Efficacy of Noninvasive Positive Pressure Ventilation in Elderly Patients with Acute Hypercapnic Respiratory Failure

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Key Words

Elderly patients • Acute hypercapnic respiratory failure • Noninvasive positive pressure ventilation • Glasgow Coma Scale • APACHE II score

Abstract

Background: There have been no reports on the efficacy of noninvasive positive pressure ventilation (NPPV) in elderly patients. **Objectives:** The purpose of this study was to clarify the efficacy and identify the predictors of a successful outcome of NPPV in patients over the age of 75 years with acute hypercapnic respiratory failure (AHRF). **Methods:** We retrospectively evaluated the data of 42 patients (21 men) with AHRF who were treated at our unit. The patients were divided into survivor and nonsurvivor groups, and the clinical parameters measured prior to the initiation of NPPV were compared between the 2 groups. **Results:** The mean age of the patients was 83.0 ± 6.3 years. The etiology of the respiratory failure was acute exacerbation of chronic obstructive pulmonary disease in 19 patients, acute cardiogenic pulmonary edema in 18 patients, idiopathic pulmonary fibrosis in 3 patients, sequelae of tuberculosis in 1 patient, and asthma in 1 patient. Of the 42 patients, 33 (78.6%) survived. All patients with a Glasgow Coma Scale (GCS) score ≥ 9 and/or an APACHE II score < 29 survived after the initiation of NPPV. **Conclusion:** An APACHE II score < 29 and a GCS score ≥ 9 were predictors of a successful outcome of NPPV in elderly people.

Introduction

Noninvasive positive pressure ventilation (NPPV) is a ventilatory technique that is being increasingly adopted for both acute and chronic respiratory failure. NPPV has been a subject of considerable academic and clinical interest over the last 10 years. There have been dozens of randomized controlled trials and at least 12 systematic reviews and meta-analyses [1–12]. NPPV obviates the need for endotracheal intubation and affords survival benefits in appropriately selected patients. NPPV has yielded the greatest benefit in patients with severe exacerbations of chronic obstructive pulmonary disease (COPD) [3, 13–15] or those with acute cardiogenic pulmonary edema (CPE) [16–19]. This technique has also been reported to be beneficial in other circumstances, e.g. respiratory failure following lung resection surgery [20] or solid-organ transplantation [21], respiratory failure associated with immunocompromise [22], and prevention of extubation failure [23]. Use of NPPV has also been reported to be associated with a significantly reduced risk of nosocomial pneumonia [24].

There are some parameters that have been reported to be predictive of a successful outcome in patients undergoing NPPV. With regard to the influence of age, while some reports have cited younger age as a predictor of a successful outcome [25, 26], others have not [17, 27–29]; however, old age has not been identified as a predictor

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of failure of NPPV. There have been no reports on the efficacy of NPPV in elderly patients. The purpose of our study was to clarify the efficacy and identify the predictors of a successful outcome of NPPV in patients over the age of 75 years with acute hypercapnic respiratory failure (AHRF).

Methods

The study protocol was approved by the Human Ethics Review Committee of Kainan Municipal Hospital. The committee did not require the patients' approval or informed consent for the retrospective review of their records.

We retrospectively evaluated the data of 42 patients over the age of 75 years with AHRF (21 men and 21 women) who were treated at our unit. In all cases, the patients or their families had refused to consent to intubation and mechanical ventilation but provided consent for NPPV. Written informed consent for participation in this study was obtained from all of the patients. The diagnosis of AHRF and determination of its etiology were based on laboratory evaluation, radiological examination, history, and physical examination findings. The characteristics of the patients are summarized in table 1. The mean age of the patients was 83.0 ± 6.3 years. The etiology of the respiratory failure was acute exacerbation of COPD in 19 patients, CPE in 18 patients, idiopathic pulmonary fibrosis (IPF) in 3 patients, sequelae of tuberculosis in 1 patient, and asthma in 1 patient. The average values of the laboratory data of the patients were as follows: arterial blood gas analysis before the start of NPPV: pH 7.24 ± 0.11 , PaCO₂ 81.6 ± 26.1 mm Hg, PaO₂ 76.1 ± 36.9 mm Hg, HCO₃ 34.8 ± 10.0 mEq/l; vital signs before the start of NPPV: body temperature $37.2 \pm 1.0^\circ\text{C}$, average blood pressure 85.6 ± 12.8 mm Hg, heart rate 98.6 ± 20.9 beats/min, respiratory rate 30.1 ± 5.9 breaths/min, Glasgow Coma Scale (GCS) score 7.8 ± 3.1 , APACHE II score 28.4 ± 6.6 points.

Patients with acute exacerbation of their primary disease were initiated on NPPV when they fulfilled the following criteria: rapid deterioration of neurological status, acute onset of severe hypercapnia (PaCO₂ >45 mm Hg), acute decrease in blood pH (<7.35), tachypnea, and/or paradoxical respiration. We used the NIP nasal A[®] and Mirage[®] Full Face Mask (Teijin Pharma Limited, Tokyo, Japan) device for administering NPPV. The initial setting for NPPV was the spontaneous/timed (S/T) mode. The inspiratory positive airway pressure (IPAP) was 8–10 cm H₂O and the expiratory positive airway pressure (EPAP) was 4 cm H₂O; the IPAP level was gradually increased to 16 cm H₂O and the EPAP was 8 cm H₂O. Oxygen delivery was set at the lowest value to keep the PaO₂ at >60 mm Hg (oxygen 1–15 liters/min). All patients were treated at an intermediate care station or at a regular station and did not need sedation to accept NPPV. NPPV was used all day except at mealtime. In spontaneous mode the device triggers IPAP when flow sensors detect spontaneous inspiratory effort and then cycles back to EPAP. In timed mode IPAP/EPAP cycling is purely machine triggered at a set rate typically expressed in breaths per minute. In S/T mode, like in spontaneous mode, the device triggers IPAP based on patient inspiratory effort. However, in S/T mode a 'backup' rate is also set to ensure that patients still

Table 1. Characteristics of subjects

Patients, n	42
Sex (male), n	21
Age, years	83.0 ± 6.3
Body height, cm	161.2 ± 9.3
Body weight, kg	51.8 ± 15.5
Etiology, n	
COPD	19
CPE	18
IPF	3
Sequelae of tuberculosis	1
Asthma	1
Arterial blood gas	
pH	7.24 ± 0.11
PCO ₂ , mm H ₂ O	81.6 ± 26.1
PO ₂ , mm H ₂ O	76.1 ± 36.9
HCO ₃ , mEq/l	34.8 ± 10.0
Vital signs	
Body temperature, °C	37.2 ± 1.0
Average blood pressure, mm Hg	85.6 ± 12.8
Heart rate, beats/min	98.6 ± 20.9
Respiratory rate, breaths/min	30.1 ± 5.9
GCS	7.8 ± 3.1
APACHE II score	28.4 ± 6.6
Mortality, %	21.4 (9/42)

receive a minimum number of breaths per minute if they fail to breathe spontaneously. NPPV was considered successful when the blood pH increased to >7.35 and the PaCO₂ decreased to <45 mm Hg during spontaneous breathing without further worsening of the neurological signs and with improvement of the tachypnea and paradoxical breathing. NPPV stopped when we judged that the NPPV treatment succeeded.

The patients were divided into survivor and nonsurvivor groups, and the clinical parameters measured prior to the initiation of NPPV were compared between the 2 groups. The survivor group was defined as discharged from the hospital in our study. The patients of the survivor group were discharged with intermittent noninvasive ventilation.

A Mann-Whitney U test was used for comparison of the quantitative variables, while the qualitative variables were compared using a χ^2 test; $p < 0.05$ was considered statistically significant.

Results

Of the 42 patients, 33 (78.6%) survived (table 1). Among the parameters measured before the start of NPPV, the GCS scores were significantly higher and the APACHE II scores were significantly lower in the survivor group than in the nonsurvivor group (table 2). The mortality rates by etiology were as follows: COPD, 15.8% (3/19); CPE, 22.2% (4/18); IPF, 33.3% (1/3); sequelae of tuberculosis, 100%

Fig. 1. Relation between GCS, APACHE II score, and prognosis. All patients with a GCS score ≥ 9 or an APACHE II score < 29 were rescued using NPPV.

Table 2. Characteristics of subjects divided into 2 groups by the eventual clinical outcome

	Survivor	Nonsurvivor	p
Patients, n	33	9	
Sex (male), n	16	5	
Age, years	81.9 $\pm$ 6.0	86.7 $\pm$ 6.1	0.08
Body height, cm	154.8 $\pm$ 13.5	164.5 $\pm$ 5.2	0.12
Body weight, kg	52.0 $\pm$ 18.6	55.8 $\pm$ 14.5	0.29
Etiology, n			
COPD	16	3	
CPE	14	4	
IPF	2	1	
Sequelae of tuberculosis	0	1	
Asthma	1	0	
Arterial blood gas			
pH	7.27 $\pm$ 0.08	7.18 $\pm$ 0.18	0.12
PCO ₂ , mm H ₂ O	78.6 $\pm$ 21.2	91.9 $\pm$ 39.4	0.29
PO ₂ , mm H ₂ O	80.5 $\pm$ 38.5	59.9 $\pm$ 26.2	0.07
HCO ₃ , mEq/l	34.6 $\pm$ 9.5	35.6 $\pm$ 12.3	0.53
Vital signs			
Body temperature, °C	37.1 $\pm$ 0.9	37.5 $\pm$ 1.3	0.06
Average blood pressure, mm Hg	85.5 $\pm$ 12.8	86.2 $\pm$ 13.4	0.85
Heart rate, beats/min	96.4 $\pm$ 19.9	106.7 $\pm$ 23.6	0.1
Respiratory rate, breaths/min	30.2 $\pm$ 5.6	30.0 $\pm$ 7.2	0.75
GCS	8.9 $\pm$ 2.4	4.0 $\pm$ 1.7	<0.01
APACHE II score	26.4 $\pm$ 5.3	35.9 $\pm$ 5.5	<0.01

Statistical analysis was carried out using a Mann-Whitney U test and a χ^2 test.

(1/1), and asthma, 0% (0/1). All patients with a GCS score ≥ 9 and/or an APACHE II score < 29 survived after the initiation of NPPV (fig. 1).

The gas exchange within the first 1–2 h after the initiation of NPPV of all survival patients was not improved. In 3 survival cases, the PaCO₂ was not temporarily improved within the first 1–2 h after the initiation of NPPV;

however, the parameters were improved 4 and 6 h after the initiation of NPPV (fig. 2a). Nevertheless, the heart and respiratory rates, neurological signs, and paradoxical breathing improved within the first 1–2 h after the initiation of NPPV in all survival cases. On the other hand, in all nonsurvival cases, the gas exchange and heart and respiratory rates were not improved (fig. 2b).

Fig. 2. Trend of CO₂ under NPPV. The gas exchange within the first 1–2 h after the initiation of NPPV of all survival patients was not improved. In 3 survival cases, the PaCO₂ was not temporarily improved within the first 1–2 h after the initiation of NPPV; however, the parameters were improved 4 and 6 h after the initiation of NPPV (**a**). The heart and respiratory rates, neurological signs, and paradoxical breathing improved within the first 1–2 h after the initiation of NPPV in all survival cases. On the other hand, in all nonsurvival cases, the gas exchange and heart and respiratory rates were not improved (**b**).

Discussion

Our study was conducted to clarify the efficacy and identify the predictors of a successful outcome of NPPV in patients over the age of 75 years with AHRF.

Previous studies have suggested some predictors of a successful outcome of NPPV as follows: younger age, lower severity of illness (lower APACHE II score), ability of the patient to cooperate, better neurologic score, ability of the patient to coordinate breathing with a ventilator, less air leakage, intact dentition, hypercarbia but not too severe ($45 < \text{PaCO}_2 < 92$ mm Hg), acidemia but not too

severe ($7.35 > \text{pH} > 7.10$), improvement of gas exchange and heart and respiratory rates within the first 1–2 h after the initiation of NPPV, no pneumonia, and the ability of the patient to clear respiratory secretions [17, 25–29].

The GCS and APACHE II scores were the predictors of a successful outcome of NPPV in patients over the age of 75 years with AHRF in our study.

A GCS score < 10 was previously reported as a contraindication for NPPV [28]. However, there were 6 patients with a GCS score < 10 among the subjects in our study, and the mortality rate in these patients was limited to 60%. The GCS scores in the survivor group ranged from

7 to 9. A good level of consciousness is a prerequisite for the patient's cooperation with NPPV therapy, as is his/her ability to coordinate breathing with the ventilator. Such cooperation and coordinated breathing with a ventilator enable improvement of the gas exchange and of the heart and respiratory rates within the first 1–2 h after the start of NPPV. The findings of our study showed that a good level of consciousness as a predictor of a good outcome of NPPV also applies to the elderly. Based on our observations, we suggest that a GCS score ≥ 9 is a predictor of a successful outcome of NPPV. Lower APACHE II scores and a higher level of consciousness in acutely ill patients started on NPPV have been reported as predictors of a successful outcome. We could rescue all of the patients with an APACHE II score <25 . In general, the mortality of nonoperative patients with an APACHE II score ≥ 25 has been reported to exceed 50% [30]. The mortality rate in our cases with an APACHE II score ≥ 25 was 27.6% (9/28). We consider this result to be possibly attributable to the good level of consciousness of the patients. We should carefully think about adaptations for patients with APACHE II scores ≥ 25 .

NPPV may be useful for compassionate use, providing relief from dyspnea and avoiding aggressive approaches for elderly patients with AHRF. Mollica et al. [31] report-

ed that mechanical ventilation did not appear to have a significant impact on the survival of patients with end-stage IPF. NPPV may be useful for compassionate use, providing relief from dyspnea and avoiding aggressive approaches. It should be considered as an interesting alternative to conventional ventilation.

The number of patients in our study was very small, and typical geriatric assessment variables were not available to perform a stratified analysis of special geriatric assessments such as multimorbidity, activities of daily living assessment, medication strategies, and the involvement of human resources to support especially the more severe cases. Besides, there were a few patients with dementia or severe acidosis (pH <7.10). It will be necessary to examine the efficacy of NPPV in patients with the above mentioned conditions in the future. Our further studies should be conducted in a prospective way with inclusion of typical geriatric assessment variables to evaluate the circumstances in which NPPV should be withheld.

In conclusion, if no predictors of failure such as high APACHE II scores (<29) and/or low level of consciousness (GCS score ≥ 9) are present, NPPV may be expected to yield a successful outcome in elderly patients with AHRF.

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