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The factors affecting noninvasive mechanical ventilation failure in COPD exacerbations

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Aim: To evaluate causes of noninvasive mechanical ventilation (NIMV) failure. The rate of NIMV failure in respiratory failure due to chronic obstructive pulmonary disease (COPD) exacerbations was reported as 5%-40%.

Materials and methods: The necessity of endotracheal intubation was accepted as NIMV failure. The causes of NIMV failure were assessed in 54 patients (45 males; mean age: 67.7 ± 11.0 years) treated with NIMV because of COPD exacerbations and respiratory failure in an intensive care unit (ICU).

Results: There was NIMV failure in 20 patients (37.0%). The rates of hospital-acquired pneumonia and in-hospital mortality were higher (P = 0.003 and P = 0.002, respectively) and the duration of ICU stay was longer (P < 0.0001) in patients with NIMV failure. On admission, arterial pH, serum albumin, and Glasgow Coma Scale levels were lower (P = 0.032, P = 0.024, and P = 0.013, respectively) in the NIMV failure group. Arterial pH was lower (P = 0.039) and respiratory rate was higher (P = 0.010) after 1 h, and the PaO2/FiO2 rate was lower (P = 0.017) and respiratory and heart rates were higher (P = 0.002 and P = 0.020, respectively) after 3 h in the NIMV failure group.

Conclusion: The present data strongly suggest that baseline and follow-up clinical and arterial blood gas evaluations can give important clues about NIMV failure in COPD exacerbations.

Key words: COPD exacerbation, noninvasive ventilation, respiratory failure, treatment failure

KOAH alevlenmesinde noninvaziv mekanik ventilasyon başarısızlığını etkileyen faktörler

Amaç: Kronik obstrüktif akciğer hastalığı (KOAH) alevlenmesi nedeniyle oluşan solunum yetmezliğinde noninvaziv mekanik ventilasyon (NİMV) başarısızlığı oranı % 5-40 arasındadır. Bu çalışmanın amacı NİMV başarısızlığının nedenlerini değerlendirmektir.

Yöntem ve gereç: Endotrakeal entübasyon gerekliliği NİMV başarısızlığı olarak kabul edilmiştir. Yoğun bakım ünitesi (YBÜ)'nde KOAH alevlenmesi ve solunum yetmezliği nedeniyle tedavi edilen 54 olguda (45'i erkek, ortalama yaş: 67,7 ± 11.0) NİMV başarısızlığı değerlendirilmiştir.

Bulgular: 20 olguda (% 37,0) NİMV tedavisi başarısızlığı vardı. Noninvaziv mekanik ventilasyonun başarısız olduğu olgularda, hastane kökenli pnömoni ve hastane içi mortalite oranları daha yüksek (sırasıyla P = 0,003 ve P = 0,002), yanı sıra YBÜ kalış süreleri daha uzundu (P < 0.0001). NİMV'nin başarısız olduğu grupta; başvuru anında, arteriyel pH, serum albumin ve Glasgow koma skalası değerleri daha düşüktü (sırasıyla P = 0,032, P = 0,024 ve P = 0,013). Noninvaziv mekanik ventilasyonun başarısız olduğu grupta; birinci saatte arteriyel pH daha düşük (P = 0,039) ve solunum sayısı daha yüksek (P = 0,010), üçüncü saatte ise; PaO2/FiO2 oranı daha düşük (P = 0,017), solunum sayısı ve kalp hızı daha yüksekti (sırasıyla P = 0,002, P = 0,020).

Sonuç: Başlangıç ve izlemde yapılan klinik ve arteriyel kan gazı değerlendirmelerinin, KOAH alevlenmesinde NİMV başarısızlığı hakkında önemli ipuçları verebileceği mevcut verilerle kuvvetle desteklenmiştir.

Anahtar sözcükler: KOAH alevlenmesi, noninvaziv ventilasyon, solunum yetmezliği, tedavi başarısızlığı

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Introduction

Noninvasive mechanical ventilation (NIMV) is more successful than standard medical treatment alone in respiratory failure, especially in respiratory acidosis due to chronic obstructive pulmonary disease (COPD) (1,2). In selected patients, NIMV reduces endotracheal intubation and prevents invasive mechanical ventilation (IMV)-related complications, including hospital-acquired pneumonia (HAP) (3-10). Noninvasive mechanical ventilation can be performed effectively and safely in both intensive care units (ICU) and wards by well-trained teams (7,9). However, in the guidelines of the American Thoracic Society and the British Thoracic Society, NIMV treatment is not recommended for all patients with respiratory failure. Noninvasive mechanical ventilation should not be used as a substitute for intubation and invasive mechanical ventilation when the latter is clearly more appropriate (11,12).

The rate of NIMV failure in respiratory failure due to COPD is reported as 5%-40% (3). It is important to identify the patients most likely benefit from NIMV treatment. Continuation of NIMV in patients with treatment failure will delay IMV and increase the mortality rate. Therefore, the clinical and laboratory data that can estimate NIMV failure should be carefully evaluated. The aim of this study was to investigate the causes of NIMV failure in patients treated with NIMV because of respiratory failure associated with COPD exacerbations in an ICU.

Materials and methods

This study was carried out between January 2006 and January 2008 in an 8-bed respiratory ICU in the chest disease department of a university hospital. The ICU team consisted of 1 associate professor, 1 chest specialist, 2 registrars, and 3 nurses, and NIMV treatment has been applied in the ICU since 2002. The results of NIMV treatment were evaluated retrospectively in hospitalized patients with a COPD diagnosis, as according to the consensus report of the Global Initiative for Chronic Obstructive Lung Disease (GOLD) (13), for whom NIMV was applied due to respiratory failure with acute exacerbations.

Exclusion criteria were as follows: 1) cardiac and respiratory arrest, 2) severe hemodynamic instability, 3) encephalopathy, 4) craniofacial pathologies including surgery and trauma, and 5) severe gastrointestinal bleeding.

NIMV applications were performed by the doctors and nurses of the ICU. A portable ventilator (BiPAP, Moritz biLEVEL, Germany) and oronasal masks (Respironics, USA; 2 adult sizes: medium and large) were used for applications. Inspiratory positive airway pressure (IPAP) of 10 cmH_2O and expiratory positive airway pressure (EPAP) of 4 cmH_2O were first applied. The airway pressures were increased by 1-2 cmH_2O each time according to the arterial blood gas (ABG) results and respiratory rates, if tolerated by the patient. Maximum airway pressures were 20 cmH_2O for IPAP and 8 cmH_2O for EPAP. Ventilator settings were adjusted on the basis of continuous oximetry and measurements of ABG. Clinical signs and ABG levels were determined at baseline, after 1 and 3 h, and at intervals of 3-6 h thereafter. The patients were not sedated. Standard medical treatment (2.5 mg of salbutamol and 500 mg of ipratropium bromide with a nebulizer every 4-6 h; hourly theophylline infusion of 0.2 mg/kg during the first 72 h; methylprednisolone at 40 mg/day; low-molecular-weight prophylactic dose of heparin; and antibiotics, expectorants, and diuretics, if needed) and supplemental oxygen administration to achieve a level of arterial oxygen saturation (by oximetry) above 90% were given in addition to NIMV treatment.

During the first 24 h, NIMV was performed continuously; it was later reduced progressively according to the degree of clinical improvement. Ventilatory support was stopped if the patient improved and remained stable (pH > 7.35 and SaO_2 > 90% with supplemental oxygen). NIMV treatment was not applied again unless clinical and laboratory deterioration occurred.

All patients were evaluated only during the period of ICU stay. Demographic findings, knowledge about COPD diagnosis and treatment, causes of exacerbation, and laboratory and ABG analysis data before NIMV treatment were all recorded. Clinical findings and ABG analysis data were evaluated after 1 and 3 h of NIMV treatment. Durations, complications, and failures of NIMV treatment were assessed during the follow-up period. The necessity of endotracheal intubation and IMV was

called "NIMV failure." The criteria for endotracheal intubation included: 1) worsening of the pH and carbon dioxide tension ($PaCO_2$) in arterial blood despite NIMV administration, 2) the need to protect the airways (coma or seizure disorders) or to manage copious secretions, 3) hemodynamic instability, and 4) agitation and inability to tolerate the mask. The decision to intubate was made by the same doctor for all patients.

If NIMV failure developed within the first 2 days, it was called "early failure," and if it developed after 2 days, it was called "late failure." The factors affecting early and late failure were investigated. Durations of mechanical ventilation and ICU stay, the rates of hospital infection, and mortality were compared in patients with early and late failure.

The study was approved by the local ethics committee and informed consent was obtained from the patients or the next of kin.

Student's t-test, NPar tests, and Mann-Whitney U-tests were used with SPSS 11 for statistical analysis of the study. The results were expressed as mean ± standard deviation. Nonparametric values were compared with chi-square tests. For parameters affecting NIMV failure, threshold values were determined, sensitivity and specificity results were obtained, and receiver operating characteristic (ROC) curves were drawn. A P-value of less than 0.05 was considered statistically significant.

Results

Included in the study were 54 patients (45 males; mean age: 67.7 ± 11.0 years) who were hospitalized in the ICU due to COPD exacerbations and who received NIMV. The most common cause of exacerbation was tracheobronchial infection (63.0%). In 13 patients (24.1%), pneumonia was detected, and in 46 patients (85.2%), comorbid diseases were detected. Demographic features and clinical and laboratory findings for all patients are summarized in Table 1.

The average IPAP and EPAP levels during NIMV application were 16.2 ± 1.7 cmH_2O and 4.9 ± 1.7 cmH_2O, respectively. There was no major complication related to NIMV treatment; the most common minor complication (70.4%) was skin necrosis over the nasal bridge.

Table 1. Demographic, clinical, and laboratory characteristics on admission.

Age (years) (mean ± SD)	67.7 ± 11.0
Sex (male) [n (%)]	45 (83.3%)
Comorbid disease [n (%)] *	
CVD	30 (55.5%)
Diabetes mellitus	9 (16.7%)
Others †	18 (33.3%)
Cause of exacerbation [n (%)] ‡	
Tracheobronchial infection	34 (63.0%)
Pneumonia	13 (24.1%)
Heart failure	4 (7.4%)
Others #	5 (9.3%)
Respiratory rate (bpm) (mean ± SD)	28.0 ± 7.1
Heart rate (bpm) (mean ± SD)	105.6 ± 22.7
APACHE II (mean ± SD)	17.3 ± 5.0
GCS (mean ± SD)	13.4 ± 2.1
pH (mean ± SD)	7.23 ± 0.1
PaO_2 (mmHg) (mean ± SD)	63.2 ± 19.3
$PaCO_2$ (mmHg) (mean ± SD)	72.4 ± 13.2
PaO_2/FiO_2 (mean ± SD)	221.4 ± 82.1

Abbreviations: CVD = cardiovascular disease, APACHE = Acute Physiology and Chronic Health Evaluation, GCS = Glasgow Coma Scale.

* There were 3 comorbid diseases in 1 patient and 2 comorbid diseases in 9 patients.

† Other comorbid diseases: obstructive sleep apnea syndrome (4 patients), chronic renal failure (3 patients), lung cancer (2 patients), extrapulmonary malignancy (3 patients), chronic liver disease (2 patients), cerebrovascular disease (2 patients), obesity (1 patient), obesity-hypoventilation syndrome (1 patient).

‡ The causes of exacerbation were tracheobronchial infections and heart failure in 2 patients.

Other causes of exacerbation: metabolic causes (3 patients), inappropriate drug use (2 patients).

NIMV was performed successfully in 34 patients (63.0%), and failure was detected in 20 patients [early failure in 11 patients (20.3%) and late failure in 9 patients (16.7%)]. HAP was observed in 11 patients (20.4%) during the follow-up period. The mean durations of NIMV treatment and ICU stay were 4.5 ± 4.6 and 11.6 ± 10.7 days, respectively, and the rate of mortality was 24.1%.

There was no relationship between NIMV failure and the demographic features of the patients. The failure rate of NIMV was higher (53.8% versus 31.7%)

in patients with pneumonia on admission, but this difference was not statistically significant.

When the data for NIMV failure and successful groups on admission were assessed, it was observed that arterial pH, serum albumin, and Glasgow Coma Scale (GCS) levels were higher (P = 0.032, P = 0.024, and P = 0.013, respectively) in the successful group (Table 2). Follow-up data were also compared in both groups; the arterial pH was lower (P = 0.039) and the respiratory rate was higher (P = 0.010) after 1 h, and the PaO_2/FiO_2 rate was lower (P = 0.017) and respiratory and heart rates were higher (P = 0.002 and P = 0.020, respectively) after 3 h in the NIMV failure group when compared to the successful group (Table 3).

ROC curves of the baseline and follow-up parameters affecting NIMV failure were drawn, and their threshold values were determined (Figures 1a-1c). Clinical and laboratory features on admission such as pH < 7.30 (sensitivity 64.7%, specificity 60.0%), albumin < 3.5 g/dL (sensitivity 71.7%, specificity 65.0%), and GCS < 13 (sensitivity 85.3%, specificity 45.0%) were found to be useful in estimating NIMV failure. During the follow-up, respiratory rate > 27/min (sensitivity 60.6%, specificity 60.0%) and pH < 7.30 (sensitivity 82.4%, specificity 31.6%) after 1 h and respiratory rate > 27/min (sensitivity 57.6%, specificity 60.0%), heart rate > 100/min (sensitivity 61.8%, specificity 70.0%), and PaO_2/FiO_2 rate < 200 (sensitivity 73.5%, specificity 36.8%) after 3 h affected NIMV failure significantly. In addition, the highest rates of NIMV failure were found in patients with respiratory rate > 27/min and PaO_2/FiO_2 rate < 200 after 3 h of NIMV (85.7%) and in patients with GCS < 13 and pH < 7.30 on admission (80.0%) (Table 4).

The patients with early and late NIMV failure were compared to those treated successfully. In patients with early failure, the respiratory rates were higher after 1 and 3 h (P = 0.045 and P = 0.006, respectively), and the PaO_2/FiO_2 rate was lower (P = 0.027) after 3 h. In patients with late failure, respiratory rates were higher after 1 and 3 h, and heart rate was higher after 3 h (P = 0.037, P = 0.019, and P = 0.015, respectively) (Table 5).

During the follow-up period, HAP was found to be higher in patients with NIMV failure than in the successfully treated group (55.0% versus 8.8%, P = 0.003). The duration of NIMV treatment was longer

Table 2. The comparison of clinical and laboratory characteristics on admission according to the success of noninvasive mechanical ventilation treatment.

Parameters*	**NIMV success (n = 34)**	**NIMV failure (n = 20)**	**P-value**
Respiratory rate (bpm)	27.2 ± 6.6	29.5 ± 7.8	NS
Heart rate (bpm)	103.5 ± 22.3	109.1 ± 23.6	NS
APACHE II	16.9 ± 4.9	18.0 ± 5.0	NS
GCS	13.9 ± 1.7	12.5 ± 2.5	0.013
pH	7.32 ± 0.1	7.28 ± 0.1	0.032
PaO_2 (mmHg)	62.3 ± 21.2	64.8 ± 15.8	NS
$PaCO_2$ (mmHg)	71.1 ± 10.9	74.7 ± 16.6	NS
PaO_2/FiO_2	228.1 ± 86.8	209.9 ± 74.2	NS
CRP (mg/dL)	7.9 ± 10.8	11.8 ± 10.4	NS
Albumin (g/dL)	3.6 ± 0.5	3.3 ± 0.5	0.024

Abbreviations: NIMV = noninvasive mechanical ventilation, APACHE = Acute Physiology and Chronic Health Evaluation, GCS = Glasgow Coma Scale, CRP = C-reactive protein, NS = nonsignificant.
*Data given as mean ± SD.

Table 3. The comparison of clinical and laboratory characteristics after 1 and 3 h according to the success of noninvasive mechanical ventilation treatment.

Parameters*	NIMV success (n = 34)	NIMV failure (n = 20)	P-value
After 1 h			
Respiratory rate (bpm)	24.8 ± 6.8	30.1 ± 7.2	0.010
Heart rate (bpm)	98.6 ± 22.4	110.7 ± 22.0	NS
pH	7.36 ± 0.1	7.31 ± 0.1	0.039
PaO_2 (mmHg)	67.4 ± 16.8	70.1 ± 24.7	NS
$PaCO_2$ (mmHg)	65.5 ± 11.0	68.3 ± 14.2	NS
PaO_2/FiO_2	227.8 ± 71.7	222.2 ± 76.7	NS
After 3 h			
Respiratory rate (bpm)	25.9 ± 6.8	33.0 ± 8.7	0.002
Heart rate (bpm)	97.9 ± 19.0	111.7 ± 22.4	0.020
pH	7.37 ± 0.1	7.34 ± 0.1	NS
PaO_2 (mmHg)	63.3 ± 10.5	60.3 ± 12.5	NS
$PaCO_2$ (mmHg)	61.8 ± 11.8	65.3 ± 14.4	NS
PaO_2/FiO_2	237.3 ± 56.8	199.4 ± 47.1	0.017

Abbreviations: NIMV = noninvasive mechanical ventilation, NS = nonsignificant.
*Data given as mean ± SD.

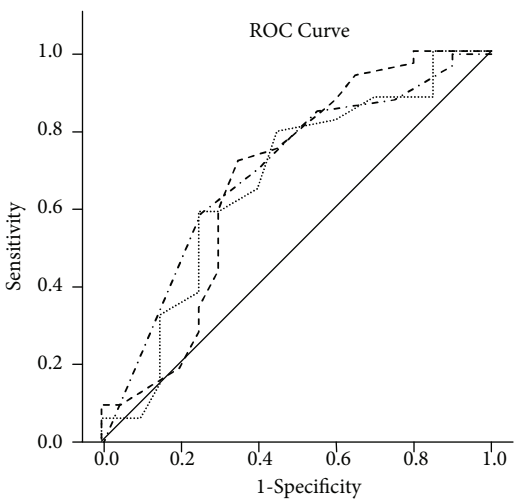
in patients treated successfully with NIMV (5.3 ± 5.1 versus 3.0 ± 3.0 days, $P < 0.05$), whereas the duration of ICU stay was longer in the NIMV failure group (19.5 ± 12.9 versus 6.9 ± 5.3 days, $P < 0.0001$). There was in-hospital mortality in 10 patients (50.0%) with NIMV failure, and only 3 of 34 patients (8.8%, $P = 0.002$) in the successfully treated group died.

Discussion

In the present study, NIMV treatment was successful in 63.0% of patients with respiratory failure due to COPD exacerbations, whereas treatment failure was observed in 20 patients (early failure in 11, late failure in 9). When admission data were compared between the NIMV failure and success groups, arterial pH, serum albumin, and GCS levels were higher in the successful group. During the follow-up, it was found that the arterial pH was higher and the respiratory rate was lower after 1 h, while the PaO_2/FiO_2 rate was higher and respiratory and heart rates were lower after 3 h in the successful group. The rates of in-hospital mortality and HAP were observed to be higher and the duration of ICU stay was longer in the NIMV failure group.

The rate of success of NIMV in respiratory failure due to COPD exacerbations ranges from 60% to 95%. Confalonieri et al. (14) showed that NIMV application in acute exacerbations of COPD was effective in 77.1% of 1033 patients. Similarly, Antonio et al. (15) successfully treated 34 of 44 episodes (77.0%) of chronic airflow limitation with acute hypercapnic respiratory failure with NIMV, and endotracheal intubation was avoided. In another study carried out in our clinic, NIMV was useful and IMV treatment was not required in 28 of 38 patients (73.7%) (16). In the present study, NIMV treatment was successful in 63.0% of patients with respiratory failure due to COPD exacerbations.

The failure of NIMV was evaluated as early failure or late failure and the causes of failure were investigated in certain studies. Moretti et al. (17) applied NIMV treatment in 136 patients with COPD acute exacerbations, and they determined late failure in 31 patients (23%). Carratu et al. (18) evaluated NIMV success in 122 patients with respiratory failure due to COPD exacerbations, and they observed early failure in 13 patients (10.7%) and late failure in 10 patients (8.2%). We found early failure in 11 patients

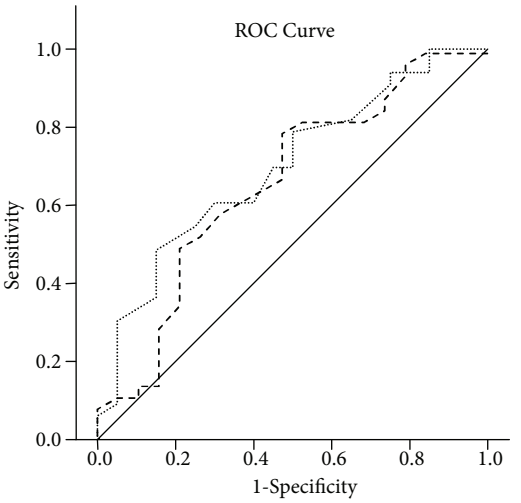


a. Baseline

pH (AUC= 0.663, CI=0.505-0.821)

Albumin (AUC= 0.673, CI=0.510 -0.837)

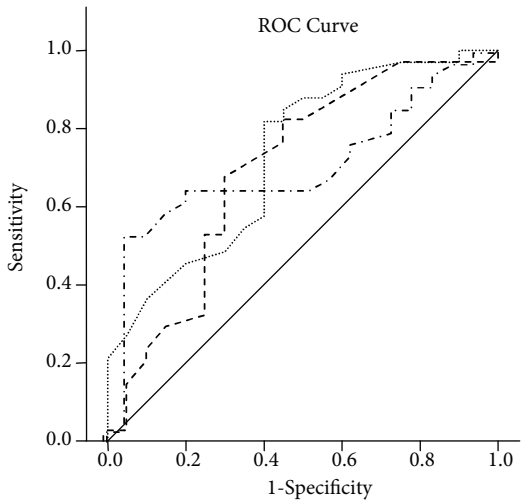
GCS (AUC= 0.700, CI=0.553 -0.847)



b. First hour of NIMV;

Respiratory rate (AUC = 0.696, CI=0.552 -0.841)

pH (AUC= 0.667, CI=0.510-0.825)



c. Third hour of NIMV;

Respiratory rate (AUC = 0.731, CI=0.590 -0.872)

Heart rate (AUC= 0.697, CI=0.543 -0.8 51) ,

PaO 2/FiO 2 (AUC= 0.696, CI=0.550 -0.842).

Figure 1. ROC curves, area under the curves (AUC), and confidence intervals (CI) of the factors affecting success rates a) at the baseline, b) after 1 h, and c) after 3 h of noninvasive mechanical ventilation treatment (NIMV).

(20.3%) and late failure in 9 patients (16.7%). The rates of failure in our study were similar to other rates found in the literature.

It is important to elucidate the risk factors for NIMV failure on admission. Levels of GCS < 11, Acute Physiology and Chronic Health Evaluation II (APACHE II) scores > 28, respiratory rate > 29/min, and pH < 7.25 at baseline were found to be related in more than 70% of NIMV failure cases (14). Antonio et al. (15) showed that the level of consciousness was the only factor affecting NIMV success. In another

Table 4. The effect of baseline and follow-up clinical and laboratory characteristics on noninvasive mechanical ventilation failure.

Parameters	NIMV failure rate (%)
Baseline	
GCS < 13 and pH < 7.30	80.0
GCS < 13 and albumin < 3.5 g/dL	63.6
Albumin < 3.5 g/dL and pH < 7.30	53.8
After 1 h	
Respiratory rate > 27/min and pH < 7.30	50.0
After 3 h	
Respiratory rate > 27/min and PaO_2/FiO_2 < 200	85.7
Heart rate > 100/min and PaO_2/FiO_2 < 200	66.7
Respiratory rate > 27/min and heart rate > 100/min	60.0

Abbreviations: NIMV = noninvasive mechanical ventilation, GCS = Glasgow Coma Scale.

Table 5. The comparison of clinical and laboratory characteristics after 1 and 3 h according to early and late noninvasive mechanical ventilation failure.

Parameters*	NIMV success (n = 34)	NIMV early failure (n = 11)	NIMV late failure (n = 9)
After 1 h			
Respiratory rate (bpm)	24.8 ± 6.8	30.1 ± 8.8 *	30.1 ± 5.3 *
Heart rate (bpm)	98.6 ± 22.4	108.6 ± 22.2	113.2 ± 22.8
pH	7.36 ± 0.1	7.31 ± 0.1	7.30 ± 0.1
PaO_2 (mmHg)	67.4 ± 16.8	73.1 ± 28.8 †	65.9 ± 18.8
$PaCO_2$ (mmHg)	65.5 ± 11.0	69. 8 ± 14.7	66.1 ± 14.1
PaO_2/FiO_2	227.8 ± 71.7	232.5± 91	207.8 ± 53.7
After 3 h			
Respiratory rate (bpm)	25.9 ± 6.8	33.7 ± 10.1 ‡	32.1 ± 7.2 †
Heart rate (bpm)	97.9 ± 19.0	107.7 ± 23.3	116.6 ± 21.7 ‡
pH	7.37 ± 0.1	7.32 ± 0.1	7.35 ± 0.1
PaO_2 (mmHg)	63.3 ± 10.5	61.6 ± 11.1	58.9 ± 14.4
$PaCO_2$ (mmHg)	61.8 ± 11.8	69.3 ± 16.4	60.9 ± 11.3
PaO_2/FiO_2	237.3 ± 56.8	190.4 ± 29.6 #	209.4 ± 61.6

Abbreviation: NIMV = noninvasive mechanical ventilation.
Comparison of success and early failure: *P = 0.045, †P = 0.033, ‡P = 0.006, #P = 0.027.
Comparison of success and late failure: *P = 0.037, †P = 0.019, ‡P = 0.015.
*Data given as mean ± SD.

study, poor consciousness was also related to NIMV failure (19). In 111 patients with acute hypercapnic respiratory failure (COPD in 43 patients), high APACHE II scores and high heart rates on admission were detected as estimated parameters of NIMV success (20). In our previous study carried out in our ICU, high APACHE II scores on admission were determined as a factor predicting NIMV outcomes (16). When baseline data of NIMV failure and success groups were assessed in this study, arterial pH, serum albumin, and GCS levels were higher in the successful group. Similar to other investigations, arterial pH and GCS were the parameters affecting the success of NIMV. It was reported that serum albumin levels had no effect on NIMV results (17). However, in our study, mean serum albumin level was found to be lower in patients with NIMV failure (3.3 g/dL versus 3.6 g/dL). Therefore, future studies evaluating the relationship between serum albumin level and NIMV success are needed. The evaluation of baseline characteristics together showed that NIMV failure was more common in patients with GCS < 13 and pH < 7.30 (80.0%).

The presence of pneumonia at the beginning of treatment also affected NIMV success (18). In our study, the failure rate of NIMV was higher in patients with pneumonia on admission, but the difference was not statistically significant.

The effect of follow-up findings on NIMV failure should also be evaluated. Improvements in the level of consciousness and in values of pH and $PaCO_2$ after 1 h were found to be related to treatment success (15). The risk of NIMV failure for a pH value of less than 7.25 after 2 h of treatment was determined to be 90.0% (14). In our study, lower arterial pH and higher respiratory rates were detected after 1 h, and a lower PaO_2/FiO_2 rate and higher respiratory and heart rates were found after 3 h in the NIMV failure group. The most important follow-up parameter affecting NIMV success was the respiratory rate. The assessment of follow-up characteristics together indicated that the highest rates for NIMV failure were found in patients with respiratory rate > 27/min and PaO_2/FiO_2 < 200 (85.7%) and in patients with heart rate > 100/min and PaO_2/FiO_2 < 200 (66.7%).

The evaluations for early and late failure of NIMV were also performed separately. Moretti et al. (17) reported that late failure of NIMV was related to the comorbid diseases and low arterial pH on admission. In another study (18), higher values of APACHE II scores and respiratory and heart rates, and lower values for GCS scores, PaO_2/FiO_2 rate, and arterial pH values at baseline, were found to be the characteristics for early failure. In addition, accompanied pneumonia and cardiac and renal diseases in patients with early failure, and accompanied cardiac and renal diseases in patients with late failure, were significantly more frequent. In our study, it was found that the respiratory rate and PaO_2 were higher after 1 h, and the respiratory rate was higher and PaO_2/FiO_2 was lower after 3 h in the early failure group. The value of PaO_2 was unexpectedly higher in patients with early failure. It was thought that administration of more supplemental oxygen than required after 1 h could be the explanation for this finding. Therefore, use of the PaO_2/FiO_2 rate might be more appropriate. Respiratory rate after 1 h and both respiratory and heart rates after 3 h were higher in patients with late failure. Although it was demonstrated that comorbidity, especially cardiovascular disease, decreased the success rate of NIMV in COPD exacerbations (15,18,19,21), comorbid diseases in our study did not affect NIMV results.

It was reported that the risk of HAP was lower in patients treated with NIMV compared to IMV patients (9,10). In our study, the rate of HAP in the NIMV success group was also lower (8.8% versus 50.0%). In addition, the duration of ICU stay was longer (19.5 ± 12.9 versus 6.9 ± 5.3 days) in the NIMV failure group, similar to the results of Phua et al. (20). Endotracheal intubation due to NIMV failure and IMV-related complications such as HAP prolong the duration of ICU stay and increase the cost of treatment.

Moretti et al. (17) detected a mortality rate of 53.0% in patients treated with IMV because of NIMV failure. They found a mortality rate of 92.0% if NIMV treatment continued in spite of failure. It was concluded that the mortality rate increased in patients with NIMV failure, especially in those treated with NIMV in spite of failure. In our study, in-hospital mortality was detected in 50.0% of patients with NIMV failure, whereas only 8.8% of the successfully treated patients died.

There are some limitations of this study. First, the number of cases is small. Therefore, multiple regression analysis could not be carried out. Second, this study is retrospective and not comparative.

Despite these limitations, we have been performing NIMV since 2002 and wanted to present the experience of our center. We have found that arterial pH, serum albumin, and GCS on admission are important factors that affect the success of NIMV, similar to other results in the literature. We particularly emphasize that the serum albumin level is a prognostic factor in predicting NIMV success. In our study, unlike previous studies in the literature, the presence of comorbid conditions did not affect the NIMV response.

Conclusion

In the present study, use of NIMV avoided endotracheal intubation in 63.0% of patients with respiratory failure due to COPD exacerbations, whereas NIMV was not useful in 11 patients in the early period and IMV was required in 9 patients in the late period. It was thought that clinical, laboratory, and ABG analysis data on admission and after 3 h gave important clues about NIMV success. The evaluation of baseline and follow-up data may be useful in determining whether to begin NIMV treatment in respiratory failure due to COPD exacerbation, and it may prevent the delay of intubation in patients with high probabilities of NIMV failure.

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