



Original Article

Comparison between stair-climbing test and six-minute walk test after lung resection using video-assisted thoracoscopic surgery lobectomy

YOHEI KUBORI, PT, MSc¹*, RYOSUKE MATSUKI, PT, MSc¹, AKIRA HOTTA, PT, MSc¹, TOMOYUKI MORISAWA, PT, MSc², AKIRA TAMAKI, PT, PhD²

¹) Department of Rehabilitation, Kansai Electric Power Hospital: 2-1-7 Fukushima, Fukushima-ku, Osaka-shi, Osaka 553-0003, Japan

²) Department of Physical Therapy, School of Rehabilitation, Hyogo University of Health Sciences, Japan

Abstract. [Purpose] Currently, the six-minute walk distance (6MWD) is used to evaluate exercise capacity in people following lung resection for non-small cell lung cancer. However, it is unclear whether the 6MWD can detect changes in cardiorespiratory fitness induced by exercise training or lung resection. Conversely, the stair-climbing test is used frequently for the preoperative evaluation of lung resection candidates. It is considered a sensitive method for detecting changes associated with training, but is not used to evaluate exercise capacity after lung resection. The purpose of this study was to compare the stair-climbing test and the six-minute walk test (6MWT) after lung resection. [Subjects and Methods] Fourteen patients undergoing lung resection completed the stair-climbing test and the 6MWT preoperatively, and one month postoperatively. The postoperative values and the percentage change in the stair-climbing test and the 6MWT were evaluated. [Results] The stair-climbing test results showed a significant deterioration at one month after lung resection; however, a significant change in the 6MWD was not observed. [Conclusion] When compared with the 6MWT, the stair-climbing test was more sensitive in detecting lung resection-induced changes in cardiorespiratory fitness.

Key words: Exercise capacity, Six-minute walk distance, Lung cancer

(This article was submitted Jan. 8, 2017, and was accepted Feb. 16, 2017)

INTRODUCTION

Exercise training that includes aerobic and resistance exercises, is recommended to increase the exercise capacity of patients, following lung resection for non-small cell lung cancer (NSCLC)¹. Previous studies evaluated the six-minute walk distance (6MWD) as an index of exercise capacity in this population¹⁻³; however, Santana et al.⁴ reported that there was no correlation between changes in the 6MWD and VO₂ peak after the training period in healthy elderly men. Therefore, it is unclear whether the six-minute walk test (6MWT) can detect changes in cardiorespiratory fitness, including a reduction in exercise capacity after lung resection.

The stair-climbing test is one of the most frequently used low-technology exercise tests in the preoperative evaluation of lung resection candidates⁵. Before lung resection, associations have been observed between the altitude and the VO₂ peak, measured during the stair-climbing test⁶. However, to our best knowledge, the stair-climbing test has not been used to evaluate improvement in exercise capacity after lung resection. In addition, the difference between changes in the stair-climbing test and in the 6MWD after lung resection remains unclear. Therefore, the aim of this study was to compare the stair-climbing test and the 6MWT after lung resection surgery.

*Corresponding author. Yohei Kubori (E-mail: kubori.yohei@a4.kepco.co.jp)

©2017 The Society of Physical Therapy Science. Published by IPEC Inc.

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License. (CC-BY-NC-ND 4.0: <http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Table 1. Changes in perioperative values

	Preoperative value	Postoperative value	
Altitude (m)	26.3 ± 12.7	18.2 ± 9.4	*
6MWD (m)	496.2 ± 61.5	468.9 ± 71.4	

Altitude: altitude reached in stair-climbing test; 6MWD: 6-min walk distance

Values are means ± SEM. * $p < 0.05$: compared with preoperative value

SUBJECTS AND METHODS

Fourteen patients undergoing lung resection using video-assisted thoracoscopic surgery lobectomy (VATS) for NSCLC from March 2013 through February 2014 were enrolled in the study after giving informed consent. This study protocol was approved by the Ethics Committee of the Kansai Electric Power Hospital (No. 2639). Patients completed the stair-climbing test and 6MWT preoperatively and one month postoperatively. The percentage change in the postoperative values in the stair-climbing test and the 6MWT was calculated as follows: the percentage change in postoperative value = postoperative value / preoperative value × 100 (%).

The stair-climbing test was performed as a symptom-limited exercise test⁷). Patients were instructed to climb the maximum number of steps at a pace of their own choice, and to stop only in case of exhaustion, limiting dyspnea, leg fatigue or chest pain. A physiotherapist accompanied the patients to monitor the development of any symptom; in addition, the patients were continuously monitored using a pulse oximeter. Heart rate, blood pressure, and respiratory rate were measured before and immediately after completion of the tests. Each test was performed on a staircase located in the hospital, which was easily accessible in case of severe complications requiring advanced care management. The staircase was composed of 36 flights of stairs; each flight comprised 20–31 steps of 0.18–0.19 m height each. The altitude climbed (number of steps multiplied by the height of each step) were recorded for each patient⁸).

The 6MWT was performed once on the same day as the stair-climbing test based on The American Thoracic Society guideline for 6MWT⁹). A physiotherapist accompanied the patients, who were continuously monitored using a pulse oximeter. Heart rate, blood pressure, and respiratory rate were also measured before and immediately after completion of the tests. The 6MWD was recorded for each patient; the 6MWT was performed before the stair-climbing test in a nonrandomized order¹⁰).

Postoperative respiratory treatment consisted of daily chest physiotherapy administered by physiotherapists, an early mobilization, endurance training and incentive spirometer for all patients. All data were expressed as the mean ± SD. The paired t-tests were used to determine the significance of changes in the altitude reached at the stair-climbing test and in the 6MWD before and after VATS. The percentage change in postoperative value and heart rate after test-completion were analyzed using the unpaired t-test. Differences with p values of $p < 0.05$ were considered significant.

RESULTS

The mean age of the patients in the study was 70.1 ± 9.1 years and seven of fourteen patients were female. The mean body mass index was 21.2 ± 2.4 kg/m². The mean preoperative forced vital capacity of the predicted value was $106.2 \pm 13.1\%$; and the mean preoperative forced expiratory volume in one second was 2.03 ± 0.67 l.

The altitude reached in the stair-climbing test was significantly reduced at one month postoperatively, as compared to preoperatively (26.3 ± 12.7 m vs. 18.2 ± 9.4 m; $p < 0.05$, Table 1). However, the difference between the preoperative and postoperative 6MWD value was not significant (496.2 ± 61.5 m vs. 468.9 ± 71.4 m, Table 1). Additionally, the percentage change in the postoperative altitude reached at the stair-climbing test was significantly lower than the percentage change in the postoperative 6MWD value ($71.4 \pm 12.9\%$ vs. $95.0 \pm 18.1\%$; $p < 0.05$). The heart rates after the stair-climbing test were significantly higher than after 6MWT, both preoperatively (120.1 ± 25.6 bpm vs. 96.4 ± 18.3 bpm; $p < 0.05$) and postoperatively (121.5 ± 23.0 bpm vs. 104.1 ± 20.1 bpm; $p < 0.05$).

DISCUSSION

Lung resection causes the lung volume to decrease, thereby reducing the ventilation volume and size of the pulmonary vascular bed. These changes can lead to a postoperative reduction of exercise capacity¹¹). Nagamatsu et al.¹²) have reported that maximum oxygen uptake per minute per square meter of body surface area decreased significantly to 80.3% of the baseline value one month after lung resection. The present analysis indicated that there was a significant deterioration to 71.4% of the baseline value in the stair-climbing test after lung resection; whereas, a significant change in 6MWD was not observed. These results confirmed that changes in exercise capacity could be detected based on changes in the stair-climbing test, and not the 6MWT.

The mean 6MWD was 496.2 ± 61.5 m preoperatively and 468.9 ± 71.4 m at one month postoperatively, corroborating

previously data³). Roul et al.¹³) suggested that in cases of 6MWD <300 m, there was a significant correlation between the 6MWD and the VO₂ peak. In our study, none of the patients walked <300 m before and after VATS. Following lung resection, the 6MWT is likely to measure patients' daily activity levels rather than the true maximal capacity. Therefore, this could explain why the 6MWT was not able to detect a reduction in exercise capacity after lung resection.

The heart rate after the stair-climbing test was significantly higher than after the 6MWT, both preoperatively and postoperatively. Corroborating this result, another study has shown that the ventilation as well as the oxygen consumption during stair climbing is significantly greater than while walking¹⁴). Thus, exercise intensity in the stair-climbing test could be higher than in 6MWT, which might lead to differences in the percentage change in both two low-technology exercise tests after lung resection.

In conclusion, the results indicated that the stair-climbing test, as compared to the 6MWT, is more sensitive at detecting changes in cardiorespiratory fitness induced by lung resection.

REFERENCES

- 1) Cavalheri V, Tahirah F, Nonoyama M, et al.: Exercise training for people following lung resection for non-small cell lung cancer—a Cochrane systematic review. *Cancer Treat Rev*, 2014, 40: 585–594. [[Medline](#)] [[CrossRef](#)]
- 2) Arbane G, Tropman D, Jackson D, et al.: Evaluation of an early exercise intervention after thoracotomy for non-small cell lung cancer (NSCLC), effects on quality of life, muscle strength and exercise tolerance: randomised controlled trial. *Lung Cancer*, 2011, 71: 229–234. [[Medline](#)] [[CrossRef](#)]
- 3) Cesario A, Ferri L, Galetta D, et al.: Post-operative respiratory rehabilitation after lung resection for non-small cell lung cancer. *Lung Cancer*, 2007, 57: 175–180. [[Medline](#)] [[CrossRef](#)]
- 4) Santana MG, de Lira CA, Passos GS, et al.: Is the six-minute walk test appropriate for detecting changes in cardiorespiratory fitness in healthy elderly men? *J Sci Med Sport*, 2012, 15: 259–265. [[Medline](#)] [[CrossRef](#)]
- 5) Brunelli A, Charloux A, Bolliger CT, et al. European Respiratory Society and European Society of Thoracic Surgeons Joint Task Force on Fitness for Radical therapy: ERS/ESTS clinical guidelines on fitness for radical therapy in lung cancer patients (surgery and chemo-radiotherapy). *Eur Respir J*, 2009, 34: 17–41. [[Medline](#)] [[CrossRef](#)]
- 6) Brunelli A, Xiumé F, Refai M, et al.: Peak oxygen consumption measured during the stair-climbing test in lung resection candidates. *Respiration*, 2010, 80: 207–211. [[Medline](#)] [[CrossRef](#)]
- 7) Bolton JW, Weiman DS, Haynes JL, et al.: Stair climbing as an indicator of pulmonary function. *Chest*, 1987, 92: 783–788. [[Medline](#)] [[CrossRef](#)]
- 8) Brunelli A, Al Refai M, Monteverde M, et al.: Stair climbing test predicts cardiopulmonary complications after lung resection. *Chest*, 2002, 121: 1106–1110. [[Medline](#)] [[CrossRef](#)]
- 9) ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories: ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med*, 2002, 166: 111–117. [[Medline](#)] [[CrossRef](#)]
- 10) Holden DA, Rice TW, Stelmach K, et al.: Exercise testing, 6-min walk, and stair climb in the evaluation of patients at high risk for pulmonary resection. *Chest*, 1992, 102: 1774–1779. [[Medline](#)] [[CrossRef](#)]
- 11) Brunelli A, Xiumé F, Refai M, et al.: Evaluation of expiratory volume, diffusion capacity, and exercise tolerance following major lung resection: a prospective follow-up analysis. *Chest*, 2007, 131: 141–147. [[Medline](#)] [[CrossRef](#)]
- 12) Nagamatsu Y, Maeshiro K, Kimura NY, et al.: Long-term recovery of exercise capacity and pulmonary function after lobectomy. *J Thorac Cardiovasc Surg*, 2007, 134: 1273–1278. [[Medline](#)] [[CrossRef](#)]
- 13) Roul G, Germain P, Bareiss P: Does the 6-minute walk test predict the prognosis in patients with NYHA class II or III chronic heart failure? *Am Heart J*, 1998, 136: 449–457. [[Medline](#)] [[CrossRef](#)]
- 14) Swinburn CR, Wakefield JM, Jones PW: Performance, ventilation, and oxygen consumption in three different types of exercise test in patients with chronic obstructive lung disease. *Thorax*, 1985, 40: 581–586. [[Medline](#)] [[CrossRef](#)]