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Original Article

The Effects of Preoperative Short-term Intense Physical Therapy in Lung Cancer Patients: A Randomized Controlled Trial

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Background: We planned to investigate the effect of preoperative short period intensive physical therapy on lung functions, gas-exchange, and capacity of diffusion, and ventilation-perfusion distribution of patients with non-small cell lung cancer.
Methods: Sixty patients with lung cancer, who were deemed operable, were randomly allocated into two groups. Intensive physical therapy was performed in patients in the study group before operation. Both groups received routine physical therapy after operation.
Results: There was no difference in pulmonary function tests between the two groups. Intensive physical therapy statistically significantly increased peripheral blood oxygen saturation. At least one complication was noted in 5 patients (16.7%) in the control group, and 2 (6.7%), in the study group. However, there was no statistically significant difference (p = 0,4). The hospital stay has been found to be statistically significantly shortened by intensive physical therapy (p <0.001). Ventilation-perfusion distribution was found to be significantly effected by intensive physical therapy. The change was prominent in the the contralateral lung (p <0.001).
Conclusions: Intensive physical therapy appeared to increase oxygen saturation, reduce hospital stay, and change the ventilation/perfusion distribution. It had a significant, positive effect on the exercise capacity of patients.

Key words: Intensive physical therapy, lung cancer, pulmonary functions, arterial blood gases, diffusion capacity

Introduction:

Cancer is second only to cardiovascular disease as a cause of death among adults in the United States. Lung cancer is the leading cause of cancer death in men and women.[1, 2] The important components of lung cancer treatment are chemotherapy, radiotherapy and surgery.[3]

The incidence of postoperative pulmonary complications after thoracotomy and lung resection is about 30% and is related not only to removal of lung tissue but is also caused by alterations in chest-wall mechanics due to the thoracotomy itself. All spirometric measurements fall precipitously, immediately, postoperatively and do not return to normal until 6 weeks to 6 months, postoperatively.[4, 5]

Pulmonary complications are important forms of postoperative morbidity after major cardiothoracic and abdominal operations.[3]

The reality of pulmonary rehabilitation has changed since the 1974 definition proposed by the American College of Chest Physicians Committee on Pulmonary Reha-

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bilitation. Several factors have contributed to the resurgent interest in pulmonary rehabilitation over the past years. First, the prevalence of patients with COPD has increased. Second, there is greater awareness that such patients are deconditioned. Third, the emergence of lung volume reduction surgery for patients with advanced emphysema has prompted institutions to develop and/or expand both preoperative and postoperative pulmonary rehabilitation. Fourth, managed healthcare programs have encouraged administrators to consider pulmonary rehabilitation programs as an integral part of health-care delivery/preventive medicine. And fifth, publications have highlighted the principles and practice of pulmonary rehabilitation.[6] These benefits should decrease postoperative complication rates; improve postoperatively adherence to exercise regimens.[7] In postoperative settings it prevents probable complications related to immobilization and pain and proves postoperative exercise regime and capability of exercise practice.[8, 9]

In the preoperative and postoperative settings, the overall goal of chest physiotherapy is to maximize the advantages derived from the planned surgery. In addition to the aforementioned benefits, other proposed but unproven benefits for surgical patients include improved tolerance of the surgical procedure, increased ability to clear secretions, and decreased work of breathing as a result of improvement in diaphragmatic function.

These benefits reduce the risk of postoperative complications, decrease symptoms, decrease disability, facilitate to understand of sickness and facilitate the management of the disease process.[6]

We planned to investigate the effect of short-period intensive physical therapy before resectional surgery on lung functions, gas exchange, capacity of diffusion and ventilation-perfusion distribution on lung cancer patients who underwent resectional surgery.

Materials and Methods

Between January 2007 and August 2008, 60 consecutive, operable (stage IA to IIIB) lung cancer patients without major cardiac morbidity (ASA II or better) were included in this study.

Routine blood tests included hemoglobin, alkaline phosphatase and serum calcium estimations. All patients underwent postero-anterior and lateral chest radiographs, bronchoscopy, and basic pulmonary function tests with or without DLCO and V/Q scan, and blood gases analysis. Computerized tomography (CT) scans of the thorax, abdomen (or abdominal ultrasonography), and cranium (or cranial MRI), whole body bone scintigraphies were done in most patients for pretreatment staging.

Mediastinal lymph node sampling using cervical mediastinoscopy were carried out in all patients. Patients, before planned operation after standard cervical mediastinoscopy which was performed for preoperative mediastinal staging, were randomly allocated (according to hospital record number) to control or study group. In the study group, intensive physical therapy (IPT) (chest physiotherapy and walking exercise) was achieved, one week before the planned surgery. In the study group of patients, the program was continued with the same frequency during the postoperative period until discharge. Chest physiotherapy consisted of diaphragmatic, pursed lip, segmental breathing exercise, usage of incentive spirometry, coughing exercise. The walking exercise was done by the patient on a treadmill three times a day, according to the patient's tolerance to exercise speed and time. During the walking exercise, a warm-up and cool-down were included. Oxygen saturation, heart rate and Borg scale of patients were monitored during exercise. The method for calculating heart rate (working heart rate) during exercise according to the "Karvonen method" is as follows: '0.65–$0.8 \times$ [220-age (year)]' formula.[10] IPT was applied by a physical therapist of our surgery department twice a day, and patients were encouraged to continue their exercise programme, wandering in and around the surgical center throughout the day. In the control group, no IPT was done, and patients were discharged one day after the mediastinoscopy and recalled the night before the planned resectional surgery. Routine physical therapy was performed until discharge in both groups. The exercise capacity was evaluated with maximum walking distance, duration and maximum speed. The study scheme is depicted in **Fig. 1**.

The various features on plain chest X-ray films were classified according the severity into three classes: class 1 with normal appearance on x-ray film, class 2 with moderate infiltrate, and class 3 with important infiltrate or atelectasis. The designation of postoperative pneumonia and bronchopneumonia were made according to the consensus report.[11]

Informed consent was obtained from all patients before their participation in the study. The Institutional Review Board approved the study before its commencement. The randomized trial was in accordance with the 2001 checklist of the Consolidated Standards of Reporting Trials (CONSORT) Statement.

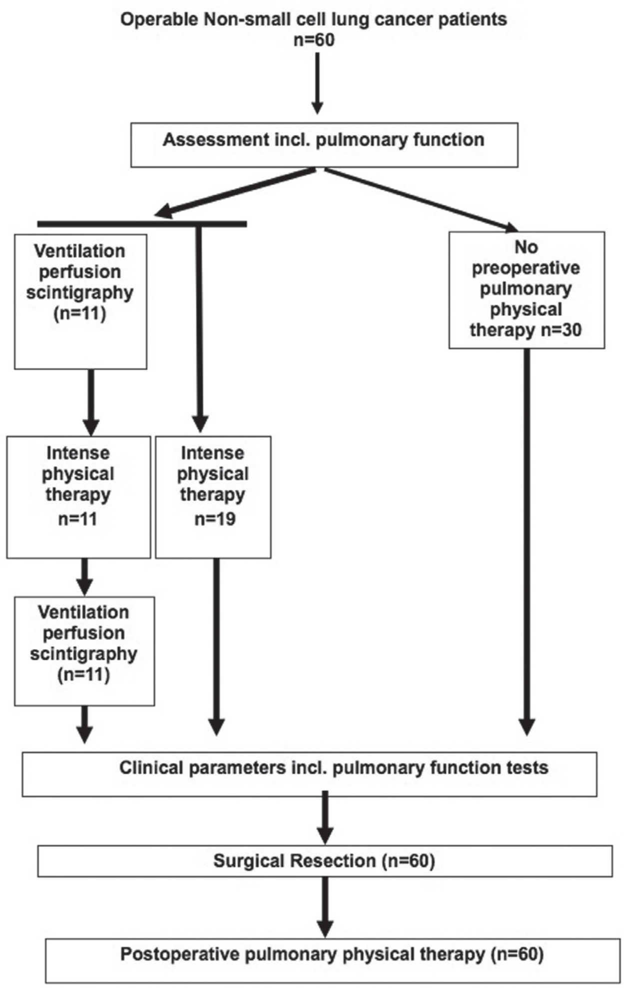

Fig. 1 Scheme of the study.

After mediastinoscopy, before the operation, pulmonary function tests (incl. dynamic and static parameters with carbon dioxide diffusion capacity), arterial blood gases analysis and ventilation-perfusion scintigraphy were performed in all patients. A second ventilation-perfusion scintigraphy was taken in 11 patients who accepted the procedure after preoperative IPT before resectional surgery. No patient smokes at the beginning of the study (They quitted or never smoked).

The primary endpoint of the study is to reduce hospital-stay. Patients involved in the study were allocated to IPT and no-IPT groups with randomized manner. Randomization was performed according to an internet-based-random number generator. Type-I error (α) and type-II (β) error were set to be 5%. Our aim was to produce 40% difference in hospital stay with δ_0 of 10%. With a one-sided alternative, we needed to include 30 patients in each arm.

Statistical Analysis

SPSS 11.0 statistical software program was used in data analysis. Student t-test, paired t-test, covariance analysis, Fisher Exact test were carried out. The difference was deemed significant when $p < 0{,}05$. Covariance analysis was also performed. As lung ventilation perfusion measurements were in the normal distribution, it was evaluated with student t-test. Patient's postoperative hospitalization periods and complication rates were evaluated with Chi-square test.

Results

In our study, there were 30 patients in the control group and 30 patients in the study group. There was no statistically significant difference between groups according to age, weight, height, body mass index (BMI) and cigarette smoking and performed operations. The distribution of parameters was balanced as shown in **Table 1**.

Preoperative initial pulmonary function test parameters (before randomization) of patients in the study and control groups are shown in **Table 2**. The pulmonary function parameters and arterial blood partial gas pressures except peak expiratory flow (PEF) did not differ between two groups (**Table 2**). Mean PEF and DLCO were significantly lower in the group of patients who underwent IPT. In the study group, 11 patients had ventilation perfusion scintigraphy measurement. **Table 3** shows the preoperative V/Q distribution differences in patients caused by IPT, the difference of after and before IPT). The contra lateral V/Q distribution was statistically significantly modulated by IPT ($p < 0.001$) (**Table 3**). IPT significantly increased contra lateral perfusion.

Despite preoperative IPT in the study group, pulmonary function test parameters did not differ between two groups after IPT period (i.e., before operation) (**Table 4**). IPT statistically significantly improved pulmonary function parameters such as FVC, FEV_1 and DLCO ($p = 0.003$, 0.01 and $p < 0.001$ respectively; **Table 5**). IPT was also found to statistically significantly increase PaO_2, and decrease $PaCO_2$ ($p < 0.001$; **Table 5**).

There was statistically significant decrease in final heart rate, whereas total walking duration, total walking distance and maximum speed increased after IPT (**Table 6**).

Postoperative morbidity was observed in five patients (16.7%) in the control group, whereas one patient (3.3%) in the study group had a complication. The difference was statistically significant (**Table 7**; $p = 0.04$). No postoperative mortality occurred in two groups. Mean hospital

Table 1 Demographic characteristics of patients

	Study Group n = 30 mn ± sd	Control Group n = 30 mn ± sd	p value
Age (year)	54.10 ± 8.53	54.76 ± 8.45	0.7
Weight (kg)	68.76 ± 10.75	65.20 ± 8.95	0.1
Height (m)	1.68 ± 6.62	1.68 ± 4.67	0.8
BMI (kg/m2)	23.86 ± 3.15	23.24 ± 3.18	0.4
Smoking (pack.year)	46.80 ± 23.55	50.76 ± 26.62	0.5
Operations			
Lobectomy	19 (63.3%)	24 (80.0%)	0.3
Bilobectomy	-	-	
Pneumonectomy	11 (36.7%)	6 (20%)	

BMI: Body-mass Index
mn ± sd: (mean ± standard deviation)

Table 2 Preoperative initial pulmonary function parameters

Parameters	Study Group N = 30 mean ± sd	Control Group N = 30 mn ± sd	p value
$FVC_{measured}$ (L)	2.87 ± 0.59	3.18 ± 0.77	0.08
FVC $_{\%predicted}$ (L)	72.95 ± 12.51	77.15 ± 15.83	0.2
$FEV_{1measured}$ (L/sec)	2.10 ± 0.54	2.8 ± 0.73	0.09
$FEV_{1\ (\%predicted)}$	65.40 ± 14.20	77.04 ± 20.01	0.1
FEV_1 /$FVC_{measured}$ (%)	74.00 ± 11.85	72.40 ± 16.76	0.6
FEV_1 /$FVC_{\%predicted}$	80.29 ± 9.09	76.12 ± 8.50	0.07
$PEF_{measured}$ (L/sec)	4,01 ± 1,49	5.24 ± 1.89	0.07
$PEF_{\%predicted}$	49.12 ± 17.26	64.56 ± 22.12	0.04
$DLCO_{measured}$ (mmol/k.Pa.sec)	19.96 ± 7.33	21.30 ± 6.13	0.4
$DLCO_{\%predicted}$	71.16 ± 22.54	76.46 ± 21.06	0.3
DLCO/$VA_{measured}$ (DLCO/L)	4.04 ± 0.94	4.25 ± 0.31	0.2
DLCO/$VA_{\%predicted}$	88.24 ± 18.35	97.65 ± 7.92	0.01
PaO_2 (mmHg)	76.75 ± 9.97	79.52 ± 2.19	0.1
$PaCO_2$ (mmHg)	38.09 ± 5.95	37.28 ± 4.05	0.5
SaO_2 (%)	94.66 ± 2.59	94.90 ± 3.31	0.7

FVC: forced vital capacity; FEV_1: forced expiratory volume in one second; PEF: peak expiratory flow;
DLCO: diffusion lung capacity for carbon monoxide; PaO_2: partial arterial oxygen pressure;
$PaCO_2$, partial arterial carbondioxide pressure; SaO_2: Oxygen saturation
mn ± sd: (mean ± standard deviation)

Table 3 Mean perfusion distributions in the study group before and after intensive physical therapy (IPT)

Sides	First measurement (Before IPT) n = 11 mn ± sd:	Second measurement (After IPT) n = 11 mn ± sd:	p value
Tumor side (mean %)	44.40 ± 8.22	41.54 ± 7.62	p <0.001
Contralateral lung (mean %)	55.59 ± 8.22	58.45 ± 7.62	p <0.001

mn ± sd: (mean ± standard deviation)
IPT: intensive physical therapy

stays were 5.40 ± 2.67 and 9.66 ± 3.09 days in the study and control groups respectively. The difference was statistically highly significant ($p < 0.001$). The mean postoperative peripheral blood oxygen saturation was found higher in the study group ($p = 0.008$) whereas, $PaCO_2$ and PaO_2 levels did not differ significantly ($p = 0.08$ and $p = 0.07$ respectively).

Table 4 Pulmonary function parameters after intensive physical therapy before operation in the study and control groups

	Study Group n = 30 mn ± sd	Control Group n = 30 mn ± sd	p value
FVC (%)	19.26 ± 2.33	16.35 ± 2.40	0.6
FEV_1 (%)	15.84 ± 2.10	8.92 ± 3.5	0.3
FEV_1/FVC (%)	6.58 ± 2.5	6.09 ± 2.4	0.9
PEF (%)	6.4 ± 3.2	9.78 ± 3.5	0.3
DLCO (%)	21.89 ± 2.7	19.35 ± 2.48	0.6
DLCO/VA (%)	15.71 ± 4.8	9.02 ± 2.4	0.06

FVC: forced vital capacity; FEV_1: forced expiratory volume in one second; PEF: peak expiratory flow; DLCO: diffusion lung capacity for carbon monoxide; DLCO/VA: diffusion lung capacity for carbon monoxide of alveoli
mn ± sd: (mean ± standard deviation)

Table 5 Pulmonary functions and arterial blood gases before and after preoperative IPT in the study group

	Before IPT mean ± sd	After IPT mean ± sd	Δ	p value
FVC (L)	2.87 ± 0.59	3.10 ± 0.62	0.23 ± 0.39	0.003
FEV_1 (L)	2.10 ± 0.54	2.28 ± 0.63	0.16 ± 0.35	0.01
FEV_1/FVC (%)	74.00 ± 11.85	71.87 ± 17.04	–2.13 ± 19.66	0.5
PEF (L/sc)	4.01 ± 1.49	4.31 ± 1.75	0.30 ± 1.38	0.2
PaO_2 (mmHg)	76.75 ± 9.97	79.01 ± 9.44	4.59 ± 13.15	p <0.001
$PaCO_2$ (mmHg)	38.09 ± 5.95	36.63 ± 3.85	1.46 ± 2.57	0.004
SaO_2 (%)	94.66 ± 2.59	95.96 ± 7.10	2.96 ± 2.93	0.3
DLCO(mmol/ k.Pa.sc.)	19.96 ± 7.33	21.03 ± 6.89	1.06 ± 1.43	p <0.001
DLCO/VA (DLCO/L)	4.04 ± 0.94	4.60 ± 2.87	0.61 ± 2.93	0.2

IPT: intensive physical therapy; FVC: forced vital capacity; FEV_1: forced expiratory volume in one second; PEF: peak expiratory flow; DLCO: carbon monoxide diffusion capacity; PaO_2: partial arterial oxygen pressure; $PaCO_2$ partial arterial carbon dioxide pressure. Diffusion lung capacity for carbon monoxide. DLCO/VA: diffusion lung capacity for carbon monoxide per volumes of alveoli
(Δ: The difference after rehabilitation-before rehabilitation)
mn ± sd: (mean ± standard deviation)

Table 6 Parameters recorded during the first and last walking settings in the study group

	Before intensive physical therapy mn ± sd	After intensive physical therapy mn ± sd	p value
Initial heart rate (pulse/min)	90.10 ± 10.45	90.03 ± 9.99	0.9
Final heart rate (pulse/min)	113.60 ± 11.35	109.10 ± 9.48	0.04
Recovery heart rate (pulse/min)	102.90 ± 10.13	100.16 ± 8.32	0.06
Duration (min)	18.23 ± 7.40	39.66 ± 16.23	p <0.001
Distance (m)	614 ± 415.157	991 ± 534.51	p <0.001
Maximum speed (km/h)	4.03 ± 0.97	4.96 ± 1.15	p <0.001
Borg score	4.25 ± 2.28	3.91 ± 1.52	0.3

mn ± sd: (mean ± standard deviation)

Table 7 Postoperative complications seen in the study and control groups*

	Study group n = 30		Control group n = 30		Total n = 60	
	n	%	n	%	n	%
Atelectasis	-	-	1	3.3	1	1.7
Fever	1	3.3	2	6.7	3	5
Dyspnea	-	-	1	3.3	1	1.7
Hemorrhagic drainage	-	-	1	3.3	1	1.7
Pneumonia	-	-	-	-	-	-
Pulmonary embolism	-	-	-	-	-	-
Total	1	3.3	5	16.6	6	10.0

* The difference was statistically significant. p = 0.04

Discussion

Minimal data exist regarding IPT before lung resection. This fact may be due in part to the relatively brief time between cancer diagnosis and surgery, which does not allow for significant patient participation in physical therapy programs. In one of the few existing studies to date, Weiner et al.[10] randomized 32 patients with COPD undergoing resection for primary lung neoplasm to receive either incentive spirometry and inspiratory muscle training for 2 weeks before lung resection or no training at all. The investigators found that inspiratory muscle strength, as measured by the maximum inspiratory pressure at residual volume, increased significantly in the training group, but remained unchanged in the group that received no training.[12] The relevance of these data on clinical outcomes has not yet been established; however, the data suggest a potential beneficial impact of inspiratory muscle training on patient lung mechanics.[7]

In our study, blood gas analysis, and ventilation/perfusion distributions of lungs of patients who were deemed to be operable for non-small cell lung cancer in control and study groups were analyzed. Complications emerged during postoperative term and periods of postoperative hospitalization were documented. Our IPT included intensive chest physiotherapy and lower extremity exercise training done by walking during a week-time. So our study was different from the studies above. In addition, both groups had postoperative routine physical therapy and the effects of preoperative IPT on measured postoperative parameters were studied.

Many of the common complications after thoracic surgery (atelectasis, pneumonia, and pulmonary embolism) are pulmonary in nature. Although pulmonary embolism cannot be prevented through improvement in pulmonary hygiene, atelectasis and pneumonia can be prevented through active patient involvement. Coughing, deep breathing, using an incentive spirometer, walking, sitting to eat, and performing other seemingly minor activities all can contribute to improved pulmonary hygiene and a decreased incidence of postoperative pneumonia.[13] In the study of Varela et al.,[14] 119 patients were operated on after intense physical therapy, and 520 patients were operated on without physical therapy training. In the group having physical therapy, atelectasis development and periods of hospitalization were found fewer comparing those developed in the control group.

It is proved that it is beneficial for both the patient and physical therapist to have a chance to study with the patient before the operation. Gürses et al.[15] showed that when preoperative and postoperative chest physical therapy was applied to patients having a heart operation, the postoperative pulmonary complication incidence was 8%, atelectasis was seen in 3% of patients. In our study, although there was no statistically significant difference, pulmonary complication rate decreased from 16.7% in control to 6.7% in the study group despite the fact that both groups received routine physical therapy after operation.

Hulzebos et al.[16] found that preoperative inspiratory muscle training (IMT) reduced the incidence of postoperative pulmonary complications (PPC) and duration of postoperative hospitalization in patients at high risk of developing a pulmonary complication undergoing coronary arterial bypass grafting (CABG) surgery ($p = 0.02$). In IMT group, PPC incidence was 18%, while in the control group PPC incidence was %35. Median hospitalization duration was 7 day (5–41 day) in IMT group, 8 day (6–70 day) in the control group. IMT seemed to decrease hospital stay ($p = 0.02$). In our study, IMT decreased hospital stay from 9.7 to 5.4 days. These findings suggest that, physical therapy may also lead to reduction in the utilization of other health care resources, improve the overall quality of life, and increase the participation of physical and social activity. Zeiher[17] has shown a trend toward a decrease in the use of health care resources and hospital stay.

In the study of Westerdahl et al.[18] it was pointed out that patients performing deep-breathing exercises after CABG surgery had significantly smaller atelectatic areas and better pulmonary function on the fourth postoperative day compared to the control group performing no exercises.

In our study, we intensively applied diaphragmatic, pursed lip, segmental breathing exercise, incentive spirometry, coughing exercise as chest physiotherapy for a week. Our study suggested that all patients before resection must be educated and trained on IPT. In concordance with our study, Mahler[6] concluded that two or more preoperative education settings decreased the number of postoperative complications, hospitalization duration and physical therapy time.

Basrin and et al.,[4] studied the differences between the preoperative and postoperative spirometric values in patients undergoing lobectomy for lung cancer. They found that all spirometric values decreased in the postoperative period and also did not return to a normal level in the postoperative, 6 to 8th week.

The decrease of postoperative pulmonary function in the operated patients is known after anesthesia and surgery. Gurses et al.[5] showed that pulmonary function parameters after the CABG operation decreased 22%–35%. In our study, the amount of decrease was 6 to19%.

In the study of Sekine et al.[19] on COPD patients with lung cancer and undergoing resectional surgery, they found that although in the rehabilitation group FEV_1 and FEV_1/FVC values were low, it was found that postoperative pulmonary complication development and long hospitalization were prevented, and FEV_1 in the rehabilitation group was kept normal. Although, in our study, there was no statistical difference in preoperative pulmonary function parameters, they were slightly low in the study group. Preoperative IPT was found to significantly increase FVC ($p = 0{,}003$), FEV_1 ($p = 0{,}01$) parameters in the study group.

We also found that, IPT increased the perfusion of the contra lateral lung. In the subgroup with 11 people who were able to perform ventilation / perfusion measurement. It was found that there was a decrease in cancer lung tissue ventilation after IPT and there was an increase in healthy lung tissue ventilation. As a result, it was found that IPT led to better oxygenation, reduced time of postoperative hospitalization, changed the distribution of ventilation/perfusion. However, it did not prevent postoperative complication. The *modus operandi* of this effect remains unknown. It can be thought that,hypoxic constriction of pulmonary arterial branches, of tumor involved pulmonary parenchyma, could lead to less V/Q shunting. Accordingly, we observed better gas-exchange after IPT. This may also cause better tissue oxygenation. Also, it can be speculated that, IPT could be increase muscle strength and may have caused bronchodilation to some extent. However, studies to disclose the mechanism of action are warranted. In the literature, we were not able to find any study about ventilation/perfusion changes in patients having IPT.

In the study of Oktem et al.,[20] patients with open-heart surgery were divided into two groups, breathing exercises and percussion application, which were two different chest physical therapy applications, applied to the groups separately. Pulmonary functions and blood gases were analyzed. They found that both of the two applications had positive effects over pulmonary functions and blood gases. But the decrease of $PaCO_2$ were observed in only the breathing group in the acute treatment period and the significant increase of PaO_2 was more apparent in the breathing group in the last measurements (30 minutes later). Breathing exercises could decrease secretion retention, thus it may decrease air-way resistance which could be measured as bronchodilation. This mechanism could have been in effect in our study.

In the study of Eksi et al.[21] effects of breathing exercise and transcutaneous electric nerve stimulation (TENS) on ventilation functions and arterial blood gases following open heart surgery were investigated. As a result, VC %, FVC %, FEV_1 % values showed a significant increase in Group I and II and, while pH was unchanged, PaO_2 increased in all groups after the treatment (Group I; chest physiotherapy in patients without pain, Group II; chest physiotherapy plus TENS in patients with pain and lastly, Group III; chest physiotherapy plus placebo TENS in patients with pain). $PaCO_2$ was decreased in Group I and II, whereas it was increased in Group III.

In our study, patients' arterial blood gas values in both groups were measured and compared in preoperative and postoperative period (**Table 2**). While, partial arterial oxygen pressure increased and carbon dioxide levels decreased significantly, the difference in peripheral oxygen saturation was not statistically significant. IPT affected in a positive way over oxygenation of patients. After a walking exercise that was done in treadmill during one week, the significant increase of walking duration, distance and speed were seen. Pulmonary rehabilitation caused working heart rate to decrease from 68% to 65% during walking. These findings suggested that training had a positive effect on exercise capacity. The improvement of exercise capacity, which was found in our study, was in concordance with the study of Spruit et al.[22] In their study of patients with lung cancer, in the group joined in multidiscipline inpatient exercise program with 8 weeks, statistically meaningful development was observed in pulmonary functions, functional exercise capacity and peak exercise capacity. We primarily aimed to decrease the length of stay of patients by preoperative pulmonary rehabilitation, however, an improvement in pulmonary function tests was notified in the study group.

Pulmonary rehabilitation is potentially beneficial before and after any surgery it has been applied and studied primarily in the setting of major thoracic surgical procedures, including lung volume reduction surgery, lung transplantation, and lung resection.[7] Globally, little has been known regarding the value of pulmonary rehabilitation before lung resection in patients with lung cancer. This fact may be due in part to the relatively brief time between cancer diagnosis and surgery, which does not allow for significant patient participation in rehabilitation. In the study, we aimed to investigate the effect of short-period intensive IPT which was performed before surgery in stage IA-IIA lung cancer patients. We assessed lung functions, gas exchange capacities and diffusion and ventilation-perfusion distributions, postoperative complication and hospital stay besides exercise capacity.

There are some limitations of the study, which must be addressed: We were unable to compare the 'quality of life' of patients. Also, the number of patients who underwent ventilation/perfusion scintigraphy was small. However, a statistically significant difference in terms of perfusion of lungs in the contra lateral sides between groups was found. Due to ethical considerations, patients in both groups received routine chest physiotherapy after surgery until discharge. Despite this fact, patients in the study group had slightly fewer complications and shorter hospital stay. The number of patients is also limited due to limited financial support for our study. Some respiratory parameters seemed to be worse in the control group due to the randomization. We could not have involved the selection process.

As conclusion, short-term IPT before resectional surgery can be recommended since improved gas-exchange, reduced hospital stay, increased contra lateral perfusion were observed in patients with lung cancer. Further studies in order to elucidate the mechanism of action and confirm the observed effect are warranted.

Disclosure Statement

There has been no potential conflict of interest regarding this manuscript.

References

1) Levitan N. Rehabilitation of lung cancer patients. In: Cherniack NS, ed. Rehabilitation of the Patient with Respiratory Disease. New York: McGraw-Hill; 1999; pp. 605-14.
2) Shields TW. Lung Cancer: Epidemiology and Carcinogenesis. General Thoracic Surgery, Baltimore, Phiedelphia, London; Lippincot William and Wilkins, 7. ed: TW Shields.
3) Ferguson MK. Preoperative assessment of pulmonary risk. Chest 1999; **115**: 58-63.
4) Bastin R, Moraine JJ, Bardocsky, et al. Incentive spirometry performance: A reliable indicator of pulmonary function in the early postoperative period after lobectomy? Chest 1997; **111**: 559-63.
5) Gurses HN, Yurdalan U, Polat G. Pre and postoperative ventilation function tests in coronary artery bypass surgery. Solunum 1992; **12**: 247-57. (in Turkish)
6) Mahler DA. Pulmonary rehabilitation. Chest 1998; **113**: 263S-8S.
7) Takaoka ST. The Value of preoperative pulmonary rehabilitation. Thorac Surg Clin 2005; **15**: 203–11.
8) Gurses HN. Peroperative rehabilitation as respiratory pump support for patients with cronic respiratory insufficiency. Solunum 2002; **4** (Suppl. 2): 332-8.
9) American Thoracic Society. Pulmonary rehabilitation. Am J Respir Crit Care Med 1999; **159**: 1666-82.
10) Karvonen MJ, Kentala A, Mustala O. The effects of training on heart rate: a longitudinal study. Ann Med Exp Biol Fenn 1957; **35**: 307-15.
11) Bernard GR, Artigas A, Brigham KL, et al. The American-European consensus conference on ARDS. Definitions, mechanisms, relevant outcomes, and clinical trial coordination. Am J Crit Care Med 1994; **149**: 818-24.
12) Weiner P, Man A, Weiner M, et al. The effect of incentive spirometry and inspiratory muscle training on pulmonary function after lung resection. J Thorac Cardiovasc Surg 1997; **113**: 552-7.
13) Ponn RB. Complications of pulmonary resection. In: Shields TW, LoCicero J, Ponn RB, Rusch VW, eds. General Thoracic Surgery. 6th Edn. Lippincott Williams & Wilkins, Philadelphia/Philadelphia 2005; pp. 554-87.
14) Varela G, Ballesteros E, Jimenez MF, et al. Cost-effectiveness analysis of prophylactic respiratory physiotherapy in pulmonary lobectomy. Eur J Cardiothorac Surg 2006; **29**: 216-20.
15) Gurses HN, Yurdalan U, Harutoglu H. The role of respiratory physiotherapy in prevention of early postoperative pulmonary complications after open heart surgery. Solunum 1988; **11**: 117-24.
16) Hulzebos EHJ. Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing cabg surgery. JAMA 2006; **296**: 1851-7.
17) Zeiher BG. Predicting postoperative pulmonary function in patients undergoing lung resection. Chest 1995; **108**: 68-72.
18) Westerdahl E. Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary artery bypass surgery. Chest 2005; **128**: 3482-8.
19) Sekine Y. Perioperative rehabilitation and physiotherapy for lung cancer patients with chronic obstructive pulmonary disease. Jap J Thorac Cardiovasc Surg 2005; **53**: 237-43.
20) Oktem S, Gurses HN, Bayındır O. A comparison of two different chest physiotherapy techniques in the early postoperative stage after open heart surgery. Turk J Physiother Rehabil 1994; **7**: 44-53.
21) Eksi F, Seber M, Gurses N, et al. Effects of breathing exercises on ventilation functions and arterial blood gases following open heart surgery. J Phys Med Rehabil 1990; **14**: 43-6 .
22) Spruit MA. Exercise capacity before and after an 8 week multidisciplinary inpatient programme in lung cancer. Lung Cancer 2006; **52**: 257-60.