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Noninvasive Positive Pressure Ventilation in Treatment of Non-COPD Related Acute Respiratory Failure Cases

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ABSTRACT

We used Noninvasive Positive Pressure Ventilation (NPPV) in nine patients with acute respiratory failure (ARF), not related to chronic obstructive pulmonary disease (COPD). After separating the nine patients into a hypercapnic group (five patients) and a non-hypercapnic group (four patients), we investigated its effectiveness in physiological improvement and avoiding intubation.

Dyspnea, physiological findings and ABG improved rapidly in both groups without serious adverse effects. The intubation avoidance rate was 66.7% (6 of 9) in total, and 80% in the hypercapnic group and 50% in the non-hypercapnic group. The ratio of PaO_2 to FiO_2 (P/F ratio) increased during NPPV in most cases where intubation could be avoided.

It is worthwhile to use NPPV as a bridging therapy between O_2 therapy and invasive ventilation in patients with non-COPD related ARF, regardless of the existence of hypercapnia. Careful monitoring of the P/F ratio and complications is needed to make an appropriate decision whether avoiding intubation will be possible or not.

Key words: *Noninvasive Positive Pressure Ventilation, Non-COPD related acute respiratory failure, Hypercapnea, Ratio of PaO_2 to FiO_2 (P/F ratio)*

Several randomized control trials have shown that Noninvasive Positive Pressure Ventilation (NPPV) is effective in reducing the need to intubate patients with acute exacerbations of chronic obstructive pulmonary disease (COPD) with hypercapnea[3,5,8,9,12,14]. While NPPV has been recently applied to many types of acute respiratory failure (ARF) cases[4,7,10], the success rates for avoiding intubation in non-COPD patients ranged from 20.0% to 62.5%[8,9,15], and the efficacy of NPPV for patients with non-COPD related ARF has remained controversial. Besides, whether the efficacy of NPPV is the same for patients with and without hypercapnea has also remained uncertain. Recent research has indicated that, compared with oxygen therapy, NPPV using the continuous positive airway pressure (CPAP) mode was not effective for avoiding intubation in non-hypercapnic patients[6]. In the present study, we tried respiratory management using NPPV in patients with non-COPD related ARF, and retrospectively investigated its effectiveness in physiological improvement and avoiding intubation, with a comparison between cases with and without hypercapnea.

MATERIALS AND METHODS

From April, 2000 to March, 2002, we used an NPPV device with an accurate O_2 supplement system (BiPAP Vision®; Respironics Inc) for 9 patients (6 male, 3 female, mean age: 67.7 ± 18.8 years old) who were hospitalized at Hiroshima Red Cross Hospital and Atomic bomb Survivors Hospital. They were hospitalized in the ICU or General Ward randomly. The criteria for starting NPPV was a diagnosis of non-COPD related ARF with the possibility of future intubation, including severe dyspnea at rest; PaO_2 below 60 mmHg or considered to fall below 60 mmHg without O_2 supplement; a respiratory rate (RR) greater than 30 breaths/min or a heart rate (HR) greater than 110 beats/min which failed to improve by O_2 therapy. We diagnosed the underlying disease by chest X-ray examination, chest computed tomography, electrocardiogram, echocardiogram, etc., and eliminated acute exacerbations of COPD or cases with contraindications to NPPV, such as acute myocardial infarction or pneumothorax[10]. We explained

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the need, predictable efficacy, and possible adverse effects of NPPV to the patients and families and received their consent.

In all cases, we used a pressure-limited device mode called the Spontaneous/Timed mode (S/T mode). Inspiratory positive airway pressure (IPAP), expiratory positive airway pressure (EPAP) and rise time (the time to rise from EPAP to IPAP) were set where patients felt most comfortable. We set FiO_2 to maintain SpO_2 greater than 90% and set the controlled rate at about 10–12 /min so that the T mode did not work asynchronous to patient breathing. We carefully checked that IPAP and EPAP were delivered without delay in patient respiratory effort on the monitoring panel. Nasal masks and oro-nasal masks were used as interfaces. RR, HR and arterial blood gases (ABG) were determined shortly after NPPV. We changed the NPPV settings, and decided the timing for stopping NPPV or intubation according to our clinical judgement and follow-up ABG. The 9 patients were separated into a hypercapnic group ($PaCO_2 \geq 45$ mmHg) and a non-hypercapnic group ($PaCO_2 < 45$ mmHg)[11,14].

All statistical analysis was performed with the statistical program Statview 5.0 (Abacus, Concepts, Berkley, CA). The data are presented as mean ± standard deviation (S.D.). Patient characteristics and initial settings of NPPV between the two groups were compared using the unpaired *t*-test or Mann-Whitney U test. Repeated measure one-way analysis of variance was used to compare the changes in RR, HR, ABG and the ratio of PaO_2 to FiO_2 (P/F ratio). For ABG, we added Fisher's protected least significant difference for a multi-comparison, in which each value was compared with values prior to NPPV treatment. A p - value of less than 0.05 was considered statistically significant.

Table 1. Baseline patient characteristics in Hypercapnic and Non-hypercapnic groups

Pt (No.)	Age/Gender (years)	Underlying disease	RR (/min)	HR (/min)	PaO_2 (mmHg)	/	O_2 (L/min)	$PaCO_2$ (mmHg)	pH	avoiding intubation
Hypercapnic group										
1	65/F	TBsq	42	96	40.2	/	1	87.8	7.31	S
2	78/M	TBsq	36	74	36.5	/	2.5	71.2	7.33	S
3	76/F	pneumonia	20	130	35.9	/	12	49.3	7.41	S
4	72/M	APE	39	138	64.3	/	7	60.1	7.33	S
5	81/F	APE,AS	42	120	57.8	/	2	61.8	7.31	F
Non-hypercapnic group										
6	19/M	AEP	40	140	53.9	/	0	38.0	7.30	S
7	72/M	AIP	40	96	44.5	/	3	28.7	7.45	S
8	70/F	PCP	42	98	53.7	/	15	29.7	7.41	F
9	76/M	PCP	30	114	62.2	/	2	29.9	7.47	F

Definition of abbreviations: AEP = Acute Eosinophilic Pneumonia, TBsq = Tuberculosis sequelae, PCP = Pneumocystis Carinii Pneumonia, APE = Acute Pulmonary Edema, AS = Aortic Stenosis, AIP = Acute Interstitial Pneumonia, S = Success, F = Failure.

Table 2. Baseline characteristics and initial NPPV settings in each group

	Hypercapnic group (n = 5)	Non-hypercapnic group (n = 4)	p value
Age (years old)	74.4 ± 6.2	59.3 ± 26.9	0.256
Respiratory rate (breaths/min)	35.8 ± 9.2	38.0 ± 5.4	0.686
Heart rate (beats/min)	111.6 ± 26.3	112.0 ± 20.3	0.981
pH	7.34 ± 0.04	7.45 ± 0.03	0.003
$PaCO_2$ (mmHg)	66.0 ± 14.4	31.0 ± 3.1	0.002
PaO_2 (mmHg)	46.9 ± 13.2	54.7 ± 7.6	0.334
<Initial NPPV settings>			
IPAP (cmH_2O)	7.4 ± 2.1	8.0 ± 1.8	0.663
EPAP (cmH_2O)	4.0 ± 0.0	4.3 ± 0.5	0.292
FiO_2	0.44 ± 0.20	0.75 ± 0.19	0.053
Rise time (sec)	0.15 ± 0.14	0.15 ± 0.17	> 0.999

Definition of abbreviations: NPPV = Noninvasive Positive Pressure Ventilation, IPAP = Inspiratory Positive Airway Pressure, EPAP = Expiratory Positive Airway Pressure.

RESULTS

Patient characteristics and initial settings of NPPV

Five patients were in the hypercapnic group and four patients were in the non-hypercapnic group (Table 1). One patient had previously used home oxygen therapy (HOT) with home NPPV (Patient No.1). Two patients with pneumocystis carinii pneumonia (PCP) had continued long-term treatment with corticosteroids against rheumatoid arthritis (Patient No. 8) and myeloperoxidase-antineutrophil cytoplasmic antibody-positive vasculitis (Patient No. 9). There was no statistical difference in the baseline characteristics of the two groups except that $PaCO_2$ was significantly higher and pH was significantly lower in the hypercapnic group (Table 2). As for the initial NPPV settings, FiO_2 was higher in the non-hypercapnic group with borderline statistical significance, but IPAP, EPAP and Rise time were similar between the two groups (Table 2).

Changes in physiological findings and ABG during NPPV

Dyspnea improved rapidly after NPPV in all cases. The average interval time until we first determined RR, HR, and ABG after NPPV was 91.8 ± 72.1 min in the hypercapnic group and 71.5 ± 56.1 min in the non-hypercapnic group, and there was no statistical difference ($p = 0.659$). Figure 1 shows the changes in RR, HR, ABG and the P/F ratio. In the hypercapnic group, RR decreased significantly ($p = 0.014$) and HR also decreased with borderline statistical significance ($p = 0.051$). During NPPV, $PaCO_2$ decreased ($p = 0.061$) with a significant increase of pH ($p = 0.013$)

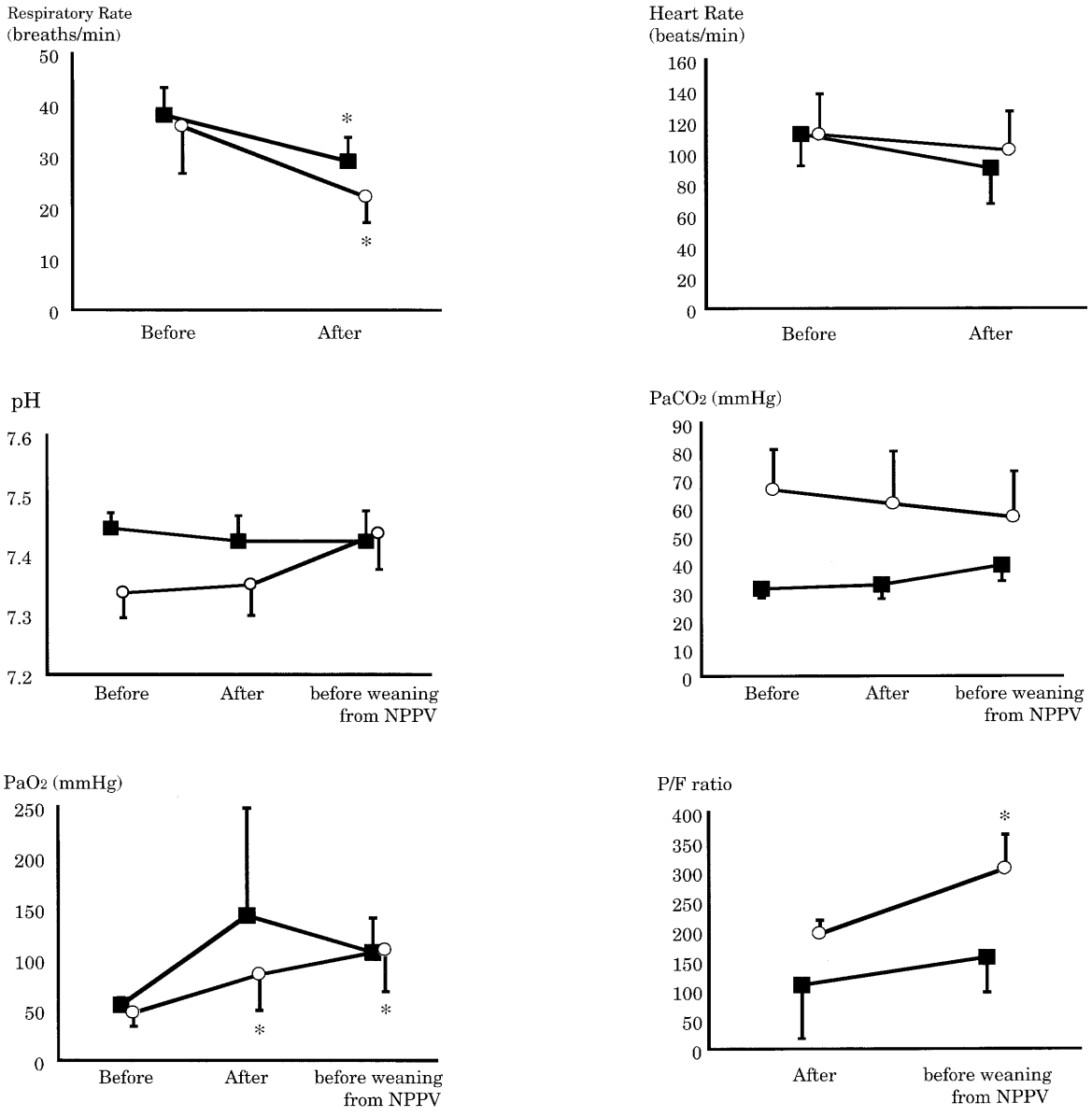

Fig. 1. Changes in physiological findings, ABG and the P/F ratio before and during NPPV in the hypercapnic group (○) and the non-hypercapnic group (■).
*$p < 0.05$ versus before NPPV.

and PaO_2 significantly increased (p = 0.018). The P/F ratio increased in all hypercapnic patients and its increase was statistically significant (p = 0.032). In the non-hypercapnic group, RR decreased significantly (p = 0.044) and HR decreased without statistical significance (p = 0.097). $PaCO_2$ increased with borderline significance (p = 0.058) and pH slightly decreased (p = 0.726). PaO_2 once increased to 142.5 ± 105.9 mmHg after NPPV but it decreased to 106.5 ± 33.5 mmHg before weaning from NPPV (p = 0.196). The P/F ratio increased in two patients and decreased in two patients. The mean P/F ratio decreased from 180.4 ± 90.9 to 154.9 ± 58.9 (p = 0.55).

Success rate for avoiding intubation and adverse effects

The overall success rate for avoiding intubation was 66.7% (6 of 9), while the success rates of the hypercapnic group and non-hypercapnic group were 80.0% (4 of 5) and 50.0% (2 of 4), respectively. In the case of the patient with acute eosinophilic pneumonia (AEP) (Patient No. 6), avoiding intubation was possible despite the fact that his P/F ratio decreased from 298.0 to 234.5 during NPPV. One patient in the non-hypercapnic group needed intubation (Patient No. 8) because tachypnea with more than 40 breaths/min appeared again under NPPV, and her P/F ratio decreased from 201.7 to 95.1. One patient in the hypercapnic group (Patient No. 5) died because of ventricular tachycardia (VT) and one patient in the non-hypercapnic group (Patient No. 9) died because of septic shock. The P/F ratio had increased from 231.1 to 239.4 in Patient No. 5 and 90.3 to 157.0 in Patient No. 9. We did not observe serious adverse effects induced by NPPV, except mild facial wounds that appeared in all cases despite using a wound-coating patch (DuoACTIVE®; ConvaTec inc.) from the beginning of NPPV.

DISCUSSION

In both groups, tachypnea, tachycardia and hypoxemia improved rapidly without high supportive pressure delivery or serious adverse effects[2,5,8,10]. Furthermore, CO_2 retention and respiratory acidemia improved in the hypercapnic group. This improvement in physiological findings and ABG is one of the most important factors for successful NPPV, which prevents immediate intubation and gives time for diagnosis, treatment, and asking about patient wishes with regard to intubation.

However, improvement in physiological findings and ABG is not enough and improvement of alveolar oxygenation by medication is another very important factor for avoiding intubation. Alveolar oxygenation is reflected by the P/F ratio, which is said to be an independent factor for predicting whether avoiding intubation will be possible[1]. Also in the present study, avoiding intubation was possible in all patients, whose P/F ratio increased during NPPV, except two patients who died because of fatal complications not related with NPPV. In the case of the patient with AEP (Patient No. 6), a discrepancy between a decrease in the P/F ratio and avoiding intubation may be explained by increased bilateral exudative pleural effusion and passive atelectasis, despite the fact that AEP itself improved by steroid therapy. In total, the P/F ratio increased during NPPV in the hypercapnic group but it decreased in the non-hypercapnic group with a low percentage of avoiding intubation, although statistical discussion is difficult due to the small number of patients. We considered that this was probably due to differences in the underlying disease and its reversibility. Although the BiPAP Vision® device is superior to other NPPV devices in that it can supply accurate high O_2 (FiO_2: 0.21–1.00) regardless of the respiratory state and NPPV settings[13] and is useful for maintaining a high PaO_2 level even in severe hypoxemia cases[6], the P/F ratio must be carefully monitored in order not to lose the appropriate time for intubation. On the other hand, $PaCO_2$ gradually increased to about 40 mmHg in the non-hypercapnic group. We must be careful in interpretation to distinguish whether this was the result of an improvement of hyperventilation due to hypoxemia or the result of continuous rapid breathing and respiratory muscle fatigue.

The results of the present study indicate that it is worthwhile to use NPPV as a bridging therapy between O_2 therapy and invasive ventilation in patients with non-COPD related ARF, regardless of the existence of hypercapnia. Careful monitoring of the P/F ratio and complications is needed to make an appropriate decision whether avoiding intubation will be possible or not.

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