

Comparison of different respiratory exercise methods in patients with chest tubes for spontaneous pneumothorax

Spontan pnömotoraks nedeni ile göğüs tüpü takılan hastalarda farklı solunum egzersizi yöntemlerinin karşılaştırılması

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ABSTRACT

Background: This study aims to investigate the effects of different respiratory expansion methods such as forced coughing, incentive spirometry, balloon inflating, and walking on respiratory function tests including pulse rate, time to complete lung re-expansion, and time to remove the chest tube in patients who had chest tubes for primary spontaneous pneumothorax.

Methods: This prospective study included 40 consecutive primary spontaneous pneumothorax patients (34 males, 6 females; mean age 26.6 years; range 16 to 60 years). All patients had tube thoracostomy between the midaxillary line and the sixth or seventh intercostal space. Patients were randomly divided into four groups with 10 patients in each as the triflow group, the balloon group, the treadmill group, and the control group. Different respiratory exercise methods were applied to obtain lung re-expansion.

Results: The groups were statistically similar in respect to age, gender, weight, height, body mass index, and side of pneumothorax. The groups' average time to complete re-expansion and duration of air leak were similar.

Conclusion: Our study demonstrated no significant difference between administration of forced coughing alone and other respiratory exercises plus forced coughing in terms of respiratory function tests in patients with chest tubes for pneumothorax.

Keywords: Balloon; breathing exercises; spontaneous pneumothorax; triflowmeter; tube thoracostomy.

ÖZ

Amaç: Bu çalışmada primer spontan pnömotoraks nedeni ile göğüs tüpü takılan hastalarda; zoraki öksürme, solunum egzersizi, balon şişirme ve yürüme gibi farklı akciğer genişletme yöntemlerinin nabız sayısı, pulmoner genişlemeyi tamamlama ve göğüs tüpünün çekilmesi zamanı gibi solunum fonksiyon testleri üzerindeki etkileri araştırıldı.

Çalışma planı: Bu prospektif çalışmaya 40 ardışık primer spontan pnömotoraks hastası (34 erkek, 6 kadın; ort. yaş 26.6 yıl; dağılım 16-60 yıl) dahil edildi. Bütün hastalara midaksiller çizgi ve altıncı veya yedinci kaburgalar arasında tüp torakostomi uygulandı. Hastalar solunum egzersizi grubu, balon grubu, yürüme bandı grubu ve kontrol grubu olmak üzere onar kişilik dört gruba ayrıldı. Pulmoner genişlemeyi sağlamak için farklı solunum egzersizi yöntemleri uygulandı.

Bulgular: Gruplar yaş, cinsiyet, kilo, boy, vücut kütle indeksi ve pnömotoraksın tarafı açısından istatistiksel olarak benzer idi. Grupların ortalama pulmoner genişlemeyi tamamlama zamanı ve hava kaçağı süresi benzer idi.

Sonuç: Çalışmamız primer spontan pnömotoraks nedeni ile göğüs tüpü takılan hastalarda sadece zoraki öksürme ve diğer solunum egzersizleri artı zoraki öksürme uygulanması arasında solunum fonksiyon testleri açısından anlamlı farklılık olmadığını göstermektedir.

Anahtar sözcükler: Balon; solunum egzersizleri; spontan pnömotoraks; triflowmetre; tüp torakostomi.



Pneumothorax is defined as the collapse of lung due to air in the pleural space. Pneumothorax without secondary causes such as emphysema, chronic obstructive disease, trauma or surgical intervention is classified as primary spontaneous pneumothorax (PSP). Treatment options for pneumothorax include medical follow-up, fine-needle aspiration, percutaneous catheter drainage, tube thoracostomy, video-assisted thoracoscopic surgery (VATS), and thoracotomy.^[1,2] According to radiological assessment, pneumothoraces which occupy 20% of the lung may require a tube thoracostomy. During follow-up, re-expansion of the lung is achieved by the removal of the air from the pleural space through the drainage system via a number of methods, including forced coughing, incentive spirometry, inflating a balloon, straining exercises, walking, pursed lip breathing, and climbing up the stairs.^[1,2] In this study, we aimed to investigate the effects of different respiratory expansion methods such as forced coughing, incentive spirometry, balloon inflating, and walking on respiratory function tests including pulse rate, time to complete lung re-expansion, and chest tube duration in patients with chest tubes applied for pneumothorax.

PATIENTS AND METHODS

The prospective study, which was conducted between May 2013 and May 2015 at Department of Thoracic Surgery, Medical Faculty of Bozok University, included 40 consecutive patients (34 males, 6 females; mean age 26.6 years; range 16 to 60 years) who had a chest tube due to PSP which was larger than 20%. All patients chest tube inserted between the midaxillary line and the sixth or seventh intercostal space under local anesthesia using 5-10 mL lidocaine hydrochloride solution (2 mL/20 mg). All patients were administered equal doses of intravenous paracetamol

relative to body weight to keep pain under control. Different respiratory training methods were applied to obtain lung re-expansion and adherence of parietal and visceral pleural layers. Following detailed radiological evaluation, patients who were diagnosed with secondary pneumothorax or significant lesions on computed tomography were excluded.^[1,2] The eligible patients were randomly assigned to one of the below four groups: forced coughing and using incentive spirometry (n=10, triflow group); forced coughing plus inflating-balloon exercise using standard balloons (n=10, balloon group); forced coughing plus exercise on a treadmill exercise of a determined distance and duration (n=10, treadmill group); and forced coughing (n=10, control group). All pulmonary exercise methods were applied in accordance with patients' maximum ability. Age, gender, weight, height, body mass index (BMI), and the lung affected with pneumothorax were recorded (Table 1). After insertion of the chest tube, each patient was followed-up to determine when complete pulmonary expansion occurred by chest X-ray. Parameters included duration of air leak, forced expiratory volume in 1 second (FEV₁) values on day 1 after application of the chest tube and day of discharge, oxygen saturation, and pulse rate values. Video-assisted thoracoscopic surgery was performed in some patients due to prolonged air leak. The patients with prolonged air leak, defined as failure to stop air leak at the end of a 10-day respiratory training, underwent surgical treatment. Thus data collection of the subjects was limited to the initial 10 days after insertion of the chest tube. The study protocol was approved by the Bozok University, Institutional Review Board. A written informed consent was obtained from each patient. The study was performed in accordance with the principles of the Declaration of Helsinki as revised in 2000.

Table 1. Clinical data of study participants

	Balloon group		Triflow group		Treadmill group		Control group		p
	n	Mean±SD	n	Mean±SD	n	Mean±SD	n	Mean±SD	
Age (years)		23±4		28±10		30±8		23±3	0.079
Gender									0.853
Female	2		1		2		1		
Male	8		9		8		9		
Height (cm)		176±5		179±9		176±7		180±8	0.572
Weight (kg)		62±6		62±9		61±7		63±7	0.941
Body mass index (kg/m ²)		20.1±1.9		19.4±1.4		19.6±1.6		19.6±0.7	0.653
Side of lung involvement									0.710
Right	8		7		8		6		
Left	2		3		2		4		

SD: Standard deviation.

Statistical analysis

Statistical analyses were performed using the PASW for Windows version 18.0 software (SPSS Inc., Chicago, IL, USA). Continuous variables are expressed as means \pm standard deviation, while categorical variables are presented as frequencies (%). Spearman tests were used for correlation analyses and the Kruskal-Wallis test was used to identify significant differences between the groups. The Wilcoxon signed rank test was used to compare changes in FEV₁, oxygen saturation, and the pulse rate between day one after application of the chest tube and the day of discharge. Categorical variables of the groups were compared using the chi-square test. A *p* value of less than 0.05 was considered to show a statistically significant result.

RESULTS

The four groups were statistically similar with respect to age, gender, weight, height, BMI, and side of pneumothorax. Forced expiratory volume in 1 second and oxygen saturation values on day 1 after chest tube insertion and on the day of discharge were statistically nonsignificant across the groups. The groups had similar average time to complete pulmonary expansion and duration of air leak. The difference in the FEV₁ values on day 1 after insertion of chest tube and on the day of discharge was defined as Δ FEV₁. The groups had similar Δ FEV₁ values. In separate analyses of the groups, each group showed a significant change in FEV₁ from day 1 after chest tube application compared to the day of discharge (*p*<0.01 for all groups). Video-assisted thoracoscopic surgery was the method of

choice for all patients undergoing for surgery. Using VATS, the patients underwent apical wedge resection and pleurectomy. The frequency of application of VATS was similar across the groups. The average day 1 oxygen saturation values of each group did not differ from the day of discharge (*p* values for balloon, triflow, treadmill, and control groups were 0.103, 0.085, 0.063, and 0.076, respectively). There was a positive correlation between the time to complete the lung re-expansion and the duration of air leak (*r*=0.800, *p*<0.001). We did not find any correlation between the duration of air leak and day 1 FEV₁ (*r*= -0.022, *p*=0.892) or first day oxygen saturation (*r*= -0.128, *p*=0.432) (Table 2).

DISCUSSION

We demonstrated that pulmonary rehabilitation methods such as forced coughing, incentive spirometry, balloon inflating, and walking had similar effects on respiratory function tests as well as pulse rate, time to complete lung re-expansion, and chest tube period.

Primary spontaneous pneumothorax is defined as pneumothorax occurs without any detectable underlying causes while secondary pneumothorax patients have underlying cause, with the most significant causes being chronic obstructive pulmonary disease.^[2] Computed tomography of thorax is the most useful and demonstrative tool for differentiating primary and secondary PSP cases. Primary spontaneous pneumothorax generally affects individuals between the ages of 20 and 40 and is observed six times more frequently among males than females. Asymptomatic patients suffering from a small PSP may be followed-up medically without the need of any intervention.

Table 2. Clinical outcomes of study participants following chest tube insertion

	Balloon group		Triflow group		Treadmill group		Control group		<i>p</i>
	n	Mean \pm SD	n	Mean \pm SD	n	Mean \pm SD	n	Mean \pm SD	
Time to complete re-expansion of the lung (day)		2.3 \pm 2.8		2.1 \pm 1.4		2.1 \pm 1.5		2.2 \pm 1.3	0.866
Duration of air leak (day)		3.5 \pm 2.3		4.3 \pm 2.4		4.1 \pm 2.4		4.6 \pm 2.5	0.333
Video-assisted thoracoscopic surgery	1		2		1		2		0.853
First day FEV ₁ (mL)		3498 \pm 706		3466 \pm 538		3333 \pm 881		3749 \pm 541	0.526
First day FEV ₁ (%)		77 \pm 11		74 \pm 11		70 \pm 20		80 \pm 6	0.147
Discharge-day FEV ₁ (mL)		4260 \pm 611		4158 \pm 612		4102 \pm 619		4299 \pm 615	0.563
Discharge-day FEV ₁ (%)		92 \pm 7		89 \pm 9		88 \pm 6		90 \pm 7	0.227
Δ FEV ₁ (mL)		762 \pm 387		692 \pm 271		768 \pm 521		550 \pm 242	0.288
First day oxygen saturation (%)		95 \pm 1		94 \pm 1		94 \pm 1		95 \pm 1	0.235
Discharge-day oxygen saturation (%)		96 \pm 2		95 \pm 2		95 \pm 2		96 \pm 1	0.171
First day pulse rate (bpm)		75 \pm 2		77 \pm 4		77 \pm 5		77 \pm 4	0.247
Discharge-day pulse rate (bpm)		74 \pm 3		75 \pm 5		75 \pm 4		75 \pm 4	0.263

SD: Standard deviation; FEV₁: Forced expiratory volume in 1 second; Δ FEV₁: Difference in FEV₁ values on day 1 after application of chest tube and on day of discharge; Bpm: Beats per minute.

Chest tube insertion is indicated for treatment if (i) the patient is symptomatic or the symptoms are increasing under medical follow-up of PSP, (ii) there is tension pneumothorax or a contralateral lung disease, or (iii) lung re-expansion is difficult during the follow-up.^[1-3]

Following chest tube insertion, lung re-expansion is rapidly achieved in most of the patients and air leak ceases usually within 48 hours. Inserted chest tubes are radiologically followed with chest X-ray to understanding of the resolution of pneumothorax. Patients with prolonged air leak of more than 10 days, recurrent pneumothorax, bilateral pneumothorax, or a first pneumothorax following pneumonectomy are directly indicated for surgical treatment. Patients with persistent air leak or failure of re-expansion of the lung must be rapidly referred for surgical intervention.^[2-4] Of the 40 patients in this study, only six were referred for surgery due to air leak that continued for more than 10 days. Bullae/bleb resection, together with apical pleural abrasion or apical/total pleurectomy, are the standard surgical treatment methods for patients with PSP. Currently, uniportal or multiportal VATS is frequently performed for suitable patients. Usually it is performed via axillary thoracotomy and/or lateral thoracotomy.^[5] We performed apical wedge resection and pleurectomy for all six patients via uniportal VATS using one posterior access incision. The frequency of VATS was statistically similar in groups.

All patients were advised to perform respiratory exercises such as forced coughing, incentive spirometry, balloon inflating, walking, and climbing up stairs to increase pulmonary capacity, prevent atelectasis, strengthen their respiratory muscles (which are weakened following anesthesia during the surgery), and finally reduce the incidence of complications.^[3,5] The basic defensive mechanism of the respiratory system is coughing. This is one of the most effective methods to remove secretions and foreign bodies from the respiratory tract. Deep breathing using incentive spirometry allows a high amount of air intake into the lungs. The pulmonary capacity improves, and as a result, the oxygen intake increases. If incentive spirometry can not be performed, coughing, breathing and walking exercises are other effective respiratory exercise methods used frequently to reduce postoperative complications.^[6-8] One or more of the methods have been used routinely in different clinical managements; however, to our knowledge, no studies are present in the literature that have compared the effectiveness of these respiratory exercise methods among patients who were administered chest tubes or thoracic surgery. Studies investigating whether spirometric exercises

are useful in low- and high-risk patients indicate that these methods are not beneficial in low-risk patients such as individuals who had colostomy.^[9] Crowe and Bradley^[10] compared the effectiveness of spirometric and respiratory physiotherapies in 185 patients that had undergone high-risk coronary bypass surgery. They did not find any difference between the groups in respect to atelectasis, oxygen saturation, pulmonary infection, and duration of hospitalization. They reported that spirometric exercises plus respiratory physiotherapy were not superior over respiratory physiotherapy alone. Celli et al.^[11] compared the efficiencies of deep breathing, spirometry, and intermittent positive pressure breathing exercises for reducing pulmonary complications. However, they did not find any differences between the methods except shorter duration of hospitalization in the spirometry group. Similarly, Gosselink et al.^[7] included 44 patients with pulmonary surgery and 30 patients with esophageal surgery and compared the effectiveness of respiratory physiotherapy and spirometry exercises. Pulmonary function, body temperature, chest X-ray, complete blood counts, and duration of hospitalization including within the intensive care unit of all patients were recorded. The groups did not differ significantly in respect to these parameters and they had similar incidences of atelectasis when assessed radiologically. The addition of spirometric exercises on top of regular respiratory physiotherapy did not shorten the duration of index hospitalization or the stay in intensive care. The groups did not show any differences related to BMI. However, having a BMI of $>27 \text{ kg/m}^2$ was an independent risk factor for pulmonary complications in patients that had undergone abdominal surgery. In the present study, BMI was not significantly related with index hospitalization ($p=0.385$). Issa et al.^[12] reported a 60% complication rate among a group that had undergone respiratory physiotherapy, while there was a 13% complication rate among groups that had undergone endotracheal aspiration via minithoracotomy.

In the present study, time to complete pulmonary expansion and duration of air leak were similar between the groups. Average ΔFEV_1 values were also similar in the groups. All of these findings indicate no significant difference of the different pulmonary exercise groups in respect to clinical outcomes. When analyzing each group separately, we detected that FEV_1 assessed on day 1 of all patients had increased significantly by the day of discharge. This may be due to the contribution of the re-expanded lung. However, the day 1 oxygen saturation of the patients did not differ significantly from the postoperative values (p values for balloon, triflow, treadmill, and control groups were 0.103,

0.085, 0.063, and 0.076, respectively). These findings imply that the collapsed lung tissue did not impair oxygen saturation.

There was a positive correlation between the time to complete lung re-expansion and the duration of air leak, indicating that the air leak stopped earlier, leading to complete lung re-expansion. The duration of air leak did not have any significant correlation either with the FEV₁ or oxygen saturation on day 1 after the application of the chest tube. This suggests that prolonged air leak did not impair the gas-exchange. Thus, we confirmed that air leak of seven to 10 days in duration might not deteriorate a patient's clinical status until the decision for surgery. This finding was consistent with the literature.

In conclusion, similar to the literature, this study confirmed that there was no difference in terms of pulmonary function tests between forced coughing alone and respiratory exercise methods added to forced coughing in patients who had chest tube for PSP. Also, we showed that forced coughing alone was enough to provide sufficient respiratory exercise. Furthermore, in respect to clinical outcomes, deep breathing exercises such as inflating a balloon or walking were as effective as incentive spirometry.

Declaration of conflicting interests

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