Control (n)</th>
<th>NIV (n)</th>
<th>ICU/Hospital stay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bott et al. 1993</td>
<td>30</td>
<td>30</td>
<td>9 d vs. 9 d</td>
</tr>
<tr>
<td>Kramer et al. 1995</td>
<td>12</td>
<td>11</td>
<td>17 d vs. 15 d</td>
</tr>
<tr>
<td>Brochard et al. 1995</td>
<td>42</td>
<td>43</td>
<td>35 d vs. 23 d*</td>
</tr>
<tr>
<td>Barbè et al. 1996</td>
<td>10</td>
<td>14</td>
<td>11 d vs. 11 d</td>
</tr>
<tr>
<td>Celikel et al. 1998</td>
<td>15</td>
<td>15</td>
<td>15 d vs. 12 d*</td>
</tr>
<tr>
<td>Martin et al. 2000</td>
<td>11</td>
<td>12</td>
<td>5 d vs. 6 d</td>
</tr>
<tr>
<td>Plant et al. 2000</td>
<td>118</td>
<td>118</td>
<td>10 d vs. 10 d</td>
</tr>
</tbody>
</table>

*P<0.05

**Acute exacerbation of COPD**

Using matched controls, Brochard et al. (4) were the first to show that NIV reduces the need for intubation, duration of mechanical ventilation, and intensive care unit stay in patients with acute exacerbation of COPD in comparison to conventional therapy. These findings were confirmed by several randomized and controlled studies of the last decade (5, 6, 7, 8, 9, 10, 11). A recent Cochrane Analysis confirmed that in acute exacerbation of COPD NIV results in a lower mortality (relative risk 0.42) and a lower need for intubation (relative risk 0.42), if using this method in addition to standard therapy (12). The studies are summarized in Table 1 and Table 2. In two of these studies the stay in the intensive care unit (ICU) or in the hospital could also be reduced significantly (7, 8). However, the latter result was not consistent in all studies (Table 3). NIV is a highly cost effective treatment that reduces mortality, even if it is used outside the ICU. Referring to the data of the United Kingdom, the incremental cost effectiveness ratio per death avoided is £ 955, - (13). Indications and contraindications for the use of NIV in acute exacerbation of COPD are summarized in Table 4.

**Table 4.** Use of NIV in acute exacerbation of COPD (2).

**Indications**
- Symptoms and signs of acute respiratory distress (dyspnea, RR >24, accessory muscle use, paradoxical breathing)
- Gas exchange abnormalities (PaCO2 >45 mm Hg, pH <7.35 or PaO2/FiO2 <200)

**Contraindications**
- Respiratory arrest
- Medical instability
- Inability to protect airways
- Excessive secretions
- Agitation or uncooperativeness
- Facial trauma, burns, surgery, anatomic abnormalities interfering with mask fit
Weaning process of invasively ventilated patients

There are three randomized, controlled trials concerning the early extubation and switching to NIV in patients with COPD. Two of the studies demonstrated a significant benefit from such a maneuver. Nava et al. (14) have shown a superior overall weaning rate after 60 days (88 % vs. 68 %), a briefer ICU stay (15.1 d vs. 24.0 d), and a better 60-day survival (92 % vs. 72 %) (all P< 0.05), and no nosocomial pneumonia in the NIV group. These results were recently confirmed by Ferrer et al. (15). Another study, however, showed only a tendency to fewer complications, but was unable to demonstrate significant improvements in other outcome measures (16). Recently, Hill et al. (1) have proposed exclusion criteria for an early extubation and thus for the too early use of NIV in the weaning process of patients with COPD (Table 5). Only does one randomized controlled study deal with the use of NIV in the prevention of extubation failure. The study has actually been published in a preliminary form (17). In that study, an increased mortality in the NIV group was shown, possibly related to a delayed reintubation. The final publication of the study should be awaited with great interest.

Table 5. Exclusion criteria for early extubation in patients with COPD (1).
- High levels of pressure support prior to extubation (>20 cmH\textsubscript{2}O)
- Inability to sustain 5-10 min of unassisted breathing
- Prior difficult intubation
- Copious secretion
- Weakness of cough
- Multiple comorbidities

Table 6. Recommendations for NIV in stable COPD (20)
- Significant symptoms of nocturnal hypoventilation
- No toleration of long-term oxygen therapy because of hypercapnia
- Repeated episodes of hospitalization

Stable disease

Two controlled studies demonstrated an improvement in gas exchange during both daytime and sleep and better quality-of-life scores, while using NIV in stable chronic COPD (18). However, in contrast to the acute setting, there has been no effect on survival. Recommendations for the use of NIV in stable COPD have to-date been proposed by Elliott (19) and are summarized in Table 6. Future studies ought to focus on patients with sustained hypercapnia with the endpoints of survival, quality of life, and economic evaluation.

REFERENCES


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