BRIEF REPORT

Improvement of postoperative atelectasis in response to biphasic cuirass ventilation in a patient who was receiving noninvasive positive pressure ventilation at home

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Introduction

Spinocerebellar degeneration is a rare disease that minimally affects the pulmonary muscles1). We describe our experience with biphasic cuirass ventilation (BCV) in a patient with spinocerebellar degeneration who was receiving noninvasive positive pressure ventilation (NPPV) at home because of respiratory failure caused by decreased respiratory muscle strength. In BCV, proper artificial ventilation is provided through a cuirass tightly fitted around the patient’s chest. The negative (positive) pressure inside the cuirass creates chest expansion (compression)2). BCV is a non-invasive, ideal technique for mechanical ventilation that overcomes the shortcomings of conventional mechanical ventilation. As BCV does not require endotracheal intubation, patients can have conversations and eat meals. BCV prevents complications associated with endotracheal intubation and preserves vocal cord function3). BCV has been used4) not only for the management of cardiac disease, acute respiratory failure, or chronic lung disease, but also for weaning from invasive ventilation, central alveolar hypoventilation, chest physiotherapy, and secretion clearance5).

Case

The patient was a 53-year-old woman. At 41 years of age, ataxic gait and articulation disorder developed. As hereditary spinocerebellar degeneration was diagnosed, the patient was treated with thyrotropin-releasing hormone and followed up on an outpatient basis. From the age of 46 years, she could not walk by herself. At 51 years of age, dyspnea was developed, and the patient was admitted to the emergency room. Pulmonary function tests showed that the predicted percentage of vital capacity and the tidal volume (VT) were extremely low (31% and 200 ± 40 ml, respectively). Respiratory failure caused by respiratory muscle paralysis was diagnosed, and the patient received NPPV at home.

At the age of 52 years, left pneumothorax was developed. Partial upper lobectomy of the left lung was performed by video-assisted thoracoscopic surgery. The ventilator settings and the results of arterial blood gas analysis are shown in the Table 1. On the 2nd postoperative day, hypercapnia (PaCO2 115 mmHg) occurred during NPPV. Tracheal intubation was performed to enable mechanical ventilation. A decrease in the level of pressure support reduced the VT, resulting in poor oxygenation and carbon dioxide retention. It was therefore difficult to wean the patient from the ventilator. On the 7th postoperative day, a tracheotomy was performed. However, the VT remained low, and atelectasis did not improve. Thus, on the 15th postoperative day, BCV was started with the use of Respiratory Therapy External (Hyek RTX, Medivent International Ltd., London, UK)2). Continuous positive airway pressure (CPAP) was concomitantly applied until the patient could be weaned from positive pressure ventilation. The actual VT was 189 ml (PEEP 5 cmH2O, pressure support 5 cmH2O).

BCV was performed for 40 minutes in a continuous negative pressure mode of −20 cmH2O, followed by a combination of clearance modes (vibration and cough modes) for 20 minutes in total, as follows. First, continuous chest vibration was provided for 7 minutes at a frequency of 600 cycles/min. Then, a 3-minute cough cycle was done at a cough rate of 15/min. Second, continuous chest vibration at a frequency of 700 cycles/min was provided for 7 minutes, and a 3-minute cough cycle was restarted at the same cough rate of 15 /min. BCV was performed 4 times/day. The actual VT was 328 ml after BCV. The sputum volume increased, and CT of the chest showed a bilateral improvement in atelectasis.

On the 17th postoperative day, the patient could be weaned from positive pressure ventilation and did not require oxygen administration. BCV was continued until the 22nd postoperative day. The actual VT was 290 ± 40 ml without BCV. The patient was discharged from the ICU. However, pneumonia developed while she was in the hospital ward. BCV was intermittently repeated for 1
week, and the patient’s condition improved. After 3 months, she was discharged from the hospital with a tracheotomy tube for sputum aspiration and for emergency situations, but did not require a ventilator or oxygen administration. She remains in good condition, 6 months after discharge.

Discussion

We previously reported that the use of BCV allowed an infant with severe respiratory failure to be weaned from a ventilator3). Although the present patient was an adult, BCV enabled weaning from a ventilator. The thorax was forcibly expanded laterally to approximate spontaneous breathing. This procedure may have allowed the alveoli, which did not respond to conventional positive pressure, to be effectively expanded. Expansion of the movable range of the thoracic cavity and diaphragm increases minute volume and functional residual capacity and improves gas exchange6),7). In addition, the vibration and cough modes4),5) are useful for improving respiratory function. The former enhances mucociliary clearance from both the central and peripheral airways. The latter removes secretions even from fourth-generation segmental bronchi for patients who are unable to cough efficiently because of respiratory muscle weakness or pain.

In our patient, chest physiotherapy and secretion clearance could be effectively carried out during BCV. Improved pulmonary thorax compliance and decreased atelectasis may have led to an increase in VT and resolution of respiratory failure. Even after the onset of pneumonia, ventilation was adequately performed with BCV mode, possibly because of chest physiotherapy and effective secretion clearance.

BCV allowed the patient to be weaned from positive pressure ventilation without requiring oxygen, despite the presence of hereditary spinocerebellar degeneration. In addition, she could be weaned from NPPV at home, which may have contributed to the improvement in quality of life. In the near future, home care ventilation may be introduced depending on the underlying disease. The use of BCV is expected to delay the need for home care ventilation. Home care BCV may also become one treatment option.

References


Table 1 Arterial blood gas analysis and ventilator setting

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<thead>
<tr>
<th>POD</th>
<th>NPPV: FIO2 0.5, PEEP 5 cmH2O, PS 6 cmH2O</th>
<th>PC-SIMV: FIO2 0.5, PIP 15 cmH2O, RR 8/min, PEEP 5 cmH2O</th>
<th>BIPAP: FIO2 0.3, RR 8/min, P_{high} 18 cmH2O, T_{high} 1.3 sec, P_{low} 8 cmH2O, ATC 100%</th>
<th>BIPAP: FIO2 0.25, RR 8/min, P_{high} 13 cmH2O, T_{high} 1.5 sec, P_{low} 5 cmH2O, PS 5 cmH2O, ATC 100%</th>
<th>BIPAP (4 times/day): ~ 20 cmH2O (40 min), clearance mode (20 min), CPAP 2 cmH2O (during BCV) with BCV</th>
<th>BCV (4 times/day): ~ 20 cmH2O (40 min), clearance mode (20 min), O2 28 % 3 l/min venturi mask</th>
<th>BCV off, room air</th>
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<tbody>
<tr>
<td>2</td>
<td>pH 7.11, PaCO2 115 mmHg, PaO2 87 mmHg</td>
<td>pH 7.79, PaCO2 97 mmHg, PaO2 78 mmHg</td>
<td>pH 7.47, PaCO2 56 mmHg, PaO2 110 mmHg</td>
<td>pH 7.50, PaCO2 52 mmHg, PaO2 83 mmHg</td>
<td>pH 7.37, PaCO2 71 mmHg, PaO2 90 mmHg</td>
<td>pH 7.54, PaCO2 57 mmHg, PaO2 64 mmHg</td>
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<td>7</td>
<td>Tracheotomy</td>
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<td>BCV: FIO2 0.3, RR 8/min, P_{high} 13 cmH2O, T_{high} 1.5 sec, P_{low} 5 cmH2O, PS 5 cmH2O, ATC 100%</td>
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<td>BCV off, room air</td>
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ATC, automatic tube compensation; BCV, biphasic cuirass ventilation; BIPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure; NPPV, noninvasive positive pressure ventilation; PC-SIMV, pressure control synchronized intermittent mandatory ventilation; P_{high}, pressure high; PIP, peak inspiratory pressure; P_{low}, pressure low; POD, postoperative day; PS, pressure support; RR, respiratory rate; T_{high}, time high.