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Original article

# Mechanical ventilatory assistance may reduce dyspnea during walking especially in patients with impaired cardiopulmonary function early after cardiovascular surgery

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ABSTRACT

*Background:* To determine which patients effectively respond to ventilatory assistance (VA) and to examine the factors influencing patient response in patients who underwent cardiovascular (CV) surgery.

*Methods:* We conducted the first walking session after surgery either with or without VA in a randomized order. The patients walked with 3 $cmH_2O$ of inspiratory pressure support. We measured dyspnea and leg fatigue during initial walking either with or without VA by using a modified Borg scale. Ventilatory parameters were measured by mechanical ventilation before and immediately after walking. Lung function and maximal inspiratory pressure (MIP) were measured and chest radiographs were analyzed by the same cardiac surgeon on the same day as walking.

*Results:* From the total of 74 patients who underwent CV surgery, 56 patients were successively enrolled in the study. Thirty-five out of 56 patients had dyspnea and 18 patients (30% of the total patients) effectively responded to VA (responders). Minute ventilation/estimated maximum voluntary ventilation immediately after walking significantly decreased with VA, and MIP was lower in responders than in non-responders after surgery. The responders revealed greater pulmonary edema scores than non-responders.

*Conclusions:* The findings of the present study suggest that VA may possibly facilitate successful mobilization early after CV surgery, especially in patients with impaired cardiopulmonary function.



## Introduction

Dyspnea is one of the major complaints when ventilation is accelerated by physical activities in patients who have undergone cardiovascular (CV) surgery [1]. The ventilation-perfusion mismatch caused by increasing pulmonary congestion and atelectasis are reported as possible underlying mechanisms of exercise-induced hyperpnea in post-surgical patients [2,3]. In the immediate post-surgical phase, patients cannot respond to increased respiratory demands because of a reduction in vital capacity and weakness of the respiratory muscles [3–5], and consequently suffer from dyspnea. A delay in early mobilization because of dyspnea results in skeletal muscle weakness and limits improvements in activities of daily living [6]. Therefore, a strategy to control dyspnea during early mobilization may serve as a new physiotherapy intervention for early postoperative CV surgery.

Mechanical ventilatory assistance (VA) was reported to improve ventilatory efficiency and exercise performance by reducing the amount of respiratory muscle work in patients with chronic heart failure (CHF) [7–10]. Immediately after CV surgery, patients have similarities in cardiorespiratory conditions owing to reduced cardiorespiratory function [3]. We hypothesized that early mobilization with VA could possibly improve dyspnea, and in turn, improve walking capacity during the early postoperative period. Therefore, this study aimed (1) to describe who effectively

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responds to VA and (2) to examine the factors involved in response to VA in patients who had undergone CV surgery.

## Methods

### *Patients*

From March 2013 to March 2014, ambulatory patients >20 years of age who underwent CV surgery at Kitano Hospital were consecutively enrolled in this study. Patients with a past history of a psychiatric disorder, those who developed symptoms of a psychomotor disturbance, and those with serious CV and cerebrovascular complications after surgery were excluded. The Research Ethics Committee of Kitano Hospital approved the study and informed consent was obtained from each patient (approval number: P11-12-006).

### *Study design*

The study was conducted as a prospective case series. At first walking session after surgery, patients were randomly assigned either to start walking without VA (session A) followed by walking with VA (session B) or walking in reverse order by using a computer-generated randomization table (Fig. 1). Between the sessions, patients took 10 min rest in a sitting position. We encouraged patients to walk as far as possible to a maximum of 100 m. During session B, patients were supported through the use of mechanical ventilation (Hamilton-C2, Hamilton Medical AG, Bonaduz, Switzerland) with a nasal pillow mask (Swift FX, Res Med, Sydney, Australia), which was carried by the same physical therapist (Fig. 2). Pressure support (PS) was carefully adjusted upward in increments of 1 $cmH_2O$ to 5 $cmH_2O$. We confirmed that the PS of 3 $cmH_2O$ was optimal for most patients, because of maintaining a natural breathing pattern. The thoracostomy tube was removed in all patients before the study.

### *Dyspnea and leg fatigue*

Exertional dyspnea and leg fatigue were measured using a modified Borg scale [11] before and after a session A and B. Before measurement, we explained to the patients that a score of "0" on the modified Borg scale indicates no dyspnea or leg fatigue, "1" as very weak, "2" as weak, "3" as moderate, "4" as somewhat strong, "5" as strong, and "10" represents the worst dyspnea or leg fatigue that the patient could imagine or had ever experienced. We asked the patients to rate their experience immediately after walking.

### *Ventilatory parameters before and immediately after walking*

We measured respiratory rate (RR), tidal volume (TV), and minute ventilation (VE) before and immediately after each walking session by using the noninvasive ventilation mode of the mechanical ventilator with a FullLife mask (FullLife SE, Philips Respironics, Tokyo, Japan) in a sitting position. We used the average value during a 1-minute period.

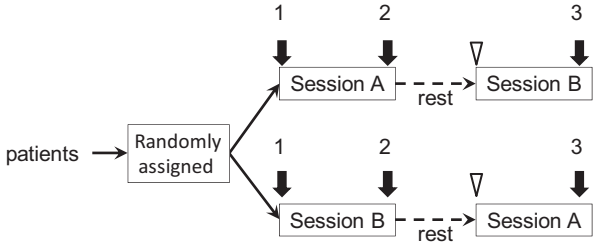


**Fig. 1.** Study design. Session A: walking without ventilatory assistance (VA). Session B: walking with VA. ↓: We measured ventilatory parameters by using mechanical ventilator. ▽: We confirmed that the Borg scale and respiratory rate recovered at the status 1.

**Fig. 2.** A scene of walking (session B). Patient walked with mobility aid and a therapist carried a ventilatory assist device.

### *Lung function*

Vital capacity (VC), forced expiratory volume in 1 s (FEV1), and forced vital capacity (FVC) were measured using a spirometric computerized test with a pressure transducer (AS507, Minato Medical Science, Osaka, Japan) in a sitting position. An estimated maximum voluntary ventilator (MVV) value was calculated by FEV1 × 38 [12].

Maximal inspiratory pressure (MIP) was determined by a deep inspiration from the residual volume against an occluded airway, thereby preventing an undesirable glottic closure. Measurement of the maximal expiratory pressure (MEP) consisted of slow inspiration to the point of total lung capacity, followed by a forced expiration against a closed circuit. All measurements were performed twice and the highest value was recorded. Lung functions were measured before surgery and on the day of walking after surgery.

### *Physical function*

Handgrip strength was measured by a grip dynamometer (JAMAR dynamometer, Sammons Preston, Bolingbrook, IL, USA). Measurements were performed 3 times each on both hands and the highest value was recorded. Knee extensor muscle strength (KEMS) during a 5-second isometric contraction was measured using a hand-held dynamometer (μTas F-1, ANIMA, Tokyo, Japan) in a sitting position. The highest peak torque of the 3 measurements was recorded. Handgrip strength was measured before surgery and on the day of walking after surgery. Leg muscle strength was measured before surgery and on postoperative day 7.

### *Chest radiographs*

Lung radiological alterations on the day of walking were analyzed by chest X-ray photograph (X-P) by the same cardiac