

## Acute Physiologic Effects of Nasal and Full-Face Masks During Noninvasive Positive-Pressure Ventilation in Patients With Acute Exacerbations of Chronic Obstructive Pulmonary Disease

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**OBJECTIVE:** To assess the efficacy of and patient tolerance for nasal and full-face masks during noninvasive positive-pressure ventilation (NPPV) with patients suffering acute exacerbations of chronic obstructive pulmonary disease. **SETTING:** A respiratory medicine ward of a referral hospital. **METHODS:** Fourteen patients were randomized to 2 groups. Seven used nasal masks and 7 used full-face masks. We used a portable ventilator and recorded arterial blood gases and indices of respiratory muscle effort before and after 15 min of NPPV. Patient tolerance was scored as follows: no tolerance (mask had to be withdrawn before the study period ended) = 0 points; poor tolerance (patient complained of discomfort from the ventilation devices but nevertheless remained compliant) = 1 point; fair tolerance (patient seemed uncomfortable but did not complain) = 2 points; excellent tolerance (patient felt better than before beginning NPPV) = 3 points. **RESULTS:** The groups were comparable in clinical and pulmonary function variables at baseline. NPPV improved both arterial blood gases and the indices of respiratory effort, with no significant differences between the groups. During NPPV the group that used full-face mask had a greater decrease in respiratory rate, but no other differences. NPPV was well tolerated in both groups. **CONCLUSIONS:** In patients suffering acute exacerbations of chronic obstructive pulmonary disease NPPV improves arterial blood gases and respiratory effort indices regardless of the type of mask used. *Key words:* noninvasive, ventilation, NPPV, chronic obstructive pulmonary disease, COPD, mask. [Respir Care 2003;48(10):922–925. © 2003 Daedalus Enterprises]

### Introduction

Noninvasive positive-pressure ventilation (NPPV) successfully treats acute hypercapnic respiratory failure from exacerbation of chronic obstructive pulmonary disease (COPD).<sup>1–7</sup> Interest in NPPV has grown in recent years with the development of comfortable and effective masks, but the selection of an appropriate patient/ventilator interface may play a key role.<sup>8–11</sup> Currently a variety of dis-

posable NPPV masks are available, classified broadly as either nasal mask or full-face mask. Both seem to be effective and each has advantages and disadvantages.<sup>12–19</sup>

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The full-face mask may be more effective because it eliminates mouth leaks,<sup>12,16,17</sup> but because of greater surface contact, leaks can occur around the contact between the mask and the face, especially in edentulous patients. Furthermore, dead space in the full-face mask leads to re-breathing of exhaled air and can interfere with patient-ventilator synchrony.<sup>12,17</sup> Full-face mask tolerance is reported to be lower, possibly because of facial discomfort, a claustrophobic sensation, and the difficulty of eliminating airway secretions.<sup>12,17</sup> Furthermore, potentially serious complications specific to the full-face mask (gastric

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distention and aspiration of vomitus) have been hypothesized and must be watched for.<sup>20</sup>

Therefore, the selection of an appropriate mask has remained open to debate,<sup>12-19</sup> as the 2 types have been directly compared in only 1 clinical trial that specifically analyzed the efficacy and patient tolerance of nasal versus full-face mask.<sup>21</sup> However, that study enrolled a nonhomogeneous group of patients. Moreover, to our knowledge no studies have investigated the response of respiratory muscles to the use of either mask. The objective of the present study was, therefore, to analyze and compare the acute physiologic response to NPPV provided via nasal mask and via full-face mask in patients suffering acute exacerbations of COPD, with specific attention to the effects on respiratory muscle function.

## Methods

### Patient Selection

Fourteen consecutive COPD patients (forced expiratory volume in the first second [FEV<sub>1</sub>] < 80% of predicted, FEV<sub>1</sub>/forced vital capacity < 70%) who were being monitored as out-patients by physicians from our respiratory medicine department were enrolled on admission to the respiratory medicine ward for acute hypercapnic respiratory failure. Upon randomization (at the beginning of NPPV) all were clinically stable after medical treatment. We excluded patients with systolic blood pressure < 90 mm Hg, unstable angina, facial deformity, tracheostomy, or those for whom intubation was necessary to remove airway secretions. Our hospital's ethics committee approved the study, and informed consent was obtained from each patient.

### Design

Patients were randomly assigned to receive NPPV via either nasal mask (7 patients) or full-face mask (7 patients). We used commercially available masks (Reusable Contour Nasal Mask and Spectrum Full Face Mask; Respironics, Murrysville, Pennsylvania) modified to hold a probe (Guenard C48; Marquat, Boissy-Saint-Léger, France) that measures transdiaphragmatic pressure (P<sub>di</sub>). Each patient received 15 min of NPPV from a portable ventilator (BiPAP ST/D 20; Respironics, Murrysville, Pennsylvania) set in the spontaneous-breathing mode, with inspiratory pressure of 15 cm H<sub>2</sub>O and expiratory pressure of 6 cm H<sub>2</sub>O.

### Measures

We recorded respiratory rate, arterial blood gases (ABGs), P<sub>di</sub>, pleural pressure, tension-time index of respi-

ratory muscles, and duty cycle (ratio of inspiratory time to total time of 1 respiratory cycle [T<sub>I</sub>/T<sub>tot</sub>]) prior to and after 15 min of NPPV. Esophageal (pleural) and gastric pressures were analyzed with a probe connected to a transducer and a computer that recorded continuous pressure measurement (Global Lab, Marlboro, Massachusetts). Placement of the probe was guided by the morphology of the pressure wave during the occlusion and compression maneuvers.<sup>22</sup> Changes in T<sub>I</sub>/T<sub>tot</sub> and tension-time index were estimated indirectly, via continuous recording of the pressure/time wave.<sup>23</sup> Patient tolerance of NPPV was scored as follows:

- No tolerance: the mask had to be withdrawn before the study period ended: 0 points
- Poor tolerance: the patient complained of discomfort from the ventilation devices but nevertheless remained compliant: 1 point
- Fair tolerance: the patient seemed uncomfortable but did not complain: 2 points
- Excellent tolerance: the patient felt better than before beginning ventilation: 3 points

### Statistical Analysis

Overall response to NPPV was analyzed with the Wilcoxon *t* test. Group differences in the evolution of each variable were compared with the Mann-Whitney test. Differences were considered statistically significant when *p* < 0.05.

Table 1. Patient Baseline Characteristics and Pulmonary Function Data Obtained in Stable Condition, Before Exacerbation

	Nasal Mask Group	Full-Face Mask Group	P
Age (y)	66 ± 6.45	65.4 ± 6.9	0.73
Sex (female/male)	2/5	2/5	—
Height (cm)	158 ± 13.4	158.8 ± 10.5	0.81
Weight (kg)	65.2 ± 13.5	74.8 ± 17.8	0.15
FEV <sub>1</sub> (% of predicted)	26 ± 4.6	27.6 ± 11.4	0.32
FVC (% of predicted)	46.1 ± 14.9	49.8 ± 14	0.14
FEV <sub>1</sub> /FVC (%)	48 ± 13.9	43.5 ± 18.2	0.12
P <sub>aO<sub>2</sub></sub> (mm Hg)	55.3 ± 6.59	57.2 ± 8.7	0.42
P <sub>aCO<sub>2</sub></sub> (mm Hg)	52.6 ± 4.5	55 ± 5.9	0.38
pH	7.41 ± 0.041	7.36 ± 0.03	0.08

Values are mean ± SD.

FEV<sub>1</sub> = forced expiratory volume in the first second.

FVC = forced vital capacity.

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Table 2. Respiratory Variables Before and During Noninvasive Ventilation

	Before NPPV		After 15 Minutes of NPPV	
	Nasal Mask	Full-Face Mask	Nasal Mask	Full-Face Mask
P <sub>pl</sub> (cm H <sub>2</sub> O)	12.2 ± 4.4	10.6 ± 1.8	7.83 ± 1.91	7.12 ± 1.21
P <sub>di</sub> (cm H <sub>2</sub> O)	15.4 ± 5.5	15.8 ± 5.5	10.9 ± 2.4	9.15 ± 1.3
Tension-time index	0.23 ± 0.06	0.27 ± 0.1	0.25 ± 0.11	0.24 ± 0.06
f (breaths/min)	21.7 ± 5	26.8 ± 4.4	18 ± 4.9	17.7 ± 3.1*
T <sub>I</sub> /T <sub>tot</sub>	0.41 ± 0.05	0.44 ± 0.1	0.43 ± 0.04	0.41 ± 0.03
P <sub>aO<sub>2</sub></sub> (mm Hg)	47.6 ± 7.8	49.7 ± 3.2	49.3 ± 8.7	54.1 ± 4.3
P <sub>aCO<sub>2</sub></sub> (mm Hg)	60.85 ± 6.7	59.14 ± 5.01	52.71 ± 6.4	48.85 ± 6.9
pH	7.40 ± 0.03	7.40 ± 0.02	7.45 ± 0.03	7.46 ± 0.04

Values are mean ± SD.

NPPV = noninvasive positive-pressure ventilation.

P<sub>pl</sub> = pleural pressure.

P<sub>di</sub> = transdiaphragmatic pressure.

f = respiratory frequency.

T<sub>I</sub>/T<sub>tot</sub> = ratio of inspiratory time to total expiratory time (duty cycle).

\*Statistically significant difference (p < 0.05) between nasal mask and full-face mask.

### Results

Clinical and respiratory function values obtained when the patients were in stable condition before hospital admission were similar in both groups (Table 1). Patients were also comparable in all the analyzed respiratory function variables just prior to beginning ventilation (Table 2).

Table 2 also shows results obtained after 15 min of NPPV. NPPV was generally well tolerated with both masks; the mean ± SD score for nasal mask tolerance was 2.42 ± 0.05 and that for full-face mask was 2.14 ± 0.37. Inspiratory effort decreased with NPPV in both groups; the before-and-after NPPV differences were: pleural pressure, p < 0.003; P<sub>di</sub>, p < 0.002; tension-time index, p < 0.002. There were no statistical differences between the groups. NPPV decreased respiratory rate (p < 0.002) with all patients, but respiratory rate improved more in the full-face mask group (p < 0.05). T<sub>I</sub>/T<sub>tot</sub> did not change with either mask. ABG values improved similarly with the 2 masks studied: P<sub>aCO<sub>2</sub></sub> decreased (p < 0.001), pH increased (p < 0.001), and P<sub>aO<sub>2</sub></sub> increased (p < 0.005).

### Discussion

Our results confirm that these nasal and full-face masks are similarly efficient over 15 min of NPPV with COPD patients recovering from acute hypercapnic respiratory failure. Patient tolerance of the masks was similar. We observed no significant differences between the masks for any variable except respiratory rate, which improved more in the full-face mask group, possibly because their initial respiratory rate was higher (though not significantly higher) at the time of starting NPPV. The minimal difference observed in the reduction of P<sub>aCO<sub>2</sub></sub> between the groups (re-

duction of 10.29 vs 8.14 mm Hg) may be explained by variability in ABG analysis. It is important to emphasize that this study enrolled stable COPD patients recovering from acute hypercapnic respiratory failure. The main objective of the study was to compare the 2 types of mask with stable patients, not to evaluate NPPV as an alternative to intubation.

Our data suggest that neither dead space in the full-face mask nor differences in leakage between the 2 masks affect the acute physiologic response to NPPV. In a recent study Navalesi et al<sup>21</sup> observed a slightly better improvement in ventilation with the full-face mask than with the other masks. However, that study enrolled a heterogeneous group of stable hypercapnic patients, and the mode of ventilation, the ventilator, and the masks selected were different from the ones we used. Moreover, it may have been that the improved ventilation they observed with the full-face mask was associated with a dangerous increase in work of breathing, although the lack of data on respiratory muscle effort did not allow them to explore this important aspect of response to NPPV. Our observation, however, of a similar reduction in inspiratory effort with these 2 masks leads us to conclude that ventilatory improvement, indicated by changes in ABGs, involves a similar effort of respiratory muscles with both masks. Consistent with this interpretation the respiratory pattern, evaluated via T<sub>I</sub>/T<sub>tot</sub>, was similar with these masks, even though we observed a greater overall reduction in respiratory rate with the full-face mask. These results suggest that NPPV does not modify the patient's spontaneous breathing pattern, perhaps because each cycle provides more effective ventilation. Once again the choice of mask was not a factor. The lack of differences in our findings between the 2 masks may be explained in part by the number of studied patients. How-

ever, the lack of even small nonsignificant differences seems to suggest that studying a larger sample would not provide evidence for a physiologic effect arising from choice of mask.

Tolerance to NPPV was generally good with both masks over the 15-min period of data collection, but differences in tolerance of the 2 masks might appear over a longer period. Our finding of similar effects on respiratory muscles, ABG values, and breathing pattern during a brief NPPV period suggests that the choice of one type of mask over the other will not influence the final outcome of NPPV, although this should be confirmed by clinical trials.

### Conclusions

NPPV treatment of COPD patients suffering acute hypercapnic respiratory failure improves both ABG values and respiratory effort indices, regardless of whether the nasal mask or the full-face mask is chosen as the interface. Both masks are well tolerated over a period of 15 min.

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