

# Effect of Bi-Level Positive Airway Pressure (BiPAP) Nasal Ventilation on the Postoperative Pulmonary Restrictive Syndrome in Obese Patients Undergoing Gastroplasty\*

Jean L. Joris, MD; Thierry M. Sottiaux, MD; Jean Daniel Chiche, MD; Claude J. Desai, MD; and Maurice L. Lamy, MD

**Study objective:** Upper abdominal surgery results in a postoperative restrictive pulmonary syndrome. Bi-level positive airway pressure (BiPAP System; Respironics Inc; Murrysville, Pa), which combines pressure support ventilation and positive end-expiratory pressure via a nasal mask, could allow alveolar recruitment during inspiration and prevent expiratory alveolar collapse, and therefore limit the postoperative pulmonary restrictive syndrome. This study investigated the effect of BiPAP on postoperative pulmonary function in obese patients after gastroplasty.

**Design:** Prospective controlled randomized study.

**Setting:** GI surgical ward in a university hospital.

**Patients:** Thirty-three morbidly obese patients scheduled for gastroplasty were studied.

**Intervention:** The patients were assigned to one of three techniques of ventilatory support during the first 24 h postoperatively: O<sub>2</sub> via a face mask, BiPAP System 8/4, with inspiratory and expiratory positive airway pressure set at 8 and 4 cm H<sub>2</sub>O, respectively, or BiPAP System 12/4 set at 12 and 4 cm H<sub>2</sub>O. Pulmonary function (FVC, FEV<sub>1</sub>, and peak expiratory flow rate [PEFR]) were measured the day before surgery, 24 h after surgery, and on days 2 and 3. Oxygen saturation by pulse oximeter (SpO<sub>2</sub>) was also recorded during room air breathing.

**Results:** Three patients were excluded. After surgery, FVC, FEV<sub>1</sub>, PEFR, and SpO<sub>2</sub> significantly decreased in the three groups. On day 1, FVC and FEV<sub>1</sub> were significantly improved in the group BiPAP System 12/4, as compared with no BiPAP; SpO<sub>2</sub> was also significantly improved. After removal of BiPAP System 12/4, these benefits were maintained, allowing faster recovery of pulmonary function. No significant effects were observed on PEFR. BiPAP System 8/4 had no significant effect on the postoperative pulmonary restrictive syndrome.

**Conclusion:** Prophylactic use of BiPAP System 12/4 during the first 24 h postoperatively significantly reduces pulmonary dysfunction after gastroplasty in obese patients and accelerates reestablishment of preoperative pulmonary function. (CHEST 1997; 111:665-70)

**Key words:** abdominal surgery; bi-level positive airway pressure; gastroplasty; hypoxemia; nasal mask; noninvasive ventilation; obesity; positive end-expiratory pressure; postoperative complications; pressure support ventilation; pulmonary restrictive syndrome; surgery; ventilatory support

**Abbreviations:** CPAP=continuous positive airway pressure; EPAP=expiratory positive airway pressure; FRC=functional residual capacity; IPAP=inspiratory positive airway pressure; IPPB=intermittent positive pressure breathing; PCA=patient-controlled analgesia; PEEP=positive end-expiratory pressure; PEFR=peak expiratory flow rate; PSV=pressure support ventilation; SpO<sub>2</sub>=oxygen saturation by pulse oximeter (capillary hemoglobin oxygen saturation)

Both upper abdominal and thoracic surgery result in a postoperative pulmonary restrictive syndrome. This restriction of pulmonary function per-

sists for more than 2 weeks, leading to a high incidence of postoperative pulmonary complications such as sputum retention, atelectasis, and bronchopulmonary infection.<sup>1</sup> These complications cause further deterioration of pulmonary function and cause secondary hypoxemia.<sup>2</sup>

Alteration of ventilatory function is multifactorial; reflex inhibition of the phrenic nerve, anesthesia, and pain all contribute to these changes.<sup>3</sup> Different techniques and treatments have been proposed to reduce the postoperative pulmonary restrictive syn-

\*From the Departments of Anesthesia and Intensive Care Medicine (Drs. Joris, Chiche, and Lamy) and Gastrointestinal Surgery (Dr. Desai), University Hospital of Liège, Belgium; and the Department of Anesthesia and Intensive Care Medicine, Gosselies Hospital, Belgium (Dr. Sottiaux).

Manuscript received April 30, 1996; revision accepted August 30. Reprint requests: Dr. Joris, Department of Anesthesia and Intensive Care Medicine, CHU Liège, Domaine du Sart-Tilman, B-4000-Liège, Belgium

drome. Although epidural anesthesia and analgesia, using a combination of local anesthetic and opioid, decrease postoperative diaphragmatic dysfunction and provide excellent pain relief, they are unfortunately unable to reduce postoperative pulmonary complications.<sup>4</sup> Conventional chest physiotherapy, incentive spirometry, and intermittent positive pressure breathing (IPPB), used in an attempt to improve postoperative pulmonary function, may have a beneficial effect in breaking the vicious circle of postoperative pulmonary impairment.<sup>5,6</sup>

Continuous positive airway pressure (CPAP) administered by full face or nasal mask can restore functional residual capacity (FRC) to preoperative values,<sup>7,8</sup> improve oxygenation,<sup>9</sup> and spare inspiratory muscles.<sup>10</sup> Although CPAP seems to be more effective than routine chest physiotherapy,<sup>11</sup> its benefits are unfortunately not sustained, and FRC deteriorates a few minutes after interruption of CPAP.<sup>7,9</sup>

Bi-level positive airway pressure (BiPAP System; Respironics Inc; Murrysville, Pa) combining pressure support ventilation (PSV) and positive end-expiratory pressure (PEEP) can be delivered via a nasal mask via a small ventilator that allows independent adjustment of expiratory (EPAP) and inspiratory (IPAP) positive airway pressure.<sup>12,13</sup> This non-invasive ventilation mode has been used successfully to treat various pathologic conditions such as the obstructive sleep apnea syndrome,<sup>14</sup> chronic hypoventilatory respiratory failure in patients with COPD,<sup>15,16</sup> chronic ventilatory restriction caused by neuromuscular disease<sup>17</sup> or restrictive chest wall disorders,<sup>18</sup> and finally, acute respiratory failure of various etiologies.<sup>19-21</sup>

Owing to a decelerating inspiratory waveform, PSV allows recruitment of zones of alveolar collapse and results in a more homogeneous distribution of ventilation.<sup>22-24</sup> Furthermore, PSV minimizes the work of breathing.<sup>15,25</sup> However, PEEP prevents alveolar collapse and may improve oxygenation by increasing mean airway pressure and FRC. Bi-level positive airway pressure therefore could improve postoperative pulmonary function. This study investigated the effects of the prophylactic use of bi-level positive airway pressure on the pulmonary restrictive syndrome in morbidly obese patients scheduled for gastroplasty. These patients were selected because obesity is commonly associated with abnormal preoperative pulmonary function and therefore increases the risk of developing postoperative pulmonary complications.<sup>26,27</sup>

### Subjects

Thirty-three consecutive fully informed patients, scheduled for elective gastroplasty, were included in this study, which was approved by our institution's ethics committee. These patients had suffered morbid obesity (body mass index superior to 40 kg/m<sup>2</sup>) for more than 5 years, and were resistant to dietary treatment under medical control. The surgical procedure performed (gastroplasty) consisted of a reduction of the stomach, with creation of a small pouch by four vertical rows of staples. No gastric resection was performed.<sup>28</sup> None of these patients had cardiac or intrinsic pulmonary disease or medications beside pathophysiologic cardiopulmonary repercussions of obesity.

### Study Protocol

All patients were treated with the same anesthetic technique. Anesthesia was induced with thiopental sodium (thiopentone), 5 mg/kg, and sufentanil, 15 µg, IV. Orotracheal intubation was facilitated by 1 mg/kg succinylcholine. Anesthesia was maintained with isoflurane in 50% N<sub>2</sub>O/O<sub>2</sub>. Intraoperative muscle relaxation was achieved with atracurium. At the end of surgery, residual relaxation was reversed with 2.5 mg neostigmine (Prostigmin) and 1 mg atropine. None of these patients had a nasogastric tube postoperatively. When awake in the postanesthesia care unit, patients were randomly allocated to one of three techniques of ventilatory support. The first group (control group) received 98% oxygen, 10 L/min via a face mask, while groups 2 and 3 had BiPAP System ventilatory support. Patients in the two BiPAP System groups were required to keep the mask at least 2 h out of every 3 h during the first 24 h postoperatively. During the BiPAP System ventilation, the patient breathed ambient air supplemented by 5 L/min O<sub>2</sub> into the nasal mask. In group 2, the BiPAP System was set with an IPAP at 8 cm H<sub>2</sub>O and an EPAP at 4 cm H<sub>2</sub>O (BiPAP System 8/4); whereas IPAP was increased to 12 cm H<sub>2</sub>O in group 3 (BiPAP System 12/4).

Patients in all three groups had the same regimen of chest physiotherapy combined with incentive spirometry. They had also the same postoperative analgesic therapy: opioid (piritramide; Janssen Pharmaceutica; Beise, Belgium) patient-controlled analgesia (PCA). PCA setting was as follows: bolus dose=1 mg piritramide, lockout interval 5 min, maximum dose=20 mg/4 h, and no continuous infusion. They were instructed preoperatively how to use the PCA pump, how to perform pulmonary testing, and to keep the mouth closed when using the BiPAP System nasal mask.

### Ventilatory Support System

The BiPAP System ventilator is based on a standard nasal CPAP flow generator.<sup>15</sup> A pressure-controlling valve maintains pressure at two preset levels, an EPAP and an IPAP. In the spontaneous mode, the unit switches from EPAP to IPAP when the patient's inspiratory flow reaches 40 mL/s. The IPAP level is maintained for at least 180 ms. The ventilator cycles to EPAP when patient inspiratory flow decreases below a threshold level. If an expiratory effort is detected or if inspiratory period is held for more than 3 s, the device automatically switches from IPAP to EPAP. The BiPAP System differs from airway pressure release ventilation, which uses two levels of CPAP applied for set periods of time and allows spontaneous breathing to occur at both levels.<sup>29</sup>

The BiPAP System is applied through a comfortable nasal mask. The BiPAP System compensates for stable leaks through the mouth or around the nasal mask, thus maintaining the

pressure at preset levels. Due to these air leaks, direct measurement of tidal volume is not possible.

#### Data Collection

Pulmonary testing was performed in the sitting position by the same technician blind as to patient randomization, the day before surgery, and on postoperative day 1 (1 h after interruption of the BiPAP System or face mask), day 2, and day 3. The following parameters were recorded: FVC, FEV<sub>1</sub>, and peak expiratory flow rate (PEFR). These parameters were measured using a spirometer (Controlair; Mediconcept; Paris, France). Capillary hemoglobin oxygen saturation (SpO<sub>2</sub>) was also measured using a pulse oximeter (Datex Cardiocap; Datex; Helsinki, Finland) while breathing room air and without any ventilatory support.

Pain and sedation scores, respiratory rate, opioid consumption, and compliance to the study protocol (timing of the ventilatory support with the nasal BiPAP System) were recorded by nurses on the surgical ward every hour during the first 8 h postoperatively, and then every 3 h. Duration of hospital stay was also recorded.

#### Statistical Analysis

Results are reported as mean ± SD, except in the figures where SEMs were used. Data were analyzed by two-way analysis of variance followed by Newman Keuls' test. Results were considered to be statistically significant at the 5% critical level.

## RESULTS

#### Patient Characteristics

Three patients (one in group 2, and two in group 3) were excluded for noncompliance with the study protocol. Preoperative instructions were similarly respected by patients in the three groups. The three groups were similar with regard to age, sex, weight, height, history of smoking, and preoperative respiratory function (Table 1). Opioid consumption during the first 48 h postoperatively was similar in the three groups: control, 81.2 ± 39.9 mg; BiPAP System 8/4, 83.2 ± 27.6 mg; and 12/4, 71.4 ± 26.4 mg. Duration of hospitalization in the three groups did not differ significantly: 5.3 ± 1.6 days in each group.

#### Pulmonary Function and Hemoglobin Oxygen Saturation

Before surgery, pulmonary function was already markedly altered in the three groups and was characterized by a restrictive syndrome (Table 1). After surgery, the preoperative pulmonary restrictive syndrome quickly worsened in the three groups: FVC, FEV<sub>1</sub>, and PEFR significantly decreased. SpO<sub>2</sub> also decreased. Subsequently, these parameters progressively returned to preoperative values (Figs 1-4).

Prophylactic use of BiPAP System 12/4, but not 8/4, allowed significant reduction of the magnitude of this restrictive syndrome. FVC and FEV<sub>1</sub> were

**Table 1—Patient Data and Preoperative Pulmonary Function\***

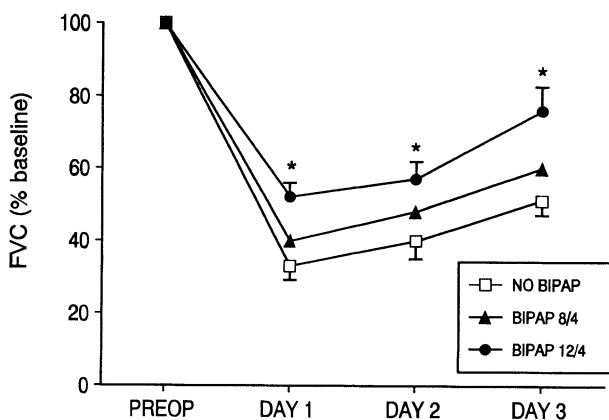
	No BiPAP System	BiPAP 8/4 System	BiPAP 12/4 System
Age, yr	31.4 ± 8.7	34.3 ± 11.7	33.4 ± 12.3
Sex, M/F	1/9	2/8	4/6
Weight, kg	117.1 ± 16.8	115.1 ± 20.7	123.4 ± 23.4
Height, cm	165.6 ± 6.0	163.7 ± 7.5	167.6 ± 13.5
FVC, L	2.89 ± 0.51	2.59 ± 0.72	2.92 ± 0.72
FEV <sub>1</sub> , L	2.35 ± 0.51	2.39 ± 0.54	2.39 ± 0.54
PEFR, L/min	331 ± 84	350 ± 57	365 ± 111
Smokers, No.	3	1	3

\*Data are mean ± SD. No significant differences were observed among groups with regard to age, sex, weight, height, preoperative pulmonary function, and history of smoking.

more than 50% greater in the BiPAP System 12/4 group than in the control group at the three postoperative time points (Figs 1 and 2). PEFR was also increased in the BiPAP System 12/4 group ( $p=0.10$ ) (Fig 3). The improvement of pulmonary function was associated with a significant increase in SpO<sub>2</sub> in the BiPAP System 12/4 group as compared with the control group on the first postoperative day. On day 1, SpO<sub>2</sub> in the BiPAP System 8/4 group was also significantly improved (Fig 4).

#### Tolerance and Complications

Data were discarded from three patients (one in group 2, and two in group 3) who could not tolerate



**FIGURE 1.** Effect of the BiPAP System on FVC. Patients had one of three modes of ventilatory support during the first 24 h postoperatively: O<sub>2</sub> via a face mask (squares); BiPAP System with 8 cm H<sub>2</sub>O inspiratory and 4 cm H<sub>2</sub>O expiratory positive airway pressures (triangles); and the BiPAP System with 12 cm H<sub>2</sub>O inspiratory and 4 cm H<sub>2</sub>O expiratory positive airway pressure (circles). Pulmonary testing was performed the day before surgery (PREOP) and on postoperative day 1 (1 h after interruption of BiPAP System usage), day 2, and day 3. Data are mean ± SEM; SEMs of the BiPAP System 8/4 group were omitted for clarity (SEMs ranged from 6 to 8 and were similar to SEMs of the two other groups). Asterisk:  $p < 0.05$  was considered a significant difference vs no BiPAP System usage.

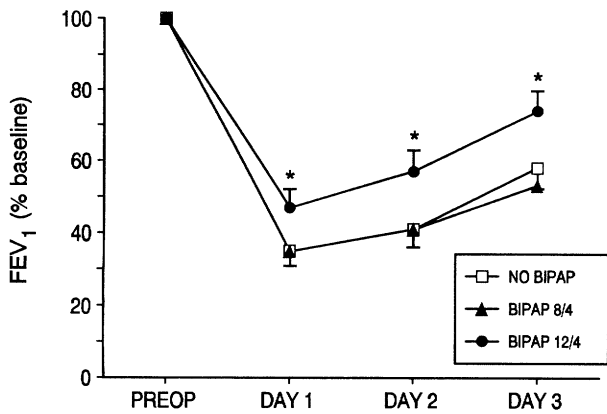


FIGURE 2. Effect of BiPAP on FEV<sub>1</sub>. For the method, see legend of Figure 1. Data are mean±SEM; SEMs of the BiPAP System 8/4 group were omitted for clarity (SEMs ranged from 5 to 6, and were similar to SEMs of the two other groups). Asterisk: p<0.05 was considered a significant difference vs no BiPAP System usage.

the nasal mask due to discomfort. The other patients did use the BiPAP System as initially recommended (2 h out of every 3) and the degree of synchrony was always satisfactory. No severe complications, such as nasal abrasion, aspiration, or gastric distention, were observed. No episodes of hypopnea (respiratory rate ≤10/min) or apnea were detected.

### DISCUSSION

This study demonstrates that the prophylactic use of BiPAP System 12/4 during the first 24 h postoperatively significantly reduces the pulmonary restrictive syndrome developing after upper abdominal surgery in morbidly obese patients. A 50 to 60%

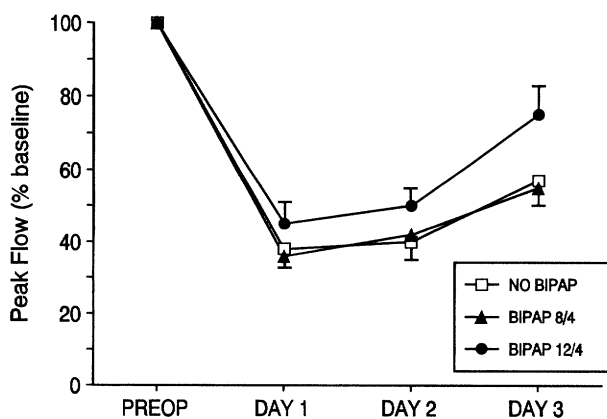


FIGURE 3. Effect of BiPAP System (Respironics) on PEFR. For the method, see the legend of Figure 1. Data are mean±SEM; SEMs of the BiPAP System 8/4 group were omitted for clarity (SEMs ranged from 4 to 6, and were similar to SEMs of the two other groups).

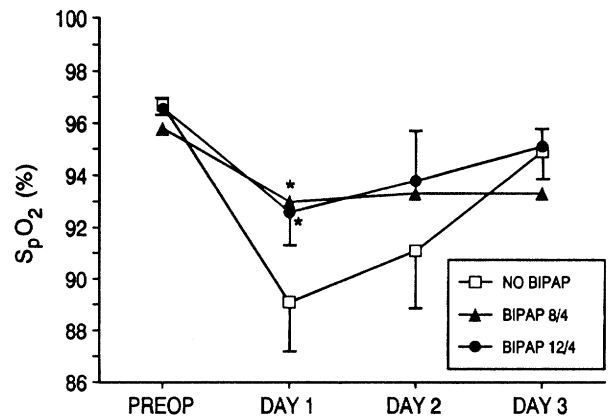


FIGURE 4. Effect of BiPAP System on SpO<sub>2</sub>. For the method, see legend of Figure 1. Data are mean±SEM; SEMs of the BiPAP System 8/4 group were omitted for clarity (SEMs ranged from 0.95 to 2.68, and were similar to SEMs of the two other groups). Asterisk: p<0.05 was considered a significant difference for BiPAP System 8/4 and 12/4 vs no BiPAP System.

increase in FVC and FEV<sub>1</sub> relative to control group resulted from ventilatory support with BiPAP System 12/4. The improvement persisted after the interruption of the BiPAP System, leading to quicker recovery of preoperative spirometric volumes. Several hypotheses may be proposed to explain the difference between our positive results with BiPAP and previously reported data with IPPB.<sup>5,6</sup>

BiPAP combines the benefits of PSV and CPAP, and “keeps the lung open” during the entire respiratory cycle. IPAP promotes lung inflation, leading to alveolar recruitment. However, EPAP prevents end-expiratory alveolar collapse and reduces the inspiratory threshold load imposed by an intrinsic PEEP, if present.<sup>15</sup> Consistently, BiPAP 12/4 significantly reduced the decrease in FVC and FEV<sub>1</sub>, whereas the effect on PEFR was less marked than FEV<sub>1</sub>. Although these two dynamic maneuvers are very similar, the time course and the magnitude of the changes in these two parameters are not always identical.<sup>30</sup>

We observed a “dose dependent effect” of IPAP on the pulmonary restrictive syndrome. Indeed, whereas FVC and FEV<sub>1</sub> were significantly improved in the group BiPAP System 12/4, BiPAP System 8/4 did not improve respiratory function. The two levels of IPAP, 8 and 12 cm H<sub>2</sub>O, were selected to avoid high airway pressures, which are usually poorly tolerated unless the patient exhibits dyspnea and therefore easily feels the benefit of BiPAP System usage. Moreover, high airway pressure can induce gastric dilation. In the BiPAP System 8/4 group, the “pressure boost” (IPAP-EPAP), the actual level of inspiratory support,<sup>12</sup> reached only 4-cm H<sub>2</sub>O. Lung inflation produced by a 4 cm H<sub>2</sub>O pressure boost

may not be sufficiently increased as compared with no inspiratory support. Indeed, the respiratory compliance of obese patients is decreased, and probably further deteriorates after upper abdominal surgery. Brochard et al<sup>25</sup> used a pressure boost between 12 and 20 cm H<sub>2</sub>O in patients with acute exacerbation of COPD. In a patient with acute restrictive respiratory failure, a 6-cm H<sub>2</sub>O pressure boost significantly reduced diaphragmatic activity and allowed recovery of normal thoracoabdominal motion. When the pressure boost was increased to 11 cm H<sub>2</sub>O, diaphragmatic activity disappeared.<sup>31</sup> This suggests that pressure boost must reach a threshold to place the diaphragm at rest. This threshold may differ, depending on the stage and the type of respiratory disease, as well as the respiratory compliance. Patients with normal preoperative compliance might require a lower pressure boost to yield a reduction of the postoperative pulmonary restrictive syndrome.

The effects of the BiPAP System on pulmonary function appear to be clinically relevant. Indeed, we observed an increase in FVC and FEV<sub>1</sub> of more than 50%, associated with improved SpO<sub>2</sub>. Although BiPAP System 8/4 had no effect on postoperative pulmonary restrictive syndrome, SpO<sub>2</sub> on day 1 was also significantly increased. Since postoperative hypoxemia is more correlated to change in FRC than FVC and FEV<sub>1</sub>,<sup>32</sup> this apparent discrepancy might reflect greater sensitivity of FRC to pressure boost. Further studies are therefore needed to investigate the effects of the BiPAP System on FRC.

Interestingly, the benefits observed after a 24-h treatment are preserved over the following days despite interruption of the ventilatory support. The changes in pulmonary function are almost parallel in the three groups. Whether prolongation of BiPAP System ventilatory support beyond 24 h would further accelerate the recovery to preoperative values certainly deserves to be investigated. The fact that the treatment can be limited to the first 24 h postoperatively is clinically advantageous. Since the patient usually is bedridden during this early postoperative period, the use of this ventilatory support modality does not interfere with patient mobilization and is not disabling.

However, ventilatory support with BiPAP System was well tolerated. Unlike IPPB, BiPAP might reduce the work of breathing. Indeed, during IPPB, inspiratory to expiratory cycling is pressure dependent. This ventilatory support may therefore result in an expiratory effort to reach the preset level that triggers expiration. Furthermore, patient demand (inspiratory drive) is not always matched by the gas flow delivered by the ventilator.<sup>33</sup> Noninvasive, intermittent, volume-cycled ventilation can be poorly tolerated.<sup>21,34,35</sup> Conversely, noninvasive PSV

with specifically designed ventilators allows better synchronization between the patient and the ventilator, results in lower peak inspiratory pressure, and minimizes air leak. Moreover, because inspiratory support stops before the patient's inspiratory flow reaches zero, no expiratory effort is required. Consequently, patient acceptance is generally good and is limited only by the tolerance of the nasal mask.<sup>36</sup> In our study, three of 23 patients were unable to tolerate the mask at least for 2 h of every 3 h. Our impression is that patient tolerance was facilitated by the residual sedative effect of the anesthetic agents, as well as of the opioid administered for postoperative analgesia. Preoperative education, relaxation, and reassurance were also helpful to improve tolerance of the ventilatory support with the BiPAP System.

This study was not designed to show any potential benefit of decreasing the restrictive syndrome with the BiPAP System on the incidence of postoperative pulmonary complications. Therefore, we did not perform postoperative chest radiographs to diagnose atelectasis or other pulmonary complications. No significant differences in hospital stay were observed among the three groups. Indeed, the hospital stay after gastroplasty is standardized and mainly dependent on patient adaptation to the small gastric pouch.

In conclusion, prophylactic BiPAP System therapy using a 12-cm H<sub>2</sub>O IPAP and a 4-cm H<sub>2</sub>O EPAP during the first 24 h postoperatively allows a significant reduction in the magnitude of the postoperative pulmonary restrictive syndrome in obese patients undergoing upper abdominal surgery. Consequently, recovery of preoperative respiratory function is accelerated. These data suggest that prophylactic use of BiPAP may prove to be helpful in patients at high risk of developing pulmonary complications.

ACKNOWLEDGMENT: BiPAP is a registered trademark of Respiration Inc, Murrysville, Pa.

## REFERENCES

- 1 Clergue F, Pansard JL. Respiratory changes induced by upper abdominal and cardiac surgery. In: Vincent JL, ed. Update in intensive care and emergency medicine. Berlin: Springer-Verlag, 1990; 166-73
- 2 Hedenstierna G. Mechanisms of postoperative pulmonary dysfunction. *Acta Chir Scand* 1988; 550:152-58
- 3 Ford GT, Rosenthal TW, Clergue F, et al. Respiratory physiology in upper abdominal surgery. *Clin Chest Med* 1993; 14:237-52
- 4 Jayr C, Thomas H, Rey A, et al. Postoperative pulmonary complications: epidural analgesia using bupivacaine and opioids versus parenteral opioids. *Anesthesiology* 1993; 78: 666-76
- 5 Oikkonen M, Karjalainen K, Kähärä V, et al. Comparison of incentive spirometry and intermittent positive pressure

- breathing after coronary artery bypass graft. *Chest* 1991; 99:60-5
- 6 Celli BR. Perioperative respiratory care of the patient undergoing upper abdominal surgery. *Clin Chest Med* 1993; 14:253-61
  - 7 Stock MC, Downs JB, Corkran ML. Pulmonary function before and after prolonged continuous positive airway pressure by mask. *Crit Care Med* 1984; 12:973-74
  - 8 Lindner KH, Lotz P, Ahnefeld FW. Continuous positive airway pressure effect on functional residual capacity, vital capacity and its subdivisions. *Chest* 1987; 92:66-70
  - 9 Pinilla JC, Oleniuk FH, Tan L, et al. Use of a nasal continuous positive airway pressure mask in the treatment of postoperative atelectasis in aortocoronary bypass surgery. *Crit Care Med* 1990; 18:836-40
  - 10 Martin JG, Shore S, Engel LA. Effect of continuous positive airway pressure on respiratory mechanics and pattern of breathing in induced asthma. *Am Rev Respir Dis* 1982; 126:812-17
  - 11 Ricksten SE, Bengtsson A, Soderberg C, et al. Effects of periodic positive airway pressure by mask on postoperative pulmonary function. *Chest* 1986; 89:774-81
  - 12 Strumpf DA, Carlisle CC, Millman RP, et al. An evaluation of the Respironics BiPAP Bi-Level CPAP device for delivery of assisted ventilation. *Respir Care* 1990; 35:415-22
  - 13 Sanders MH, Kern N. Obstructive sleep apnea treated by independently adjusted inspiratory and expiratory positive airway pressures via nasal mask: physiologic and clinical implications. *Chest* 1990; 98:317-24
  - 14 Waldhorn RE. Nocturnal nasal intermittent positive pressure ventilation with bi-level positive airway pressure (BiPAP) in respiratory failure. *Chest* 1992; 101:516-21
  - 15 Nava S, Ambrosino N, Rubini F, et al. Effect of nasal pressure support ventilation and external PEEP on diaphragmatic activity in patients with severe stable COPD. *Chest* 1993; 103:143-50
  - 16 Ambrosino N, Nava S, Bertone P, et al. Physiologic evaluation of pressure support ventilation by nasal mask in patients with stable COPD. *Chest* 1992; 101:385-91
  - 17 Bach JR. Management of neuromuscular ventilatory failure by 24 hours non-invasive intermittent positive pressure ventilation. *Eur Respir Rev* 1993; 3:284-91
  - 18 Hill NS, Eveloff SE, Carlisle CC, et al. Efficacy of nocturnal nasal ventilation in patients with restrictive thoracic disease. *Am Rev Respir Dis* 1992; 145:365-71
  - 19 Meduri GU, Abou-Shala N, Fox RC, et al. Noninvasive face mask mechanical ventilation in patients with acute hypercapnic respiratory failure. *Chest* 1991; 100:445-54
  - 20 Pennock BE, Kaplan PD, Carlin BW, et al. Pressure support ventilation with a simplified ventilatory support system administered with a nasal mask in patients with respiratory failure. *Chest* 1991; 100:1371-76
  - 21 Vitacca M, Rubini F, Foglio K, et al. Non-invasive modalities of positive pressure ventilation improve the outcome of acute exacerbations in COPD patients. *Intensive Care Med* 1993; 19:450-55
  - 22 Al-Saady N, Bennett ED. Decelerating inspiratory flow waveform improves lung mechanics and gas exchange in patients on intermittent positive-pressure ventilation. *Intensive Care Med* 1985; 11:68-75
  - 23 Chan K, Abraham E. Effects of inverse ratio ventilation on cardiopulmonary parameters in severe respiratory failure. *Chest* 1992; 102:1556-61
  - 24 Ravenscraft SA, Burke WC, Marini JJ. Volume-cycled decelerating flow: an alternative form of mechanical ventilation. *Chest* 1992; 101:1342-51
  - 25 Brochard L, Isabey D, Piquet J, et al. Reversal of exacerbations of chronic obstructive lung disease by inspiratory assistance with a face mask. *N Engl J Med* 1990; 323:1523-30
  - 26 Hall JC, Tarala RA, Hall JL, et al. A multivariable analysis of the risk of pulmonary complications after laparotomy. *Chest* 1991; 99:923-27
  - 27 Johnson D, Litwin D, Osachoff J, et al. Postoperative respiratory function after laparoscopic cholecystectomy. *Surg Laparosc Endosc* 1992; 2:221-26
  - 28 Laws H. Standardized gastroplasty orifice. *Am J Surg* 1981; 141:393-94
  - 29 Hess DR, Kacmarek RM. Modes of mechanical ventilation. In: *Essentials of mechanical ventilation*. New York: McGraw-Hill, 1996; 17-23
  - 30 Schulze S, Sommer P, Bigler D, et al. Effect of combined prednisolone, epidural analgesia and indomethacin on the systemic response after colonic surgery. *Arch Surg* 1992; 127:325-31
  - 31 Carrey Z, Gottfried SB, Levy RD. Ventilatory muscle support in respiratory failure with nasal positive pressure ventilation. *Chest* 1990; 97:150-58
  - 32 Craig DB. Postoperative recovery of pulmonary function. *Anesth Analg* 1981; 60:46-52
  - 33 Brochard L. Pressure support ventilation. *Intensive Care World* 1989; 6:12-4
  - 34 Foglio C, Vittaca M, Quadri A, et al. Acute exacerbations in severe COPD patients: treatment using positive ventilation by nasal mask. *Chest* 1992; 101:1533-38
  - 35 Marino W. Intermittent volume cycled mechanical ventilation via nasal mask in patients with respiratory failure due to COPD. *Chest* 1991; 99:681-84
  - 36 Sottiaux T. Nasal mask ventilation in acute respiratory failure [letter]. *Chest* 1993; 104:1315-16

**Effect of Bi-Level Positive Airway Pressure (BiPAP) Nasal Ventilation on the Postoperative Pulmonary Restrictive Syndrome in Obese Patients Undergoing Gastroplasty**

Jean L. Joris, Thierry M. Sottiaux, Jean Daniel Chiche, Claude J.

Desaive and Maurice L. Lamy

*Chest* 1997;111; 665-670

DOI 10.1378/chest.111.3.665

**This information is current as of January 29, 2009**

<b>Updated Information &amp; Services</b>	Updated Information and services, including high-resolution figures, can be found at: <a href="http://www.chestjournal.org/content/111/3/665">http://www.chestjournal.org/content/111/3/665</a>
<b>Citations</b>	This article has been cited by 11 HighWire-hosted articles: <a href="http://www.chestjournal.org/content/111/3/665#related-urls">http://www.chestjournal.org/content/111/3/665#related-urls</a>
<b>Open Access</b>	Freely available online through CHEST open access option
<b>Permissions &amp; Licensing</b>	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: <a href="http://chestjournal.org/misc/reprints.shtml">http://chestjournal.org/misc/reprints.shtml</a>
<b>Reprints</b>	Information about ordering reprints can be found online: <a href="http://chestjournal.org/misc/reprints.shtml">http://chestjournal.org/misc/reprints.shtml</a>
<b>Email alerting service</b>	Receive free email alerts when new articles cite this article. sign up in the box at the top right corner of the online article.
<b>Images in PowerPoint format</b>	Figures that appear in CHEST articles can be downloaded for teaching purposes in PowerPoint slide format. See any online article figure for directions.

A M E R I C A N C O L L E G E O F



P H Y S I C I A N S<sup>®</sup>