CASE REPORT

Marked Improvement of Extensive Atelectasis by Unilateral Application of the RTX Respirator in Elderly Patients

Koji Kato1, Naoki Sato1, Shinhiro Takeda1, Takeshi Yamamoto1, Ryo Munakata1, Masafumi Tsurumi1, Daigo Suzuki1, Kaori Yagi1, Keiji Tanaka1 and Kyoichi Mizuno2

Abstract

The RTX respirator is a biphasic external cuirass-style ventilator that supports both inspiration and expiration at various cycle rates and pressures, as well as allowing application of the vibration and cough modes. With this respirator, the duration and pressure can be altered in both the inspiratory and expiratory phases, and it can promote the removal of secretions by switching between the vibration mode (which involves external high-frequency oscillation: EHFO) and the cough mode. We used this respirator to remove secretions in two elderly patients with extensive atelectasis. They were nursed in the lateral decubitus position with the cuirass attached to one side of the chest only. The vibration mode removed secretion to reduce the viscosity of secretions and loosen impacted bronchial secretions. The cough mode interrupts the vibration mode and forces secretions towards the pharynx. The lateral decubitus position was useful for postural drainage. The extensive atelectasis of both patients was improved by this procedure. The RTX respirator may be a useful tool for the management of elderly patients with sputum retention.

Key words: RTX respirator, external high-frequency oscillation (EHFO), atelectasis

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Introduction

Pneumonia is a common and critical illness among the elderly. Decreased clearance of mucus and increased bacterial colonization lead to progression of pneumonia, while drainage of secretions is an effective method for its treatment.

The RTX respirator (Medivent Ltd., London, UK) is a biphasic external cuirass-style noninvasive ventilator. It can support both inspiration and expiration and is reported to be as effective as positive pressure ventilation for exchanging oxygen and carbon dioxide (1). The cuirass is a plastic shell that encloses the chest and upper abdomen with edges covered by soft foam rubber to create an airtight seal. By choosing the appropriate cuirass size, the apparatus can be used to ventilate a wide range of patients from infants to obese adults. With the RTX respirator, the inspiratory/expiratory (I/E) ratios can be automatically or manually preset and are controlled by a negative feedback loop (2) and also the duration and pressure can be altered in both the inspiratory and expiratory phases. It can promote the removal of secretions by switching between the vibration mode (which involves external high-frequency oscillation: EHFO) and the cough mode (a long high pressure inspiratory phase followed by a short sharp expiratory phase).

Continuous positive airway pressure (CPAP) may be harmful for patients who have developed respiratory failure due to massive retention of mucus (3). In such cases, mechanical ventilation under sedation is usually initiated and mucus is removed by irrigation, but this can lead to complications such as ventilator-associated pneumonia. On the other hand, the RTX respirator is reported to be effective for patients with postoperative sputum retention (4).

Case Reports

We report two elderly patients with extensive atelectasis

1Intensive and Cardiac Care Unit, Nippon Medical School, Tokyo and 2Department of Internal Medicine (Divisions of Cardiology, Hepatology, Geriatrics, and Integrated Medicine), Nippon Medical School, Tokyo
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Correspondence to Dr. Koji Kato, katokoji@nms.ac.jp
Figure 1. Chest X-ray films of an 86-year-old woman with a pacemaker, who was admitted with congestive heart failure and pneumonia. (A) Extensive right-sided atelectasis. (B) After using the RTX respirator the atelectasis was dramatically improved.

Case 1

An 86-year-old woman was admitted to Nippon Medical School Hospital because of dyspnea and orthopnea. The patient had suffered from cough and pyrexia for the previous one week. She had received a pacemaker for complete atrioventricular block at the age of 68 years and had suffered from myocardial infarction at age 70.

On admission, a chest X-ray film revealed pneumonia in the right lung and bilateral congestion, then, treatment with CPAP, diuretics, and antibiotics were initiated. On the following day, CPAP was ceased because of improvement of respiratory failure. On the 7th hospital day, however, her respiratory status suddenly worsened and arterial blood gas analysis showed a pH 7.405, pCO2 45.7 mmHg, pO2 56.8 mmHg, HCO3- 29.4 mmol/L, and SaO2 88.2% at 10 L/min of oxygen via a face mask. Her consciousness level was clear but her spontaneous breathing was too weak to remove the secretions. Right-sided atelectasis was detected on a chest X-ray film (Fig. 1-A), which was considered to be probably due to the retention of sputum. Therefore, the RTX respirator was attached to the right side of the chest with the patient in the left lateral decubitus position (Fig. 2). Before the procedure, her blood pressure was 168/90 mmHg, heart rate was 70 bpm with pacing rhythm and respiratory rate was 24/min. Then, continuous chest vibration was provided for 5 minutes (active inspiration followed by active expiration) at a frequency of 600 cycles/min and with an inspiratory pressure during each cycle of -10 cmH2O and an expiratory pressure of 10 cmH2O. At 4 minutes after the initiation of ventilation, a 2-minute cough cycle was started at a cough rate of 60/min. During this phase, the I/E ratio was 5:1. The inspiratory pressure was -25 cmH2O and a positive pressure of +10 cmH2O was generated during the active expiratory phase. The total cycle time, including the vibration phase and cough phase, was 6 minutes and the complete cycle was repeated 5 times over 30 minutes. During the procedure, her blood pressure was 176/98 mmHg, heart rate was 70 bpm. After this treatment, a large quantity of mucus was expectorated, and the patient’s respiratory status improved markedly (pH 7.430, pCO2 45.4 mmHg, pO2 98.2 mmHg, HCO3- 29.6 mmol/L, and SaO2 97.9% at 10 L/min of oxygen via a face mask). After the procedure, her blood pressure was 164/98 mmHg, heart rate was 70 bpm and respiratory rate was 20/min. Her chest X-ray findings also improved dramatically (Fig. 1-B). She received two cycles of treatment per day for another 2 days.

Case 2

An 88-year-old man was admitted to Nippon Medical School Hospital with disturbance of consciousness. On admission, his heart rate was 38 bpm with a junctional escape rhythm. His heart rate increased and his consciousness became clear after an intravenous injection of atropine. He was diagnosed as having Adams-Stokes syndrome because of bradydysrhythmia atrial fibrillation associated with digoxin toxic-
A chest X-ray film revealed bilateral pulmonary congestion with a right pleural effusion. He was treated with diuretics and catecholamines, while thoracentesis was performed for drainage of the pleural effusion. He improved with this treatment until 5 days after admission, when his respiratory status suddenly worsened and arterial blood gas analysis showed a pH 7.377, pCO2 62.1 mmHg, pO2 168 mmHg, HCO3 - 35.9 mmol/L, and SaO2 99.6% at 8 L/min of oxygen via a face mask. His consciousness level was clear, but left-sided atelectasis was detected on an X-ray film (Fig. 3-A). Therefore, we attached the RTX respirator to his left side the patient was placed in the right lateral decubitus position. Before the procedure, his blood pressure was 122/86 mmHg, heart rate was 82 bpm and respiratory rate was 24/min. The physical therapy regimen was the same that for as case 1. During the procedure, his blood pressure was 148/92 mmHg, heart rate was 112 bpm. After using the RTX respirator, a large quantity of mucus was expectorated and his respiratory status improved. Arterial blood gas analysis revealed pH 7.377, pCO2 62.1 mmHg, pO2 168 mmHg, HCO3 - 35.9 mmol/L, and SaO2 99.6% at 8 L/min of oxygen via a face mask. After the procedure, his blood pressure was 150/98 mmHg, heart rate was 118 bpm and respiratory rate was 22/min. His chest X-ray findings also were improved (Fig. 3-B). Two cycles of treatment were given daily for 3 days.

During the procedure, we continually monitored the heart rate, blood pressure by arterial line and oxygen saturation by pulse oximetry, and arterial blood gas analysis was performed in the intensive care unit (ICU). We prepared to remove sputum as soon as possible when the secretion came up to the pharynx. In this situation, if respiratory status worsens, it is necessary to perform endotracheal intubation immediately.

**Discussion**

The RTX respirator is a biphasic external cuirass-style ventilator that supports both inspiration and expiration at various cycle rates and pressures, as well as allowing application of the vibration and cough modes. It has been reported that this respirator is effective in patients with postoperative sputum retention (4), while its vibration mode (EHFO) is useful for achieving adequate gas exchange without endotracheal intubation (5-7). We used this respirator to remove secretions in two elderly patients with extensive atelectasis. They were nursed in the lateral decubitus position with the cuirass attached to one side of the chest only, although the cuirass is usually placed around the anterior chest wall with the patient in the supine position and the RTX respirator is normally used in the supine position. While there are many cuirass sizes to choose from, we used a small cuirass for the lateral position.

The efficacy of chest physical therapy is indicated by a reduction in the incidence of pulmonary infection or by improvement of pulmonary function, and chest physiotherapy is one of the most frequent interventions in the ICU (8). Mucociliary activities and a strong cough are needed for normal airway clearance. Viscous secretions, an endotracheal tube, dehydration, hypoxemia, immobility, and poor humidification of air impede mucociliary clearance and can cause the retention of secretions (9, 10). Postural drainage, percussion, vibration, encouragement of coughing, suctioning, breathing exercises, patient mobilization, and sometimes manual inflation are common methods used to remove secretions (11). Vibration is used to enhance mucociliary clearance from both the central and peripheral airways. The effectiveness of vibration for ICU patients was evaluated by Stiller et al, who reported that the addition of vibration significantly increases the rate of radiographic resolution of atelectasis in patients who have failed to respond to postural drainage, manual hyperinflation, and suction (12). In animal studies, physical stimuli such as vibration alter airflow and are associated with the pulmonary release of chemical mediators that may improve ciliary transport speed by as much as 340% (13). Coughing removes secretions from the fourth
generation of segmental bronchi, as well as from the main bronchi, trachea, and pharynx (14). Many patients who are breathing spontaneously in the ICU are unable to cough effectively because of respiratory muscle weakness, pain, or impaired consciousness. In such patients, the RTX respirator may be useful for removing secretions by employing the vibration made to reduce the viscosity of secretions (15) and loosen impacted bronchial secretions. The cough mode interrupts the vibration mode and forces secretions towards the pharynx. When the RTX respirator is set at a high I:E ratio (5 : 1) in the cough mode, this allows maximum chest expansion and leads to alveolar recruitment (16, 17), which is followed by powerful expiration to expel secretions. The frequencies and cycle time should be determined in accordance with comfort of the patient during application of the respirator. The amplitude should be selected individually, based on body weight, severities of the disease, and also compliance of the chest wall, i.e., the more obese, the more severe disease, and the higher compliance of chest wall, the higher the amplitude that would be required. The cough mode, which interrupts each vibration cycle, allows the setting of high I:E ratio (5 : 1). In the present cases, we initiated fixed parameters according to the reference from previous reports (4, 15). After that, it was necessary to modify the range for adjustment to each patient.

The RTX respirator is effective for atelectasis caused by secretion, but not effective for that due to organic obstruction such as lung carcinoma. If the RTX respirator does not prove effective, the atelectasis should be immediately treated by another way. We used the RTX respirator on patients in the lateral decubitus position for postural drainage. It is known that postural drainage enhances peripheral lung clearance, increases the functional residual capacity, and promotes mucus clearance (18, 19). Also, using the respirator unilaterally might have been more effective for removing secretions because vibrations directly reached the affected region. It is important to closely monitor the patient’s respiratory status in the ICU and also it is necessary to perform adequate suction. Massive secretion after the present procedure might worsen the healthy side of lung accompanied with insufficient suction. If the respiratory conditions are not improved, endotracheal intubation must be performed immediately. As far as we know, there has been no report regarding the usefulness of the RTX respirator on one side in the lateral decubitus position, therefore, its safety has not been established and it should be used carefully, and further examination will be necessary in the future.

A potentially serious problem of the RTX respirator is dysynchrony between the patient and the respirator. Although it will be necessary to determine which patient can adapt to the respirator, in our cases, they were so severe that their spontaneous breathing was too weak to remove secretions due to weak respiratory muscles. Therefore, they obediently accepted the control using the RTX respirator. In conclusion, the RTX respirator may be a useful tool for the management of elderly patients with sputum retention.

References

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