Associated factors with non-invasive mechanical ventilation failure in acute hypercapnic respiratory failure

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ÖZET

Akut hiperkapnik solunum yetmezliğinde noninvaziv mekanik ventilasyon başarısızlığı ile ilişkili faktörler

Bu çalışmada amaç; akut hiperkapnik solunum yetmezliğinde noninvaziv mekanik ventilasyon (NİMV) başarısızlığı ile ilişkili faktörleri saptamaktır. Akut hiperkapnik solunum yetmezliği nedeniyle NİMV uygulanan 95 hasta değerlendirildi. NİMV, hastanın entübasyon ihtiyacı gelişmeden hastaneden taburcu olması halinde başarılı, invaziv mekanik ventilasyon ihtiyacı gelişmesi veya hastanın ölmesi halinde ise başarısız olarak kabul edildi. Tedavi öncesi ortalama pH değeri başarılı grupta 7.30, başarısız grupta 7.28 (p> 0.05), $PaCO_2$ başarılı grupta 71.45 mmHg, başarısız grupta ise 72.17 mmHg (p> 0.05) idi. Tedavinin birinci saatinde pH, başarılı grupta 7.33, başarısız grupta 7.26 (p= 0.01), $PaCO_2$ başarılı grupta 65.50 mmHg, başarısız grupta 73.47 mmHg (p= 0.02) olarak saptandı. Tedavinin birinci saatinde başarılı grupta pH'de anlamlı yükselme, $PaCO_2$'de anlamlı düşme izlenirken, başarısız grupta anlamlı fark saptanmadı. Başarısız grupta, tedavi öncesi "Acute Physiology Assessment and Chronic Health Evaluation (APACHE) II" skoru, serum C-reaktif protein düzeyi ve eşlik eden komplikasyon sıklığı anlamlı olarak daha yüksek, Glasgow Koma Skoru ise anlamlı olarak daha düşük saptandı. Sonuç olarak, tedavi öncesi yüksek APACHE II skoru ve C-reaktif protein düzeyi, düşük Glasgow Koma Skoru, eşlik eden ek komplikasyon varlığı ve tedavinin birinci saatinde pH ve $PaCO_2$'de düzelme olmaması NİMV başarısızlığı ile ilişkili faktörlerdir.

Anahtar Kelimeler: *Noninvaziv, mekanik ventilasyon, başarısızlık.*

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SUMMARY

Associated factors with non-invasive mechanical ventilation failure in acute hypercapnic respiratory failure

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Our aim was to determine associated factors with non-invasive mechanical ventilation (NIMV) failure in acute hypercapnic respiratory failure ninety live patients treated with NIMV for acute hypercapnic respiratory failure were evaluated. While success of NIMV was defined as absence of need of intubation with the patient's discharge from hospital, failure of NIMV was defined as death or need of intubation. The pretreatment pH level was 7.30 in success and 7.28 in failure group (p> 0.05), $PaCO_2$ was 71.45 mmHg in success and 72.17 mmHg in failure group (p> 0.05). After 1h of NIMV, pH was 7.33 in success and 7.26 in failure group (p= 0.01), $PaCO_2$ was 65.50 mmHg in success and 73.47 mmHg in failure group (p= 0.02). After 1h of treatment, in success group there was significant increase of pH and decrease of $PaCO_2$ in contrast to baseline levels, while there was no significant change in failure group. The pretreatment Acute Physiology Assessment and Chronic Health Evaluation (APACHE) II score, serum C-reactive protein level and frequency of associated complication on admission were significantly higher and Glasgow Coma Score was lower in failure group. In conclusion, high APACHE II and C-reactive protein level, low Glasgow Coma Score, associated complication on admission and inadequate response in pH and $PaCO_2$ after first hour of NIMV are associated factors with NIMV failure.

Key Words: *Non-invasive, mechanical ventilation, failure.*

In recent years non-invasive mechanical ventilation (NIMV), delivered through a facial or nasal mask, has been successfully used in selected populations as an effective treatment for acute respiratory failure (ARF) (1-3). However, none of the published studies so far has reported a 100% success rate with NIMV. Failure of NIMV has usually been defined as; (a) need for intubation because of lack of improvement in arterial blood gas tensions and clinical parameters after a few hours of ventilation (usually 1-3 hours), (b) clinical deterioration and subsequent intubation during hospital stay, and (c) death (4). Although some different results, studies specifically designed to asses the best predictors of NIMV outcomes agree that changes in pH in the first hour of ventilation and the clinical condition of the patient before ventilation are the most powerful factors linked to success or failure (5,6). Inability early to identify patients who will fail NIMV can cause inappropriate delay of intubation which can cause clinical deterioration and increase morbitidy and mortality (7). In presented study our aim was to determine associated factors with NIMV failure in patients with acute hypercapnic respiratory failure (AHRF).

MATERIALS and METHODS

The study was performed in respiratory intensive care unit (ICU) with 6 beds where invasive and noninvasive ventilatory support is available. There is at least one doctor on duty. The nurse to patient is 1/2 or 1/3 for the day shift and 1/3 or 1/6 for the night shift. A physiotherapist is present for performing postural drainage, passive or active limb training of limb and respiratory muscles. Total parenteral nutrition and enteral nutrition is planned by a specialized team. Every patient with AHRF treated with NIMV plus standard medical treatment are followed with a same protocol in our clinic and patient's characteristics and laboratory findings were obtained from their records. AHRF was defined as severe dyspnea at rest, respiratory rate > 25 breaths per minute, hypercapnia ($PaCO_2$ > 45 mmHg) and acute respiratory acidosis (pH < 7.35) (8).

Exclusion criteria were:

1. Pneumothorax,

2. Unable to spontaneously clear secretions from the airway,

3. Unable to cooperate to NIMV,

4. Airway or facial deformity, and

5. Presence of a diagnosis of malignancy.

Patients were ventilated with NIMV (Respironics BIPAP Vision, Pennsylvania, USA) using a full face mask. The mask best fitting the patient's face was chosen and the tolerance of mask by patient was controlled closely and changed if necessary. Initially the patients were encouraged to continue NIMV as much as he/she could. Intervals were permitted for eating, drinking or expectoration. When clinical findings and blood gases improved, the duration of NIMV was decreased. The inspiratory positive airway pressure (IPAP) was adjusted according to patient's tolerance to obtain a tidal volume of 7-10 mL/kg with an expiratory positive airway pressure (EPAP) lower than 7 cmH_2O. The EPAP was set initially at 5 cmH_2O and increased in increments of 1 cmH_2O until fractional inspired oxygen (FiO_2) requirement was less than 0.5. The humidification was not used during NIMV. Oxygen was added to achieve a SaO_2 of > 90%. The medical therapy consisted of oxygen by nasal cannula or face mask and antibiotics if indicated for all patients and methylprednisolone for 5-10 days and bronchodilators in chronic obstructive pulmonary disease (COPD) patients.

As associated complications, factors reported by Jimenez et al. were used (9). Patients were divided into two groups according to outcome of NIMV. While success of NIMV was defined as absence of need of intubation with the patient's discharge from hospital, failure of NIMV was defined as death related with the episode of AHRF or need of intubation.

Statistical Analysis

All statistical analyses were performed using the SPSS version 10.0. The categorical values were analyzed using the Chi-Square test. Comparison of differences of successful versus failure treatment was performed using a Student unpaired t test and comparison of baseline pH and $PaCO_2$ with those recorded after 1 h of NIMV was performed using a paired t test. A p value of less than 0.05 was considered as statistically significant.

RESULTS

During the study period 95 patients with AHRF treated with NIMV plus standard medical therapy were evaluated. Baseline characteristics of patients were shown in Table 1. For these 95 patients, the most common etiology of AHRF was exacerbation of COPD (79 patients), followed by obesity-hypoventilation syndrome (OHS) (7 patients), kyphoscoliosis (5 patients) and pulmonary fibrosis (4 patients). NIMV failure was observed in 23 of 95 patients and NIMV was successful in the remainder 72 patients. While NIMV was successful in 61 of 79 patients with COPD and 4 of 5 patients with kyphoscoliosis, it was successful in all patients with OHS and unsuccessful in all patients with pulmonary fibrosis. We divided patients into two groups according to underlying diseases to compare NIMV success: obstructive and restrictive diseases. NIMV was successful in 61 of 79 patients with obstructive diseases and 11 of 16 with restrictive diseases. The difference was not significant ($p > 0.05$). We couldn't compare NIMV success between each disease due to small number of patients with non COPD diseases. Table 2 shows the comparison of characteristics of the success and failure groups. The length of stay in hospital was significantly higher in failure group (21.64 ± 12.08 days vs. 10.45 ± 11.62 days, $p < 0.05$). After initial adjustments, the mean IPAP and EPAP values were higher in restrictive group (IPAP: 18 ± 4 cmH_2O vs. 16 ± 4cmH_2O, EPAP: 5 ± 2 cmH_2O vs. 5 ± 2 cmH_2O), but the difference was not significant. Total duration of NIMV in success group was 5.42 ± 4.18 days and 2.73 ± 3.11 days in failure group. There was no significant difference between patients managed successfully versus unsuccessfully with regard to baseline pH, $PaCO_2$, total protein, albumin, leucocyte count, heart rate, systolic and diastolic blood pressure. However, baseline CRP level and APACHE II score were significantly higher in failure group and also baseline Glasgow Coma Score was significantly lower in failure group.

Table 1. Characteristics of the study group: parameters recorded at admission.

n	95
Sex (M/F)	48/47
Age (years)	68.14 ± 10.75
Diagnosis	
COPD	79
Kyphoscoliosis	5
Pulmonary fibrosis	4
Obesity-hypoventilation syndrome	7
Heart rate (pulse/min)	96.62 ± 20.37
Systolic blood pressure (mmHg)	124.34 ± 22.22
Diastolic blood pressure (mmHg)	69.72 ± 13.51
Total protein (g/dL)	6.55 ± 0.77
Albumin (g/dL)	3.30 ± 0.65
C-reactive protein (mg/L)	6.88 ± 4.71
Leucocytes (/mm^3)	10923.40 ± 4997.92
APACHE II	21.34 ± 3.70
Glasgow Coma Score	14.01 ± 0.90
pH	7.30 ± 0.05
$PaCO_2$ (mmHg)	71.63 ± 11.90

APACHE: Acute Physiology Assessment and Chronic Health Evaluation.

Table 2. Characteristics of 95 patients with AHRF; comparison of failure and success groups.

	Success	Failure	p
n	72	23	
Total protein (g/dL)	6.61 ± 0.7	6.38 ± 0.76	0.215
Albumin (g/dL)	3.31 ± 0.64	3.09 ± 0.46	0.07
Leucocytes (/mm^3)	10078.31 ± 5040.89	11556.52 ± 4918.03	0.48
Heart rate (pulse/min)	94.40 ± 20.58	103.56 ± 18.42	0.06
Systolic blood pressure (mmHg)	125.33 ± 19.89	121.26 ± 28.65	0.53
Diastolic blood pressure (mmHg)	69.63 ± 12.92	70.00 ± 15.51	0.92
C-reactive protein (mg/L)	4.72 ± 5.84	13.65 ± 7.34	**0.04**
Glasgow Coma Score	14.84 ± 0.12	13.86 ± 1.10	**0.02**
APACHE II score	18.40 ± 3.44	24.43 ± 3.69	**< 0.05**
Associated complication	31/72	16/23	**< 0.001**
pH (baseline)	7.30 ± 0.05	7.28 ± 0.04	0.67
After 1 h of NIMV	7.33 ± 0.04	7.26 ± 0.05	**0.01**
$PaCO_2$ (mmHg) (baseline)	71.45 ± 12.10	72.17 ± 11.49	0.82
After 1 h of NIMV	65.50 ± 12.27	73.47 ± 12.19	**0.02**

APACHE: Acute Physiology Assessment and Chronic Health Evaluation,
AHRF: Acute hypercapnic respiratory failure,
NIMV: Non-invasive mechanical ventilation.

While there was no significantly difference for baseline pH and $PaCO_2$ between two groups, after 1 h of NIMV, pH was significantly higher and $PaCO_2$ was significantly lower in success group. When we compared pH and $PaCO_2$ on admission and after one hour of NIMV, in success group there was a significant increase of pH (from 7.30 ± 0.05 to 7.33 ± 0.04) ($p < 0.001$), while there was no significant change in failure group (from 7.28 ± 0.04 to 7.26 ± 0.05) ($p > 0.05$), and we also found a significant decrease of $PaCO_2$ in success group (from 71.45 ± 12.10 to 65.50 ± 12.27) ($p < 0.001$) and no significant change in failure group (from 72.17 ± 11.49 to 73.47 ± 12.19) ($p > 0.05$).

While no major complication was observed during NIMV, in one patient aerophagia, in five patients eye irritation and in nine patients nasal lesions were developed. In success group, on admission there was associated complication in 31 of 72 patients and 16 of 23 patients in failure group. The frequency of presence of associated complication was significantly higher in failure group ($p < 0.001$). The frequency of cardiac complication (9 of 23 patients in failure group and 21 of 72 patients in success group), pneumonia (5 of 23 patients in failure group and 10 of 73 patients in success group) and metabolic complication (2 of 23 patients in failure group and none in success group) were all significantly higher in failure group ($p < 0.05$). For COPD patients we also found significantly higher rate of cardiac complication and pneumonia in whom NIMV failed, however we couldn't evaluate this comparison for other diseases due to small number of patient.

DISCUSSION

NIMV is not always successful in the management of AHRF for example, it has been reported that the rate of failure of NIMV in patients with COPD with AHRF ranges from 5% to 40% (10). In our study NIMV was successful in 72 of 95 (76%) patients and this result was similar with previous reports.

This study shows that, failure of NIMV was associated with high APACHE II score, CRP level, low GCS, presence of associated complication at admission and no improvement in pH and $PaCO_2$ after 1 h of treatment.

One of reported predictors of NIMV failure is baseline pH and $PaCO_2$ level (5,7,11). Nava et al. reported that in patients with hypercapnic respiratory failure the best NIMV success/failure predictor is the degree of acidosis/academia (pH and $PaCO_2$ at admission and after one hour of NIMV), whereas mental status and severity of illness are less reliable predictors (7). Ambrosino et al. observed that in a group of 47 patients with decompensated COPD, patients who were more acidemic before starting NIMV (pH 7.22 vs. 7.28) subsequently failed to NIMV. They concluded that lower baseline pH and higher $PaCO_2$ predicted NIMV failure (5). Plant et al. studied 236 patients with COPD exacerbations and observed that severe acidemia (pH < 7.30) at study entry was associated with NIPPV failure (11). In our study, in failure group baseline pH was lower and $PaCO_2$ was higher than success group, however the difference was not significant. We also did not find a statistically difference in baseline systolic and diastolic blood pressure, total protein, albumin and leucocyte count between two groups. However, heart rate between success and failure group was in the limit of significance. Garpestad et al. reported that, the best predictors of success of NIMV are reduction in respiratory rate, improvement in pH, oxygenation and $PaCO_2$ within one to two hours (12). Soo et al. studied 12 COPD patients who were treated during 14 episodes of hypercapnic respiratory failure and observed that, successfully treated patients were able to adapt more rapidly to the nasal mask and ventilator, with greater and more rapid reduction in $PaCO_2$, correction of pH (13). Singh et al. investigated predictive factors of NIMV success and found a significant improvement in clinical and arterial blood gas parameters within first hour in success group (14). In presented study, while there was no difference in baseline pH and $PaCO_2$ between two groups, after one hour of NIMV in success group pH was significantly higher and $PaCO_2$ was significantly lower than failure group. We also compared pH and $PaCO_2$ at admission and after one hour of NIMV for both groups and we observed a significant increase of pH and decrease of $PaCO_2$ in success group, while there was no significant change in failure group.

The most commonly used indexes of severity of illness are APACHE II and Simplified Acute Physiology Score (SAPS II) (15,16). Ambrosino et al. found a significantly greater severity of illness among patients who failed to improve with NIMV (mean APACHE II score 24 vs. 18). Soo Hoo et al. reported that, unsuccessfully treated patients appeared to have a greater severity of illness than successfully treated patients, as indicated by a higher APACHE II score (mean 21 ± 4 vs. 15 ± 4). In presented study, in failure group APACHE II score was significantly higher which was consistent with these previous reports. Another reported predictive factor of NIMV failure is GCS. In a prospective cohort study of nearly 800 COPD patients treated with NIMV, Confalonieri et al. identified four factor APACHE II score, pH, respiratory rate and GCS-that, when combined in a chart, showed good predictive value at baseline (17). Garpestad et al. reported that a high GCS is associated with NIMV success (12). Our results was consistent with these reports, since GCS was significantly higher in success group.

CRP is an inflamatory marker and an increase in CRP level can be observed in several situations like infections. Although it has been reported that the presence of pneumonia is associated with NIMV failure, to our knowledge there is no report about relationship between CRP level and NIMV failure. In our study, CRP was significantly higher in failure group, hence we suggested that this relationship should be confirmed in further studies.

We investigated whether the presence of associated complication, modified by Jimenez et al. can predict NIMV success/failure. In success group, there was associated complication in 31 of 72 patients while 16 of 23 in failure group. The rate of presence of associated complication was significantly higher in failure group.

Selection of appropriate patient is crucial for the optimization of NIMV success rates. Many applications of NIMV have been tried in the critical care setting, but as of yet, only four are supported by multiple randomized controlled trials and meatanalyses; COPD exacerbations, acute cardiogenic pulmonary edema, facilitiating extubation in COPD patients and immunocompromised patients (12). The strongest level of evidence including multiple randomized trials supports the use of NIMV to treat exacerbation of COPD (17-21). In our study, NIMV was successful in 61 of 79 patients with COPD. The success rate in this group was 77% and this result was consistent with previous reports. Treatment of chronic respiratory failure in patients with thoracic cage abnormalities with NIMV is well accepted. In one small study, four kyphoscoliotic patients with acute respiratory decompensation were treated with nasal NIMV and experienced significant improvements in $PaCO_2$ and PaO_2 (22). With the success of NIMV for these patients in the chronic setting, it has been reported that NIMV is considered the treatment of first choice when decompensation occurs (23). Our study's results supported this consideration since NIMV was successful in 4 of 5 patients with kyphoscoliosis. There is little information regarding NIMV use for deteriorations of pulmonary fibrosis. In a small retrospective study of patients with idiopathic pulmonary fibrosis admitted to an ICU with acute respiratory failure, only 5 of 15 were deemed candidates for NIMV. Three of these died and the others required invasive mechanical ventilation (24). It has been reported that NIMV appears to offer little or no benefit to this subgroup of patients (25). In presented study, NIMV was unsuccessful in all patients with pulmonary fibrosis, consistent with this report. There are limited studies evaluating NIMV in OHS. Duarte et al. studied 50 morbidly obese patients with acute respiratory failure treated with mechanical ventilation. They found that a total of 33 patients were treated with NIMV, of which 21 avoided intubation (NIMV success) and 12 required intubation (NIMV failure). They also observed that, mean body mass index for the NIMV success group was significantly less than for the NIMV failure group (26). In our study, NIMV was successful in all patients with OHS and thus, we suggested that the role of NIMV in patients with OHS should be studied in further larger series.

In conclusion our study confirms that, high APACHE II score and CRP level, low GCS, presence of associated complication and no improvement in pH and $PaCO_2$ after one hour of NIMV are associated factors with NIMV failure hence, we suggested that in the presence of these factors patients should especially be monitorized closely for a need of early intubation.

REFERENCES

1. *Brochard L, Mancebo J, Wysocki M, et al. Noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease. N Engl J Med 1995; 333: 817-22.*
2. *Celikel T, Sungur M, Ceyhan B, et al. Comparison of noninvasive positive ventilation with standard medical therapy in hypercapnic acute respiratory failure. Chest 1998; 114: 1636-42.*
3. *Dikensoy O, Ikidag B, Filiz A, Bayram N. Comparison of non-invasive ventilation and standard medical therapy in hypercapnic acute respiratory failure: a randomised controlled trial at a tertiary health centre in SE Turkey. Int J Clin Pract 2002; 56: 85-8.*
4. *Moretti M, Cilione C, Tampieri A, et al. Incıdence and causes of non-invasive mechanical ventilation failure after initial success. Thorax 2000; 55: 819-25.*
5. *Ambrosino N, Foglio K, Rubini F, et al. Non-invasive mechanical ventilation in acute respiratory failure due to chronic obstructive pulmonary disease: correlates for success. Thorax 1995; 50: 755-7.*
6. *Meduri GU, Abou-Shala N, Fox RC, et al. Non-invasive face mask ventilation in patients with acute hypercapnic respiratory failure. Chest 1991; 100: 445-54.*
7. *Nava S, Ceriana P. Causes of failure of noninvasive mechanical ventilation. Respir Care 2004; 49: 295-303.*
8. *X-Phua J, Kong K, Lee KH, et al. Noninvasive ventilation in hypercapnic respiratory failure due to chronic obstructive pulmonary disease vs. other conditions: effectiveness and predictors of failure. Intensive Care Med 2005; 31: 533-9.*
9. *Jimenez P, Torres A, Roca J, et al. Arterial oxygenation does not predict the outcome of patients with acute respiratory failure needing mechanical ventilation. Eur Respir J 1994; 7: 730-5.*
10. *Wood KA, Lewis L, Von Harz B, et al. The use of noninvasive positive pressure ventilation in the emergency department. Results of a randomized clinical trial. Chest 1998; 113: 1339-46.*
11. *Plant PK, Owen JL, Eliott MW. Non-invasive ventilation in acute exacerbations of chronic obstructive pulmonary disease: long term survival and predictors of in-hospital outcome. Thorax 2001; 56: 708-12.*
12. *Garpestad E, Brennan J, Hill SN. Noninvasive ventilation for critical care. Chest 2007; 132: 711-20.*
13. *Soo Hoo GW, Santiago S, Williams AJ. Nasal mechanical ventilation for hypercapnic respiratory failure in chronic obstructive pulmonary disease: determinants of success and failure. Crit Care Med 1994; 22: 1253-61.*
14. *Singh VK, Khanna P, Rao BK, et al. Outcome predictors for non-invasive positive pressure ventilation in acute respiratory failure. J Assoc Physicans India 2006; 54: 361-5.*
15. *Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med 1985; 13: 818-29.*
16. *Le Gall JR, Lemeshow S, Saulnier F. A new Simplified Acute Physiology Score (SAPS II) based on a Europena/North American multicenter study. JAMA 1993; 270: 2957-63.*
17. *Confalonieri M, Garuti G, Cattaruzza MS, et al. A chart of failure risk for noninvasive ventilation in patients with COPD exacerbation. Eur Respir J 2005; 25: 348-55.*
18. *Brochard L, Isabey D, Piquet J, et al. Reversal of acute exacerbation of chronic obstructive lung disease by inspiratory assistance with a face mask. N Eng J Med 1990; 323: 1523-30.*
19. *Bott J, Carrol MP, Conway JH, et al. Randomised controlled trial of nasal ventilation in acute ventilatory failure due to chronic obstructive airway disease. Lancet 1993; 341: 1555-7.*
20. *Kramer N, Meyer TJ, Meharg J, et al. Randomised, prospective trial of noninvasive positive pressure ventilation in acute respiratory failure. Am J Respir Crit Care Med 1995; 151: 1799-806.*
21. *Plant PK, Owen JL, Elliot 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; 335: 1931-5.*
22. *Finlay G, Concannon D, McDonnell TJ. Treatment of respiratory failure due to kyphoscoliosis with nasal intermittent positive pressure ventilation (NIPPV). Irish J Med Sci 1995; 164: 28-30.*
23. *British Thoracic Society Standards of Care C. Non-invasive ventilation in acute respiratory failure. Thorax 2002; 57: 192-211.*
24. *Blivet S, Philit F, Sab JM, et al. Outcome of patients with idiopathic pulmonary fibrosis admitted to the ICU for respiratory failure. Chest 2001; 120: 209-12.*
25. *Maheshwari V, Hill N. Emergency applications of noninvasive ventilation. In: Fein A, Kamholz S, Ost D (eds). Respiratory Emergencies. New York: Edward Arnold, 2006: 83-97.*
26. *Duarte AG, Justino E, Bigler T, Grady J. Outcomes of morbidly obese patients requiring mechanical ventilation for acute respiratory failure. Crit Care Med 2007; 35: 732-7.*