Role of non invasive ventilation in limiting re-intubation after planned extubation

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Abstract
Introduction: In critically ill adult patients, particularly patients with chronic obstructive pulmonary disease (COPD), early use of non invasive ventilation (NIV) after weaning may be associated with the decrease of mortality. The effect of this benefit is not so clear in ICU mixed populations.

Aim of the work: Compare the efficacy of NIV to Oxygen Mask in preventing re-intubation if NIV was used immediately following planned extubation in patients with respiratory failure of various etiologies requiring mechanical ventilation for more than 48 h.

Patients and methods: One hundred and twenty patients were randomly enrolled in this study. Sixty patients assigned to the noninvasive-ventilation group received ventilation through a full facial mask from a BIPAP ventilator located in the intensive care unit immediately after extubation (group I) while the other sixty patients put on oxygen mask group will be (group II) and act as control group.

Results: There was no significant difference regarding sex distribution and smoking pattern, also APACHE II score, hemodynamic and electrolytes which might have a role in respiratory failure showed no statistically significant differences between both studied groups. The mean duration of mechanical ventilation was lower in group I than in group II, 6.2 ± 1.6 versus 7.1 ± 1.8 days, respectively, however this difference was not significant (p=0.09). The overall re-intubation rate (15%) was significantly lower in group I compared to group II which was 25% and p-value 0.04. The re-intubation rate of COPD patients in group I was statistically lower than group II (p=0.019). Hospital mortality rate showed a statistically significant difference between both groups, with four deaths during ICU stay in the NIV group (6.6%), while there were 10 deaths (16.6%) in the Oxygen Mask group (p < 0.035).

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Introduction

Mechanical ventilation supports many patients for respiration and without this, they would die within hours to days due to acute hypoxaemic and hypercapnic respiratory failure. Observational, physiological and case/control studies form a large body of evidence demonstrating that noninvasive ventilation (NIV) can be used in many situations to decrease a patient’s dyspnea and work of breathing, improve gas exchange and ultimately avoid the need for endotracheal intubation (ETI) [1–3].

In critically ill adult patients, particularly patients with chronic obstructive pulmonary disease (COPD), early noninvasive ventilation weaning is associated with the decrease of mortality, ventilator-associated pneumonia, and length of stay in the intensive care unit and hospital, total duration of mechanical ventilation, and duration of invasive ventilation [4–6]. The effect of this benefit is not so clear in ICU mixed populations [7]. Patients who require re-intubation have been noted to have a significantly higher mortality rate than those who are successfully extubated on the first attempt [8,9]. The reasons for their increased risk of death may include both difficulties encountered during the re-intubation period and the development of additional ventilator-related complications, such as pneumonia [10].

The need for re-intubation may also be a marker of increased severity of illness, but after adjustment for coexisting conditions and severity of illness, extubation failure is still an independent predictor of death [8]. This suggests that, at least to some extent, the increased mortality seen in these patients may be reduced by treatments aimed at reducing either the need for re-intubation or its subsequent complications. Noninvasive positive-pressure ventilation has been deemed by international consensus conference to be a promising therapy after failure of extubation.

The process of discontinuing mechanical ventilation must balance the risk of complications due to unnecessary delays in extubation with the risk of complications due to premature discontinuation and the need for re-intubation [11].Evidence-based guidelines recommend a trial of spontaneous breathing to determine, in any given patient, whether mechanical ventilation can be successfully discontinued [12]; with this approach, the documented need for re-intubation ranges from 13 to 19% [13,14]. By providing respiratory support without ETI, noninvasive positive pressure ventilation (NPPV) may be, in appropriately selected patients, an extremely valuable alternative to IMV. It is generally much safer than IMV and has been shown to decrease resource utilization and to avoid the myriad of complications associated with ETI, including upper airway trauma, laryngeal swelling, post extubation vocal cord dysfunction, and nosocomial infections [15].

The aim of this work was to compare the efficacy of NIV to Oxygen Mask in preventing re-intubation if NIV was used immediately following planned extubation in patients with respiratory failure requiring mechanical ventilation for more than 48 h.

Patients and methods

We undertook a randomized controlled study in the general intensive-care units of Riyadh Care Hospital, Saudi Arabia, that approved by ethics committee. One hundred and twenty patients were enrolled in the study consecutively between July 2011 and July 2012. Patients included in the study had to be older than 18 years of age suffering respiratory failure and were intubated and mechanically ventilated for 48 h or more. Patients who tolerated a weaning trial after recovery of their disease that caused respiratory failure were deemed eligible for the study.

Exclusion criteria were: facial or cranial trauma or surgery; recent abdominal surgery (during the current hospital admission); active upper gastrointestinal bleeding; excessive amount of respiratory secretions and patients with tracheostomy. Uncooperative state with inability to understand or unwillingness to follow the protocol’s instructions; upper-airway disorders were also excluded.

In all the participating intensive care units, the following procedures were in place for the discontinuation of mechanical ventilation. Discontinuation was considered appropriate when all of the following criteria were met: the underlying cause of acute respiratory failure had improved; the patient was alert and able to communicate, temperature was less than 38 °C; there was no need for vasoactive drugs, and the partial pressure of oxygen was greater than 60 mmHg while the patient was breathing an inspired fraction of oxygen of 0.40 or less with a positive end-expiratory pressure of 5 cm of water or less. Discontinuation of mechanical ventilation was performed when pressure support decreased gradually to 7 cm of water for up to 120 min.

Patients assigned to the noninvasive-ventilation group received ventilation through a full facial mask from a BIPAP ventilator located in the intensive care unit immediately after extubation. The initial IPAP and EPAP values were 10 cmH2O and 5 cmH2O, respectively. Values were adjusted whenever required. In cases of hypoxemia with PaO2 < 60 mmHg and/or SaO2 < 90%, IPAP was increased by 2 cmH2O until hypoxemia improved. Before ventilation was begun, the head of the patient’s bed was positioned at a 45-degree angle. The initial ventilator mode was followed, to a respiratory rate of less than 25 breaths per minute. The fraction of inspired oxygen and the positive end-expiratory pressure were titrated to maintain the arterial oxygen saturation above 90%. The ventilator settings were subsequently adjusted as needed for the patient’s comfort (notably, if there was a decrease in the respiratory rate and heart rate); The facial skin was assessed every 4 h to prevent damage from the tightly fitting face mask used to deliver.

Conclusion: Early application of non invasive ventilation could be effective in limiting the need for re-intubation and decrease mortality in electively extubated patients with various aetiologies of respiratory failure. Also selected patients with respiratory failure (COPD) may get more benefit from this therapy.
the ventilation. The patients in this group were encouraged to use noninvasive ventilation continuously for 12 h periods after taking medical consent. The face mask could be removed, however, for 15-to-20-min periods to allow the patient to drink fluids or receive nursing care.

Patients were reintubated if they met at least one of the following criteria (as judged after they had undergone the assigned treatment for at least 1 h):

- Lack of improvement in the partial pressure of carbon dioxide.
- Decrease in the oxygen saturation to less than 85%, despite the use of a high fraction of inspired oxygen.
- Changes in mental status.
- Signs of respiratory-muscle fatigue.
- Hypotension or copious secretions.

The final decision to reintubate was made by the treating physician, who recorded the single most relevant reason. The primary endpoint was rate of re-intubation after planned extubation. The secondary endpoint was survival till ICU discharge or death.

All patients were mechanically ventilated for at least 48 h, during this period they were subjected to the following: Full medical history is taken from the patient’s relatives and assessment of other co morbidities. Routine laboratory study was done including serum electrolyte and arterial blood gases analysis. Neurological assessment by Glasgow Coma Scale (GCS) (without sedation), APACHE II score, maximum inspiratory pressure (PIMax) just before weaning is recorded. Respiratory rate and exhaled tidal volume to get the rapid shallow breathing index (RSBI), airway occlusion pressure (P0.1) and [compliance, respiratory rate, oxygenation and pressure system (CROP) index were also recorded.

Patients were randomized immediately before planned extubation. After randomization sixty patients assigned to non invasive ventilation will be in group I, while the other sixty patients assigned to oxygen mask group will be in group II and act as the control group. Those patients belonging to group II received oxygen immediately after extubation through a facial mask with a flow of 5 L/min. Arterial blood gas analyses were carried out by radial artery puncture just before extubation for all patients or when ever needed. Patients were followed up throughout their ICU stay. The need for re-intubation was recorded as well as the length of ICU stay and mortality. Results are expressed as mean ± SD; normally distributed variables were compared by Student’s t test. Categorical data were assessed using Fisher two tailed exact tests. p < 0.05 was considered statistically significant.

Results

One hundred and twenty mechanically ventilated patients with different causes of respiratory failure (RF) were included in this study; they were 73 males and 47 females. They were divided into 2 groups: Group I: successful weaning patients followed by non invasive ventilation (60 patients), their mean age was 64.1 ± 6.6 years. Group II: successful weaning patients followed by simple face mask (60 patients) their mean age was 68.9 ± 7.2 years with no significant difference between both groups (p = 0.58). There was no significant difference regarding sex distribution and smoking pattern (p = 0.4) in both groups. Also the prevalence of chronic diseases like hypertension, diabetes mellitus and ischemic heart diseases showed no significant difference in both groups. APACHE II score, hemodynamic and electrolytes which might have a role in respiratory failure showed no statistically significant differences between both studied groups (Table 1).

The mean duration of mechanical ventilation was lower in group I than in group II, 6.2 ± 1.6 versus 7.1 ± 1.8 days, respectively, however this difference was not significant (p = 0.09). In this study, there was no significant difference between weaning predictors among both groups RSBI, CROP, P0.1, and PIMax between non invasive ventilation group (group I) and simple face mask group (group II). Also the mean weaning hours was lower in (group I) compared to (group II), 39 ± 1.8 versus 42 ± 2.3 h, respectively, however this difference was not significant (p = 0.07). The data of ABG just before extubation were as follows: Mean PaCO₂ was 39.9 ± 6.3 mmHg in NIV group and 42.8 ± 7.7 mmHg in oxygen mask group (p = 0.1). Mean PaO₂ was 64.7 ± 3.01 mmHg in NIV group and 63.6 ± 2.8 in oxygen mask group (p = 0.8). Mean pH was 7.36 ± 0.04 in NIV group and 7.35 ± 0.05 in the oxygen mask group, with no

| Parameters                                | Group I      | Group II     | p-Value |
|-------------------------------------------|--------------|--------------|---------|
| Total number of patients                  | 60           | 60           |         |
| Age (Mean ± SD)                          | 64.1 ± 6.6   | 68.9 ± 7.2   | 0.58    |
| Male n (%)                               | 39 (65%)     | 34 (57%)     | 0.36    |
| Female n (%)                             | 21 (35%)     | 26 (43%)     | 0.2     |
| Smoking n (%)                            | 21 (35%)     | 19 (32%)     | 0.4     |
| Number of diabetics n (%)                | 17 (28%)     | 14 (23%)     | 0.3     |
| Number of hypertensive n (%)             | 16 (26%)     | 17 (28%)     | 0.6     |
| Number of I.H.D n (%)                    | 5 (8%)       | 3 (5%)       | 0.1     |
| Glasgow coma scale mean ± SD             | 13.8 ± 1.1   | 13.1 ± 1.5   | 0.07    |
| APACHE II Score mean ± SD                | 23.2 ± 5.4   | 21.8 ± 6.1   | 0.08    |
| Duration of MV, mean ± SD                | 6.2 ± 1.6    | 7.1 ± 1.8    | 0.09    |
| Weaning in hours mean ± SD               | 8.3 ± 3.1    | 11.6 ± 2.6   | 0.04    |
| Number of deaths in ICU n (%)            | 4 (6.6%)     | 10 (16.6%)   | 0.047   |

I.H.D., ischemic heart disease; n (%), number (percentage); ICU, intensive care unit; MV, mechanical ventilation.
The causes for re-intubation in both groups are shown in Table 7. ICU length of stay was statistically different between the groups, with a mean of 8.3 ± 3.1 in NIV group and 11.6 ± 2.6 days in Oxygen Mask group (p = 0.037). Hospital mortality rate showed a statistically significant difference between both groups, with four deaths in the NIV group (6.6%), while there were 10 deaths (16.6%) in the Oxygen Mask group (p < 0.035). It is necessary to stress that all patients that died had been re-intubated. The causes of death in group I were pneumonia with sepsis in three patients and one with cerebrovascular accident. On the other side in (group II), six patients died due to pneumonia with sepsis, while two with cerebrovascular accident and another two patients with multipal organ dysfunction syndromes.

Discussion

The use of non invasive ventilation decreases the occurrence of ventilator associated pneumonia, length of ICU and Hospital stay, total duration of mechanical ventilation, besides reducing patients’ mortality [6,16,17]. Most of studies for non invasive ventilation have assessed its role in limiting the need for primary endotracheal intubation in patients with acute respiratory failure [18,19] Relevant published evidence revealed that in patients with acute respiratory failure early extubation with immediate application of non-invasive ventilation has a positive impact on outcomes, turning to advantage when compared with continuous invasive weaning, however this was in COPD patients that failed in spontaneous breathing trials [4]. The effect of this benefit is not so clear in ICU mixed populations [4,7].

The aim of this study is to clarify the role of non-invasive ventilation in preventing re-intubation if was used immediately following planned extubation in patients suffered respiratory failure of various aetiologies and requiring invasive mechanical ventilation for more than 48 h. The secondary objectives were to evaluate the differences between the study groups concerning intensive care unit length of stay and hospital mortality. The results of our study confirm the benefits of early use of non-invasive ventilation after extubation to diminish risk of respiratory failure.

This strategy resulted in lowered mortality in our patients used non-invasive ventilation (group I) after extubation. Those patients may have a risk of re-intubation after planned extubation, confirmed by the rate of re-intubated (25%) in group II representing the control group. However, Keenan et al., showed that if NIV is administered to those patients developed respiratory distress will not be able to prevent re-intubation [20]. The timing of the initiation of non-invasive ventilation could be important in explaining inability of NIV to prevent mortality, chronic obstructive pulmonary disease.

| Table 2 | Admission diagnosis of both studied groups. |
|----------|-------------------------------------------|
| Diagnosis, n (%) | Group I | Group II |
| COPD | 19 (31.6%) | 16 (26.6%) |
| Pneumonia | 12 (20%) | 17 (28.3%) |
| Sepsis | 7 (11.6%) | 9 (15%) |
| Pulmonary edema | 6 (10%) | 3 (5%) |
| Cerebrovascular accident | 5 (8.3%) | 6 (10%) |
| Status epilepticus | 4 (6.6%) | 1 (1.6%) |
| Renal failure | 2 (3.3%) | 4 (6.6%) |
| Hepatic encephalopathy | 0 (0%) | 3 (5%) |
| Status asthmaticus | 2 (3.3%) | 0 (0%) |
| Others | 3 (5%) | 1 (1.6%) |

COPD, chronic obstructive pulmonary disease.

| Table 4 | Laboratory study in both groups. |
|----------|---------------------------------|
| | Group I | Group II | p-Value |
| Mean albumin g/dl Mean ± SD | 3.1 ± 0.3 | 2.9 ± 0.5 | 0.06 |
| Mg (mg/dl) Mean ± SD | 1.7 ± 0.5 | 1.5 ± 0.4 | 0.4 |
| Ca (mg/dl) Mean ± SD | 7.7 ± 0.5 | 7.8 ± 0.6 | 0.9 |
| Ph (mg/dl) Mean ± SD | 3.3 ± 0.3 | 3.5 ± 0.4 | 0.5 |
| K (mg/dl) Mean ± SD | 3.6 ± 0.7 | 3.7 ± 0.6 | 0.3 |
| Na (mg/dl) Mean ± SD | 136 ± 7 | 135 ± 6 | 0.35 |
| Lactate mmol/L | 1.5 ± 0.6 | 1.4 ± 0.7 | 0.4 |

| Table 5 | Respiratory data among both groups. |
|----------|-----------------------------------|
| | Group I | Group II | p-Value |
| pH | 7.36 ± 0.04 | 7.35 ± 0.05 | 0.39 |
| Fio₂ (%) | 36% ± 6% | 37% ± 7% | 0.6 |
| Pao₂ (mmHg) | 64.7 ± 3.01 | 63.6 ± 2.8 | 0.8 |
| O sat% | 91 ± 2.6 | 92 ± 3.2 | 0.5 |
| Paco₂ (mm Hg) | 39.9 ± 6.3 | 42.8 ± 7.7 | 0.1 |
| HCO₃ mmol/L | 27.6 ± 5.8 | 26.3 ± 4.8 | 0.7 |

| Table 3 | Hemodynamic parameter in both groups. |
|----------|--------------------------------------|
| | Group I | Group II | p-Value |
| Heart rate (beats/min) | 96 ± 22 | 94 ± 26 | 0.41 |
| Temperature | 36.4 ± 0.7 | 36.8 ± 0.8 | 0.9 |
| Systolic blood pressure (mmHg) | 113 ± 12.4 | 117 ± 14.3 | 0.31 |
| Diastolic blood pressure (mmHg) | 73 ± 6.1 | 76 ± 4.7 | 0.6 |
re-intubation. In our study, the real effectiveness and relevance of rescue therapy with non-invasive ventilation may appear in limiting the rate of reintubation as there was significant difference between non invasive ventilation group and simple face mask group (p = 0.04).

Furthermore the superiority of immediate use of non-invasive ventilation over standard medical treatment appeared also in high risk COPD subgroup as the rate of reintubation was significantly lower in COPD patients belonging to group I if compared to that one in group II (p = 0.019). Our results are supported by Ferrer et al., when he found 41% of the control group were reintubated and these results confirmed also by Burns et al.[4,21]. On the other hand Esteban et al., started non invasive positive-pressure ventilation when respiratory failure first developed a matter that made his observation differed from our study as the rate of death in the intensive care unit appeared to be greater among patients assigned to non invasive ventilation than those assigned to standard therapy.

The main finding of this study is that non-invasive ventilation decreases the rate of reintubation could be related to the success of the health care team using the technique of non invasive ventilation. Another point that may explain the difference in our study was starting non invasive ventilation immediately after extubation. A finding that helps the comparison to be fair in our study, the results of some weaning predictors among both groups like CROP, RSBI, P0.1, and PImax which are reliable and integrative, they are affected by not only the respiratory system mechanics but also other factors such as chest and abdominal wall compliance[23].

Those weaning predictors as well as the arterial blood gases data before extubation showed no significant difference between both studied groups. Other factor that allowed a better evaluation, ICU length of stay was significantly lower in group I that could be explained by the lower rate of re-intubation. Further studies with a larger population should be carried out to confirm the favorable results obtained in this study and encourage the use of non invasive ventilation to prevent re-intubation in patients that needed invasive mechanical ventilation for longer duration. In conclusion early application of non invasive ventilation could be effective in limiting the need for re-intubation and decrease mortality in electively extubated patients with various aetiologies of respiratory failure. Also selected patients with respiratory failure (COPD) may get more benefit from this therapy.

Conflict of interest

None declared.

Table 6 Comparison between weaning predictors among both groups.

|                  | Group I   | Group II  | p-Value |
|------------------|-----------|-----------|---------|
| Minute ventilation (l/min) | 10.3 ± 0.9 | 9.9 ± 0.8 | 0.13    |
| Respiratory rate (breaths/min) | 27.1 ± 4.5 | 28.2 ± 5.7 | 0.64    |
| RSBI             | 93.9 ± 31.8 | 95.9 ± 34.1 | 0.7     |
| CROP             | 45.8 ± 23.4 | 46 ± 21.3 | 0.8     |
| P0.1             | 2.7 ± 1.7 | 2.4 ± 1.6 | 0.4     |
| PImax            | 33 ± 11.6 | 34 ± 13.7 | 0.65    |

RSBI, Rapid shallow breathing index; CROP, compliance, respiratory rate, oxygenation and pressure system; P0.1, Airway occlusion pressure; PIMax, maximum inspiratory pressure index.

Table 7 Causes of reintubation.

|                  | Group I   | Group II  | p-Value |
|------------------|-----------|-----------|---------|
| Excess secretion | 4 (44%)   | 5 (33%)   | 0.1     |
| COPD related hypercapnia | 1 (11%)   | 4 (26%)   | 0.04    |
| Encephalopathy   | 0 (0%)    | 1 (6%)    |         |
| Aspiration       | 2 (22%)   | 3 (20%)   | 0.6     |
| Pulmonary edema  | 1 (11%)   | 0 (0%)    | 0.07    |
| Seizure          | 1 (11%)   | 0 (0%)    | 0.07    |
| Arrhythmia       | 0 (0%)    | 2 (13%)   | 0.06    |
| Total reintubated patients COPD | 1 (5.2%) | 5 (31.2%) | 0.019   |
| Total reintubated patients | 9 (15%) | 15 (25%) | 0.049   |

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References

[1] S. Mehta, N.S. Hill, Noninvasive ventilation, Am. J. Respir. Crit. Care Med. 163 (2001) 540–577.
[2] J.V. Peter, J.L. Moran, J. Phillips-Hughes, D. Warn, Noninvasive ventilation in acute respiratory failure – a meta-analysis update, Crit. Care Med. 30 (2002) 555–562.
[3] J.V. Lightowler, J.A. Wedzicha, M.W. Elliott, F.S. Ram, Noninvasive positive pressure ventilation to treat respiratory failure resulting from exacerbations of chronic obstructive pulmonary disease: Cochrane systematic review and meta analysis, BMJ 326 (2003) 185–187.
[4] K.E. Burns, N.K. Adhikari, S.P. Keenan, M.O. Mead, Noninvasive positive pressure ventilation as a weaning strategy for intubated adults with respiratory failure, Cochrane Database Syst. Rev. 8 (2010) CD004127.
[5] K.E. Burns, N.K. Adhikari, S.P. Keenan, M. Mead, Use of noninvasive ventilation to wean critically ill adults off invasive ventilation: meta-analysis and systematic review, BMJ 338 (2009) b1574.
[6] M. Antonelli, G. Bello, Noninvasive mechanical ventilation during the weaning process: facilitative, curative or preventive, Crit. Care 12 (2008) 136.
[7] S.P. Keenan, T. Sinuff, K.E. Burns, J. Muscedere, J. Kutsogiannis, et al, Canadian Critical Care Trials Group/Canadian Critical Care Society Noninvasive Ventilation Guidelines Group: clinical practice guidelines for the use of noninvasive positive-pressure ventilation and noninvasive continuous positive airway pressure in the acute care setting, CMAJ 183 (2011) E195–E214.
[8] S.K. Epstein, R.L. Ciubotaru, J.B. Wong, Effect of failed extubation on the outcome of mechanical ventilation, Chest 112 (1997) 186–192.
[9] S.K. Epstein, R.L. Ciubotaru, Independent effects of etiology of failure and time to reintubation on outcome for patients failing extubation, Am. J. Respir. Crit. Care Med. 158 (1998) 489–493.
[10] A. Torres, J.M. Gatell, E. Aznar, et al, Reintubation increases the risk of nosocomial pneumonia in patients needing mechanical ventilation, Am. J. Respir. Crit. Care Med. 152 (1995) 137–141.
[11] International Consensus Conferences in Intensive Care Medicine, Noninvasive positive pressure ventilation in acute respiratory failure, Am. J. Respir. Crit. Care Med. 163 (2001) 283–291.
[12] N.R. MacIntyre, D.J. Cook, E.W. Ely Jr., et al, Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians, the American Association for Respiratory Care, and the American College of Critical Care Medicine, Chest 120 (Suppl.) (2001) 37S–39S.
[13] A. Esteban, I. Alia, F. Gordo, et al, Extubation outcome after spontaneous breathing trials with T-tube or pressure support ventilation, Am. J. Respir. Crit. Care Med. 156 (1997) 459–465.
[14] A. Esteban, I. Alia, M.J. Tobin, et al, Effect of spontaneous breathing trial duration on outcome of attempts to discontinue mechanical ventilation, Am. J. Respir. Crit. Care Med. 159 (1999) 512–518.
[15] M. Antonelli, G. Conti, M. Roccol, M. Buñi, R.A. De Blasi, G. Vivino, A. Gasparetto, G.U. Meduri, A comparison of noninvasive positive-pressure ventilation and conventional mechanical ventilation in patients with acute respiratory failure, N. Engl. J. Med. 339 (1998) 429–4354.
[16] G. Ferreyra, V. Fanelli, L. Del Sorba, V.M. Ranieri, Are guidelines for noninvasive ventilation during weaning still valid?, Minerva Anestesiol 77 (2001) 921–926.
[17] S. Nava, N. Hill, Non-invasive ventilation in acute respiratory failure, Lancet 374 (2009) 250–259.
[18] M. Antonelli, G. Conti, M. Roccol, et al, A comparison of noninvasive positive-pressure ventilation and conventional mechanical ventilation in patients with acute respiratory failure, N. Engl. J. Med. 339 (1998) 429–435.
[19] J.V. Peters, J.L. Moran, J. Phillips-Hughes, Effect of failed extubation on the outcome of mechanical ventilation, Chest 112 (1997) 186–192.
[20] S.P. Keenan, C. Powers, D.G. McCormack, G. Block, Noninvasive positive-pressure ventilation for post extubation respiratory distress: a randomized controlled trial, JAMA 287 (2002) 3238–3244.
[21] M. Ferrer, M. Valencia, J.M. Nicolas, O. Bernadich, J.R. Badia, A. Torres, Early noninvasive ventilation averts extubation failure in patients at risk: a randomized trial, Am. J. Respir. Crit. Care Med. 173 (2006) 164–170.
[22] A. Esteban, F. Frutos-Vivar, N.D. Ferguson, et al, Noninvasive positive-pressure ventilation for respiratory failure after extubation, N. Engl. J. Med. 350 (2004) 245260.
[23] P.L. Marino, K.M. Sutin, Discontinuing mechanical ventilation, in: P.L. Marino, K.M. Sutin (Eds.), The ICU Book, third ed., Lippincott Williams & Wilkins, Baltimore, Maryland, USA, 2007, p. 511.