

Original Article

Efficacy of pulmonary rehabilitation using cervical range of motion exercise in stroke patients with tracheostomy tubes

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Abstract. [Purpose] In this study, stroke patients who were intubated with tracheostomy tubes performed cervical range of motion exercises, and changes in their pulmonary and coughing functions were examined. [Subjects and Methods] Twelve stroke patients who were intubated with tracheostomy tubes participated in the study. The subjects were randomly assigned to either the control group (n=6), which did not perform cervical range of motion exercises, or the experimental group (n=6), which did perform exercises. [Results] With regards to forced vital capacity, forced expiratory volume at one second, and peak cough flow rate before and after the exercises, the control group did not show any significant differences while the experimental group showed statistically significant increases in all three parameters. [Conclusion] The results indicate that cervical range of motion exercises can effectively improve the pulmonary function and coughing ability of stroke patients intubated with tracheostomy tubes, and that cervical range of motion exercises can help in the removal of tracheostomy tubes.

Key words: Pulmonary rehabilitation, Stroke, Cervical range of motion exercise

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INTRODUCTION

Changes in the respiratory activity of stroke patients on the paralyzed side affect the forced vital capacity (FVC), forced expiratory volume at 1 second (FEV₁), FEV₁/FVC ratio, and peak expiratory flow rate (PEFR); changes in these pulmonary function indicators bring about a decline in the peak cough flow rate (PCFR), an indicator of coughing function^{1, 2)}. Weakened pulmonary function restricts the performance of daily living activities by making patients easily fatigued, and decreased coughing function causes serious problems in the respiratory system due to the inappropriate removal of secretions in the airway; it can also trigger complications such as pneumonia^{3, 4)}. In previous studies, inspiratory muscular training, feedback respiratory training, and other forms of muscle training exercises have been used to improve the respiratory activity of stroke patients^{5, 6)}.

Recently, studies have reported that intubated patients show restricted cervical spine motion⁷⁾. Abnormal head and cervical postures cause persistent abnormal physical stress due to muscle imbalance, and this abnormal stress brings about restrictions on lung ventilation⁸⁾. Recent reports

indicating that cervical mobilization exercises improve pulmonary functions have been published⁹⁾. Therefore, in this study, brain-damaged patients intubated with tracheostomy tubes performed cervical range of motion exercises. The aim was to analyze the changes in pulmonary and coughing functions in order to present appropriate training methods that can improve respiratory activity in such patients.

SUBJECTS AND METHODS

Subjects

The present study was conducted in stroke patients who were intubated with tracheostomy tubes in the D rehabilitation hospital, Ulsan, Korea. All patients understood the purpose of this study. And this study's subjects provided their written informed consent prior to their participation according to the ethical standards of the Declaration of Helsinki. The subjects were 12 patients with no history of respiratory system disease or damage, no findings of lung disease on radiography or breast examinations, and no cognitive impairments that would make the patients uncooperative, such as high levels of dysphasia or dementia (MMSE-K score of 24 points or higher). The subjects were randomly assigned to either a control group (n=6) that did not perform cervical range of motion exercises or an experimental group (n=6) that did perform cervical range of motion exercises. Random assignment was carried out by an individual not involved in data collection, using a computer-generated randomized table of numbers created for each participating site before the beginning of the study.

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Methods

To measure pulmonary function, the FVC, FEV₁, and FEV₁/FVC ratio were measured using the pulmonary function calculator of a micro spirometer (Micro Medical Ltd., UK). To measure coughing ability, the PCFR was measured using a peak flow meter (Cardinal Health 232 Ltd., UK). After the initial measurements, the control group did not perform cervical range of motion exercises, and these patients' pulmonary and coughing functions were then measured a second time, 8 weeks later. The experimental group performed cervical range of motion exercises 5 times per week for 8 weeks after the initial measurements, and then these patients' pulmonary and coughing functions were measured for a second time.

The exercises performed by the patients in the experimental group were those described by Cleland et al. In each session, the physical therapist manually stretched the patient's upper trapezius, scalene, sternocleidomastoid, levator scapulae, and pectoralis major and minor muscles. Each stretch was held for 30 seconds and repeated twice¹⁰. The exercises were performed within a cervical range of motion in which patients intubated with tracheostomy tubes would not feel uncomfortable: 10° for flexion, extension, and lateral flexion and 20° for rotation.

The three physical therapists who participated in the study and worked with all of the patients had at least 5 years of clinical experience. The physical therapists all underwent a standardized training regimen, which included studying a manual of standard procedures with the operational definitions of each examination and treatment procedure.

Paired t-tests were conducted to compare changes in the measured pulmonary and coughing function values over time in each group. Statistical analyses were conducted using PASW 17.0 for Windows, and the significance level was set to $\alpha = 0.05$.

RESULTS

Table 1 shows the general characteristics of the subjects. The results of paired t-tests conducted to compare the first and second measurements of pulmonary and coughing function in each group are shown in Tables 2 and 3. The control group did not show any significant differences in FVC or FEV₁, while the experimental group showed a statistically significant increase in both of these parameters ($p < 0.05$). Likewise, the control group did not show any significant difference in PCFR, but the experimental group showed a statistically significant increase in this measurement ($p < 0.05$).

DISCUSSION

Coughing serves as an important protective function in humans that discharges secretions to the outside of the body through mucociliary clearance; this prevents complications such as pneumonia. Stroke patients have a reduced ability to cough due to their weakened respiratory muscles and show a decreased PCFR, which is an indicator of coughing ability².

In the case of patients with tracheostomy tubes due to severe brain damage, these tubes can be removed successfully only when the patients' coughing ability has been

Table 1. General characteristics of the subjects (number or mean±SD)

Variables	Control group (n=6)	Experimental group (n=6)
Gender (male/female)	4/2	2/4
Paretic side (left/right)	5/1	1/5
Age (years)	77.2±10.7	76.5±10.2
Time since stroke (months)	23.5±14.6	26.2±21.5
Height (cm)	164.3±8.1	159.0±10.9
Weight (kg)	55.7±11.7	51.15±16.1

Table 2. Comparison of pre and post pulmonary and coughing function in the control group (mean±SD)

Variables	Pre	Post
FVC (mL)	650.0±238.7	671.7±267.1
FEV ₁ (mL)	458.3±181.3	483.3±205.2
FEV ₁ /FVC (%)	70.2±6.5	71.8±11.2
PCFR (L/min)	70.8±16.2	71.7±22.1

FVC: forced vital capacity, FEV₁: forced expiratory volume at 1 second, FEV₁/FVC: forced expiratory ratio, PCFR: peak cough flow rate

Table 3. Comparison of pre and post pulmonary and coughing function in the experimental group (mean±SD)

Variables	Pre	Post
FVC (mL)	643.3±206.7	740.0±275.8*
FEV ₁ (mL)	471.7±125.5	505.0±121.1*
FEV ₁ /FVC (%)	74.7±11.3	71.7±15.1
PCFR (L/min)	63.3±9.9	70.8±16.3*

FVC: forced vital capacity, FEV₁: forced expiratory volume at 1 second, FEV₁/FVC: forced expiratory ratio, PCFR: peak cough flow rate, * $p < 0.05$

recovered. The normal PCFR is at least 300 L/min. If the rate is within the range of 160–270 L/min, viral infections can occur easily. If the rate drops below 160 L/min, mucociliary clearance ability declines remarkably¹¹. The stroke patients intubated with tracheostomy tubes who participated in the present study had remarkably decreased coughing ability, demonstrated by PCFRs of lower than 160 L/min. Thus, the patients' ability to remove secretions was lost. While the control group did not show any change in PCFR after 8 weeks, the experimental group, who performed cervical range of motion exercises, showed significant increases in PCFR after intervention. This indicates that cervical range of motion exercises are effective for improving the coughing function of stroke patients intubated with tracheostomy tubes. However, Bach reported that tracheostomy tubes could be removed only when the PCFR was at least 160 L/min. The experimental group in the present study had a PCFR of 160 L/min. Therefore, longer training periods may be necessary to remove tracheostomy tubes in stroke

patients.

Chalmers et al. reported that patients with FVC values of lower than 300 mL needed continuous mechanical ventilation with tracheostomy tubes, patients with FVC values in the range of 300–700 mL needed mechanical ventilation with tracheostomy tubes at night and when necessary during the daytime, and patients with FVC values within the range of 700–1,000 mL could be helped to breathe by mechanical ventilation with nasal masks instead of tracheostomy tubes¹²). The patients in the present study had FVC values lower than 700 mL, and the patients in the experimental group had increased FVC values that exceeded 700 mL after they had performed cervical range of motion exercises. These results indicate that these exercises can help in removing the necessity for tracheostomy tubes.

Abnormal head and cervical postures cause persistent abnormal physical stress due to muscle imbalance. This abnormal stress brings about restrictions in lung ventilation and pulmonary functions⁸). Cervical muscle strengthening and stretching exercises correct abnormal postures, thus reducing the abnormal stress caused and improving restricted ventilation function, so that effective ventilation can occur¹³). Han et al. reported that these effects were the result of cervical muscle function recovery, and that reduced airway resistance resulted from postural changes⁸). It is assumed that the cervical range of motion exercises performed in the present study relaxed tense cervical muscles, thus reducing the resulting abnormal stress caused, reducing airway resistance, and improving pulmonary and coughing functions.

Compared to patients without tracheostomy tubes, patients intubated with tracheostomy tubes have lower Functional Independence Measure (FIM) scores and require longer stays in rehabilitation units¹⁴). Therefore, the removal of tracheostomy tubes is an important issue for such patients. The length of extubation is associated with mortality in intensive care units¹⁵). Extubation fails in 10–20% of patients, and when extubation has failed, the patient shows clinically poor results^{16, 17}). Therefore, reducing errors that determine the length of extubation is important. In the present study, the pulmonary and coughing functions of patients with tracheostomy tubes were examined by the measurement of FVC, FEV₁, and PCFR, and extubation-related matters were discussed. However, airway resistance and the elasticity of the respiratory system are simple and non-invasive measures that successfully predict the length of extubation^{18, 19}). The rapid shallow breathing index (RSBI) indicates the relationship between respiratory frequency and tidal volumes and has been reported to determine the length of extubation more accurately than other tools²⁰). Recently, values showing muscle fatigue were reported to be important elements that determine successful extubation²¹). Therefore, future studies should be conducted on effective training methods that can make extubation easier for patients with tracheostomy tubes, using multilateral measurement approaches with diverse training and measurement methods.

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