Clinical Outcome of Chest Physical Therapy for Patients undergoing Home Oxygen Therapy

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Abstract. Chest physical therapy (CPT) is important to introduce and continue home oxygen therapy (HOT) of patients with chronic pulmonary disease. We examined the effects of CPT for twenty-five patients undergoing HOT. To compare the effects of CPT for HOT patients and non-CPT, we evaluated respiratory rate (RR), tidal volume (V_T), rapid shallow breathing (RSB) index, muscle contraction of diaphragm and scalenus muscles while breathing (muscle contraction pattern while breathing), six minutes walk distance (6MD), Borg scale, rate of change of oxygen saturation (ΔSpO_2) and heart rate (%HRmax) during 6MD, activities of daily living (ADL), and mood disorder. Our results show that V_T , RSB index and the Borg scale were significantly better in the CPT group. These results show the efficacy of CPT for HOT patients to maintain their respiratory function.

Key words: Home oxygen therapy, Chest physical therapy, Chronic pulmonary disease.

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INTRODUCTION

It is generally accepted that home oxygen therapy (HOT) reduces mortality rate and improves quality of life (QOL) for respiratory insufficiency patients. Two large studies of the Nocturnal Oxygen Therapy Trial (NOTT) in USA in 1980¹⁾ and the British Medical Research Council trial (MRC trial) in 1981²⁾, showed many clinical advantages of HOT for patients.

In Japan, HOT has been rapidly introduced under the application of health insurance since 1985. According to the reports of the respiratory insufficiency studies group of Japanese Ministry of Health and Welfare, the number of patients receiving HOT in Japan reached about 23,000 in 1991 and is now 40,000 over.

Pulmonary rehabilitation that is chest physical

therapy (CPT) such as breathing retraining and therapeutic exercise is very important to the introduction and maintenance of HOT. Many studies have reported the effects of intensive CPT for patients with chronic respiratory insufficiency, but studies about the effects of CPT for patients undergoing HOT are very few.

The purpose of this study was to investigate the effects of CPT for HOT patients at the time of HOT introduction, to clarify the differences in effect between a CPT group and a non-CPT group, and to determine how to perform CPT effectively.

SUBJECTS

Twenty-five outpatients with HOT (13 males, 12 females, mean age 68.4 years) who had been thoroughly evaluated were selected for this study. Their underlying disease, age, degree of dyspnea (Hugh-

Jones) and lung function status are shown in Table 1.

We divided the subjects into two groups: fifteen CPT patients and ten non-CPT patients. The CPT group consisted of seven pulmonary tuberculosis patients, four pulmonary emphysema patients and four bronchiectasis patients. The non-CPT group consisted of seven pulmonary tuberculosis patients and three pulmonary emphysema patients. There were no significant differences between the two groups in Hugh-Jones, age, %VC, FEV_{1.0}%, PaO₂ and PaCO₂.

METHOD

To evaluate breath condition, we measured respiratory rate (RR), tidal volume (V_T), RSB (rapid shallow breathing) index and muscle contraction of the diaphragm and scalenus muscles while breathing (muscle contraction pattern while breathing). This muscle contraction pattern while breathing was classified into five degrees. It was evaluated in the supine position by classification of diaphragmatic breathing by graded contraction of the

diaphragm and scalenus muscles (Table 2). RR was measured with palpation in the sitting position and V_T was measured by a light respirometer (Japan BOC Co LTD). The RSB index was obtained from following formula:

$$\text{RSB index} = \text{RR (breaths/min)} / V_T (\text{l})$$

Exercise endurance was determined by measuring the six minutes walking distance (6MD). We ordered patients to walk as far as possible during six minutes. At the same time, we continuously measured SpO₂ (oxygen saturation by pulse oximeter) and heart rate (HR) using a pulse oximeter (Amuko Co LTD). We also evaluated subjects' subjective endurance using the Borg scale at the end of the 6MD exercise. Rate of change of SpO₂ (ΔSpO_2) during walking (6MD) was calculated from following formula:

$$\Delta\text{SpO}_2 = \text{SpO}_2 \text{ at rest} - \text{minimum SpO}_2 \text{ during exercise} / \text{SpO}_2 \text{ at rest}$$

%HRmax was calculated by Karvonen's formula³.

We used a particular ADL test for patients with respiratory insufficiency which was modified for

Table 1. Physical characteristics of subjects

	CPT group (n=15)	non-CPT group (n=10)
underlying disease (n)		
pulmonary tuberculosis	7	7
pulmonary emphysema	4	3
bronchiectasis	4	0
grading of Hugh-Jones (n)		
II	1	1
III	10	6
IV	4	2
V	0	1
age (years)	67.7 ± 6.4	69.4 ± 7.7
%VC (%)	58.4 ± 17.8	69.5 ± 32.6
FEV _{1.0} % (%)	55.0 ± 14.7	59.1 ± 26.6
PaO ₂ (mmHg)	70.2 ± 17.8	86.1 ± 33.6
PaCO ₂ (mmHg)	56.7 ± 7.9	51.4 ± 13.7

The chest physical therapy (CPT) and non-CPT group were not significantly different with respect to any of these variables.

Table 2. Classification of diaphragmatic breathing graded by contraction of diaphragm and scalenus muscles (muscle contraction pattern while breathing)

grade	The pattern of contraction of diaphragm and scalenus muscles
5	Diaphragm only contracts
4	After diaphragm contracts, scalenus muscles contract at the end of inspiration
3	Diaphragm and scalenus muscles contract in concurrence
2	After scalenus muscles contract, diaphragm contracts
1	Scalenus muscles only contract

outpatient clinic use only. This ADL test consisted of ten items of ADL (feeding, toileting, grooming, bathing, dressing, walking indoors, climbing stairs, carrying luggage and moderate exercise) and continuous walking distance. The walking points depended on walking distance (0, 2, 4, 8, 10 points). Furthermore these ten ADL items were divided into three subcategories, that is, speed of activity (0–3 points), degree of respiratory embarrassment (0–3 points) and flow volume of oxygen per minute (0–3 points). The ADL score amounted to 100 points at its maximum.

Mood disorder was evaluated by the Self-Rating Depression Scale (SDS) and Manifest Anxiety Scale (MAS). SDS consisted of twenty questions. The total score was eighty points in maximum over twenty points in minimum. Patients who marked fifty points or more were diagnosed as likely in a state of depression. From MAS points, their anxieties were graded into five stages (stage I, strong anxiety; stage II, moderate anxiety; stage III–V, normal).

Arterial blood gas analysis (PaO_2 , PaCO_2) and lung function test (%VC, $\text{FEV}_{1.0}\%$) were obtained from the most recent clinical data.

Data analysis

In comparison, statistics analysis was done with Wilcoxon signed-ranks test for muscle contraction pattern while breathing, and with the unpaired t-test for the other items.

RESULTS

V_T was significantly greater in the CPT group ($p<0.05$) than in the non-CPT group, and its mean values and SD were 496.6 ± 182.0 ml, and 313.3 ± 136.0 ml, respectively (Table 3). The RSB index was significantly lower in the CPT group ($p<0.05$) compared with the non-CPT group, and its mean values and SD were 45.4 ± 23.0 , and 80.4 ± 40.0 respectively. RR at rest was slightly less in the CPT group than in the non-CPT group, and its mean values and SD were 19.6 ± 4.6 breaths/min,

Table 3. Comparison of items of measurement between CPT group and non-CPT group

	CPT group	non-CPT group
RR (breath/min)	19.6 ± 4.6	21.3 ± 2.0
V_T (ml)	496.6 ± 182.0	313.3 ± 136.0
RSB index	45.4 ± 23.0	80.4 ± 40.0
muscle contraction pattern while breathing (n)		
grade 2	3	2
3	7	7
4	5	1
6MD		
distance (m)	271.7 ± 82.0	319.5 ± 45.5
Borg scale	3.4 ± 0.8	4.3 ± 1.1
ΔSpO_2 (%)	4.8 ± 5.8	4.8 ± 2.1
%HRmax (%)	23.4 ± 22.1	22.9 ± 17.7
ADL score	54.9 ± 12.6	61.6 ± 8.5
MAS		
stage I	6	3
II	1	4
III	8	3
SDS		
normal	11	9
depression	4	1

* $p<0.05$

RR=respiratory rate, V_T =tidal volume, RSB index=rapid shallow breathing index, 6MD=six minutes walk distance, MAS=manifest anxiety scale, SDS=self-rating depression scale. There were significant differences between chest physical therapy (CPT) and non-CPT group with V_T , RSB index and Borg scale at the end of 6MD exercise. CPT group exceeded non-CPT group in these respects.

and 21.3 ± 2.0 breaths/min respectively. In the muscle contraction pattern while breathing, the modal value was grade 3 (diaphragm and scalenus muscles contract in concurrence) in both groups. Five patients of the fifteen CPT patients, and one patient of the ten non-CPT patients were classified as grade 4 (after diaphragm contracts, scalenus muscles contracts at the end of inspiration), which showed a good muscle contraction pattern while breathing for the CPT group. But, there were no significant differences in RR and muscle contraction pattern while breathing between the two groups.

The 6MD was shorter in the CPT group than in the non-CPT group, and its mean values and SD were 271.7 ± 82.0 m, and 319.5 ± 45.5 m respectively. SpO_2 during 6MD decreased in both groups by about 5% ΔSpO_2 . For %HRmax, the CPT group and the non-CPT group were almost the same during 6MD, and the mean values and SD were $23.4 \pm 22.1\%$, and $22.9 \pm 17.7\%$ respectively. There were no significant differences in the 6MD, ΔSpO_2 and %HRmax between the CPT group and the non-CPT group. A low Borg scale expresses better subjective endurance generally, and the Borg scale at the end of 6MD was significantly lower in the CPT group ($p < 0.05$). The mean values and SD were 3.4 ± 0.8 in the CPT group and 4.3 ± 1.1 in the non-CPT group.

The ADL score was lower in the CPT group than in the non-CPT group, but there was no significant difference. The mean values and SD of the ADL scores were 54.9 ± 12.6 points in the CPT group and 61.6 ± 8.5 points in the non-CPT group.

For mood disorder, MAS and SDS showed no differences between the CPT group and the non-CPT group. Regarding MAS stages I and II occupied about 46% in the CPT group, and 70% in the non-CPT group. The number of depression patients diagnosed by SDS were four out of fifteen CPT patients, and one out of ten non-CPT patients.

DISCUSSION

Chest physical therapy for HOT patients at the time of HOT introduction had beneficial effects on V_T , RSB index and Borg scale at the end of the 6MD exercise, but did not affect other items.

Kozu, et al.⁴⁾ reported that good respiratory muscles function improved ability of vesicular oxygenation and lung function. These factors lead to the reduction of dyspnea, increase of exercise endurance

and improvement of ADL. Other authors⁵⁾⁶⁾ carried out breathing exercises, such as techniques of breathing and strengthening the respiratory muscles in patients with chronic obstructive pulmonary disease. Particularly, pursed lip breathing lowers respiratory rate and increases the depth of each breath. It helps to improve oxygen transfer across the lung and also to mitigate dyspnea during exercise. In this study, muscle contraction pattern while breathing tended to improve in the CPT group. From the foregoing, the reason why V_T increased in the CPT group might be the acquiring of techniques of good breathing, such as diaphragmatic breathing and pursed lip breathing, by CPT.

The higher the RSB index is, the slower and deeper respiration is. This index was calculated with V_T and RR, so a higher volume of V_T in the CPT group led to a lower RSB index.

The Borg scale at the end of 6MD exercise was significantly lower in the CPT group than in the non-CPT group. Subjective endurance like the Borg scale, relates with the grade of dyspnea during exercise for respiratory insufficiency patients. Dyspnea during exercise might be reduced in the CPT group because patients had acquired efficient breathing techniques by CPT.

On the other hand, there were no beneficial effects on 6MD, ADL score and mood disorder in this study.

Kitagawa, et al.⁷⁾ reported that intensive CPT for patients with chronic respiratory disease had the beneficial effects of significantly improving %VC, PaO_2 , 6MD and ADL score. Many other authors have reported the same conclusions⁸⁾⁹⁾. We postulate that there are two reasons why our study didn't reveal any significant differences between the CPT and non-CPT groups in exercise endurance, ADL and mood disorder. The first reason is lack of sufficient therapeutic exercise, and education and instruction of ADL and mental supports.

Kida, et al.¹⁰⁾¹¹⁾ reported on the comparison of details of pulmonary rehabilitation between Japan and the USA. These reports showed that pulmonary rehabilitation had been carried out in 55.6% of 178 medical facilities in USA, and at only 20.4% of 415 medical facilities in Japan. Gait exercise, education of ADL and mental supports had been as frequent as breathing exercise in the USA. On the other hand, in Japan, breathing exercise had been mainly carried out, but gait exercise and education of ADL had hardly been performed, and

mental supports rarely. Therapeutic exercise and education of patients about breathing pattern, ADL and their diseases status might be necessary to improve exercise endurance, ADL and mood disorder.

Secondarily, improvements of exercise endurance, ADL and mood disorder were not maintained by outclinic CPT only. We supposed that CPT patients might have expected improvements right after the time of HOT introduction.

Vale, et al.¹²⁾ reported that exercise endurance and QOL were improved by twice weekly outclinic CPT, whereas our subjects accepted outclinic CPT once every three months on average. It is difficult to maintain and to improve patients' functions by outclinic CPT alone.

HOT patients tend to be confined to their home after leaving hospital because of insufficiency of their endurance and the lack of recognition of HOT in society and their families. Therefore their activities were lower, and this decline might lead to a state of anxiety and depression.

We postulate that home exercise is very important to maintain and to improve patients' function, and to carry out effective home exercise, we have to make a home rehabilitation program according to patients' ability and environment, instructing them how to perform.

CONCLUSIONS

In this study, CPT at the time of HOT introduction improved V_T , RSB index and Borg scale at the end of 6MD significantly, but didn't improve exercise endurance, ADL and mood disorder. From these results, we consider that we should carry out more intensive CPT at the time of HOT introduction and sufficiently encourage home exercise to maintain lung function and ADL for prolonging life.

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