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Effect of Chest Tube Suction on Air-Leak Following Lung Resection

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ABSTRACT

Background: *Air-leak is of the common complications of pulmonary resection, yet there is no consensus on its management. Some authors are in the belief that if, after surgery the lung can remain open, absence of suction will quickly stop the air-leak from the chest tube, whereas others believe that using the suction is essential. This study aims to evaluate the role of chest tube suction after surgery.*

Materials and Methods: *This is a randomized clinical trial performed on 31 patients who underwent different lung surgeries. After surgery, chest tubes of all patients was connected to the suction till the next morning. Afterwards suction was discontinued for 3 hours and chest radiography was obtained. In presence of pneumothorax in chest-x-ray or in cases of air-leakage from the chest tube, use or no use of chest tube suction was determined randomly.*

Results: *In 13 out of 31 patients, chest tube suction was used. In these patients, adding the suction had no effect on shortening the duration of air-leak or hospital stay. We also tried to evaluate the probable effective causes of air-leak in these patients. In this regard we did not find any relation between the age, FEV1 and PaO_2 before the operation with air- leakage after the surgery. But there was a significant correlation between the rate of air-leakage and $PaCO_2$ before the surgery. Risk of air-leakage on the 7^{th} day after surgery was greater in those patients in whom the degree of air-leakage was higher on the first day. Use of chest tube suction had no effect on controlling the air-leakage.*

Conclusion: *In this study, use of chest tube suction had no effect on shortening the air- leak period after surgery. In our patients, $PaCO_2$ was an important factor in predicting the risk of air-leak from the chest tube.* ***(Tanaffos 2006; 5(1): 37-43)***

Key words: *Chest tube, Air-leakage, Chest tube suction*

INTRODUCTION

Air-leak is the most common complication of pulmonary resection (1).

Persistent or prolonged air-leak is defined as the persistence of air-leak longer than the usual predicted time for hospital stay following surgery (2).

This time has been reported to be 4 to 14 days after surgery in different studies as the air-leak that persisted after postoperative day 7 are reported as prolonged air-leaks (2).

According to the increased financial burden on patients suffering from prolonged air-leaks, various strategies are considered for the management of this

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problem. Also, how to safely discharge patients even with air-leaks is an acceptable therapeutic goal.

Persistent air-leak despite increasing hospital stay may cause additional complications such as wound infection, infection of the pleural space and lung parenchyma (3).

Despite the technological progresses in the field of lung surgery, prolonged air-leak after pulmonary resection is still a common complication and a routine problem, and its management has not been changed during the last ten years (2). Prevention of prolonged air-leak starts from the moment of surgery in the operating room including a meticulous surgical technique and trying to leave the remaining lung parenchyma completely expansion.

Reducing the pleural space can be helpful as well (for example creating a pleural tent).

Lung expansion after surgery and bringing the two pleural surfaces close together are the main steps in preventing air-leak. Physiologic mechanisms following pulmonary resection will help controlling the air-leak. Those include rising the diaphragm, mediastinal shift and increasing the residual lung volume. According to what was mentioned above, we must admit that there is no consensus on treatment and management of air-leak after pulmonary resection (4). This study aims to evaluate the role of chest tube suction after surgery.

MATERIALS AND METHODS

This is a randomized clinical trial and we collected the data by examining the patients, evaluating the test results and filling out the forms.

All patients who underwent lung parenchymal surgery for different reasons in Masih Daneshvari hospital in Tehran (Shaheed Beheshti University of Medical Sciences and Health Services) were considered as the understudy population. This study was started in March 2003 and lasted till June 2004.

Patients who underwent pneumonectomy or bronchoplasty for resecting a part of airway were not included in this study. According to the references (2, 4, 5) an algorithm was considered for the patients treatment which is demonstrated in figure 1.

According to this algorithm, from the first hour after surgery till the next morning (morning of the first day after surgery) the chest tube of all patients was placed to -10 to -18 cm H_2O of suction. At the first day morning, and 3-4 hours after removing the suction a chest x-ray was obtained from the patients.

Patients were divided into two groups of with or without pneumothorax according to the chest x-ray findings.

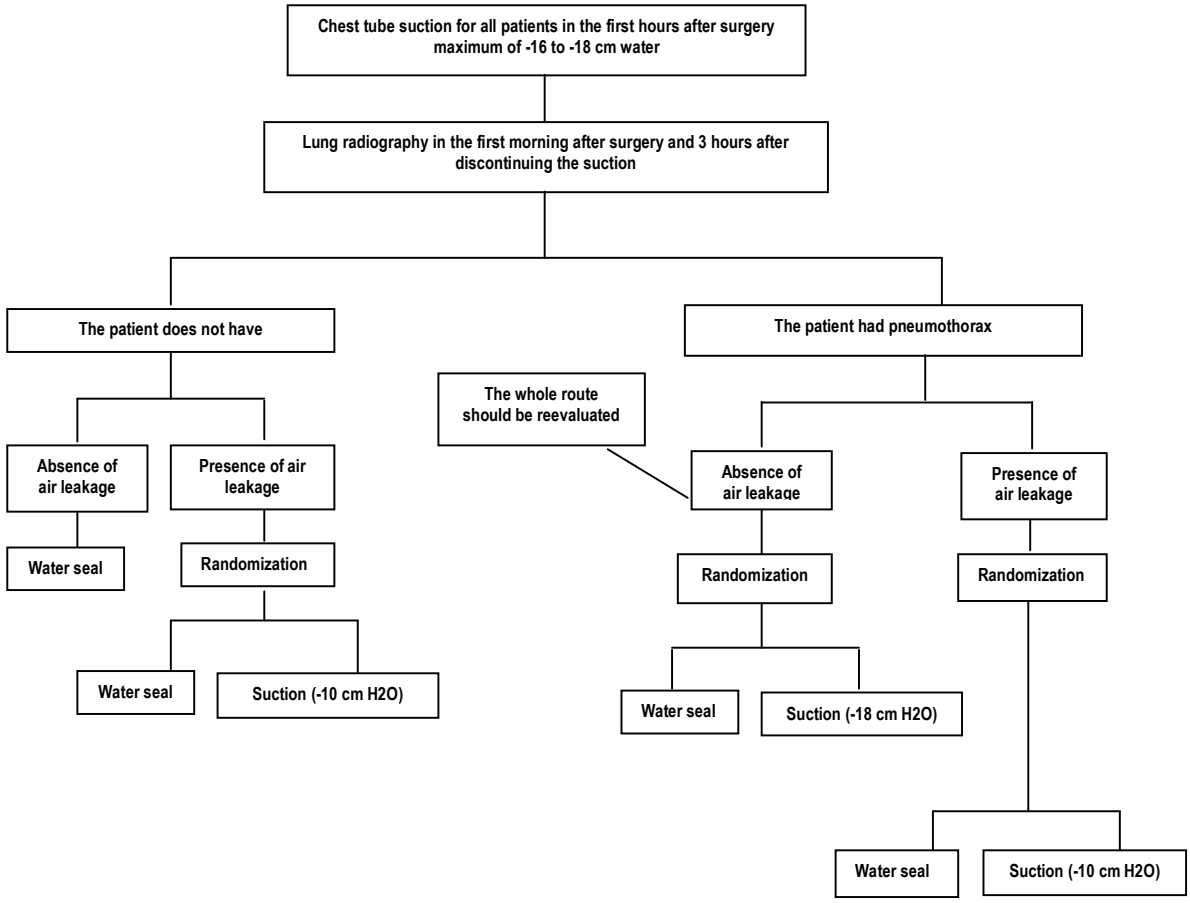
Consequently, patients were divided into 4 groups as below:

a) Patients who did not have pneumothorax according to chest x ray and there was no air-leaks from the chest tube. These patients were managed only by water seal.
b) Patients who did not have pneumothorax according to chest x- ray but chest tube air-leak was present. This group was randomly divided into two groups. Group 1 was managed by water seal and group 2 was managed by -10 cm H_2O of suction.
c) These patients had pneumothorax according to chest x-ray but air-leak from the chest tube was not present. In these patients a precise evaluation of chest tube condition was performed to resolve the probable difficulties. Afterwards patients were randomly divided into two groups, one managed by water seal and the other managed by a -16 to -18 cm H_2O of suction.
d) These patients had pneumothorax in chest x-ray evaluations and air- leak from the chest tube was present as well. These patients were divided randomly into two groups out of which one were managed by water seal and the other were managed by a -10 cm H_2O of suction.

Air-leak from the chest tube of patients was evaluated daily and divided into 4 status as follows:

1) Forced expiratory
2) Expiratory
3) Inspiratory
4) Continuous (inspiratory and expiratory)

Figure 1. How to manage air- leakage



Time at which air-leak was terminated despite the function of chest tube, has been recorded as the time of air-leak discontinuation.

If the air- leak persisted after postoperative day 7, it was considered as persistent or prolonged air- leak. These cases need special treatment which is out of the patience of this article.

In evaluating the patients and filling out the forms ABG and spirometry were performed pre and post operatively and FEV1, FVC, PaO_2 and $PaCO_2$ were recorded as the understudy variables.

If the patient had a specific underlying disease, this would be recorded in the related forms.

Early postoperative complications including arrhythmia, pneumonia, wound related complications and pneumothorax after removing the chest tube would be noted in the form if presented (in case of presence).

Out of 31 understudy patients, 12 underwent pulmonary wedge resection, 4 underwent lobectomy, 3 underwent bullectomy, 1 underwent bilobectomy and 11 underwent bronchial opening closure to treat hydatid cyst.

Among surgical incisions, except posterolateral standard thoracotomy, one clamshell incision and one median sternotomy were performed due to bilateral hydatid cyst.

Also, there was one case of chest wall resection accompanied by wedge resection of upper lobe of the right lung as the result of a tumoral lesion with chest

wall invasion. Collected data were analyzed using SPSS (11.5) software and the relation between the variables were evaluated using t-test, McNemar and Mann-Whitney-U test. p-value<0.05 were considered as a statistically significant difference.

RESULTS

31 patients were evaluated in this study and the results were as follows:

Out of 31 patients under study 22 were male (70.97%) and 9 were female (29.03%). Patients were in the age range of 3 to 71 years with the mean age of 36.81±16.41 years. The mean age in women and men were 45.44±16.99 and 33.27±5.15 years respectively.

Mean FEV1 (%predicted) before the operation was 66%±0.2 in all patients; 71%±0.2 in women and 64%±0.2 in men.

Mean PaO_2 before the operation was 71.14±17.04 mmHg in all patients and 82.1±16.61 mmHg in women and 66.65±15.40 mmHg in men.

Mean $PaCO_2$ before the surgery was 34.42±5.24 mmHg in all patients and 32.84±7.96 mmHg in women and 35.06±3.69 mmHg in men.

Out of 31 patients 25(80.65%) had air-leak from the chest tube on the first postoperative day and in 6 patients (19.35%) no air- leak was present.

In 25 patients who had air-leak on the first day after surgery, types of air-leak were as follows:

- Forced expiratory in 17 patients (68%)
- Expiratory in 6 patients (24%)
- Inspiratory in 1 patient (4%)
- Continuous in 1 patient (4%)

On the postoperative day 7, nine patients (29.03%) had air-leak from the chest tube and in 22 patients (70.97%) no air-leak was present.

Types of air-leak in those 9 patients who had air-leak on postoperative day 7 were as follows:

- Forced expiratory in 8 patients (88.89%)
- Expiratory in 1 patient (11.11%)

In 25 patients how had air-leak on the first day after surgery, mean age, FEV1 (% predicted), PaO_2 and $PaCO_2$ were 34.6 yrs, 64.48% and 68.42 mmHg and 35.62 mmHg respectively.

In 6 patients who did not have air-leak on the first day after surgery mean age, FEV1, (% predicted), PaO_2 and $PaCO_2$ were 46 yrs, 70.2%, 82.48 mmHg and 29.43 mmHg respectively.

In 9 patients who had air-leak on postoperative day 7, mean age, FEV1 (% predicted), PaO_2 and $PaCO_2$ were 36.78 yrs, 64.78%, 69.82 mmHg and 36.38 mmHg respectively. In 22 patients who did not have air-leak on postoperative day 7, mean age, FEV1, (% predicted), PaO_2 and $PaCO_2$ were 36.82 yrs, 67.36%, 71.68 mmHg and 33.61 mmHg respectively.

Statistically, there was no significant difference in mean age, FEV1 (% predicted) and PaO_2 between the patients who had air-leak on the first day after surgery with those who did not have (p=0.128 for age, p=0.236 for FEV1 and p= 0.069 for PaO_2)

The interesting point was the presence of significant statistical difference in mean $PaCO_2$ between two groups of patients one with air-leak and the other without air-leak on the first day after surgery (p=0.007).

There was no significant difference in mean age, FEV1(% predicted), PaO_2 and $PaCO_2$ between patients who had air-leak on postoperative day 7 and those who did not have air-leak. (p=0.995 for age, p=0.752 for FEV1, p=0.788 for PaO_2 and p=0.186 for $PaCO_2$). A significant correlation was revealed using McNemar test between the air-leak in the first day with air-leak on postoperative day 7 (p=0.001). In other words, every patient who had a higher degree of air-leak (inspiratory or more) on the first day after surgery had a greater risk of air-leak on postoperative day 7 and vice versa.

Of all understudy patients, 13 (41.94%) patients received suction to their chest tubes while the remaining 18 (%58.06) received water seal (without

suction). Of 18 patients who received water seal to their chest tubes, 12 did not have air-leak on postoperative day 7(66.7%) whereas the remaining 6 had air-leaks (%33.3).

Of 13 patients who received suction to their chest tubes 10 had no air-leak on the postoperative day 7(%76.9) while the remaining 3 had air-leaks (23.1%).

Statistically, there was no significant difference between presence or absence of air-leak after surgery with or without using suction in this research.

In other words, there was no preference in use or no use of suction in decreasing the duration of air-leaks after surgery (p=0.535).

Prolonged air-leak after surgery (continuation of air-leak after postoperative day 7) occurred in 9 patients (29.3%) out of which 6 had classic chest tube and 3 had suction.

Statistical tests did not show a significant correlation between use or no use of suction in the air-leak duration after surgery (p=0.535).

Using the data of this research, a chart was created to predict the risk of air-leak on the first day after surgery (figure 2).

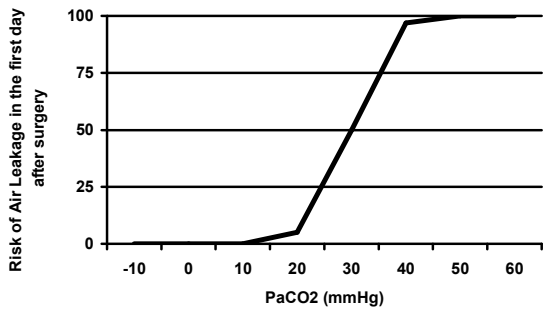


Figure 2. Risk of air-leakage on the first day after surgery considering to $PaCO_2$ rate

DISCUSSION

Various researchers including Dr. Cerfolio the renowned scientist have tried to evaluate whether suction or water-seal is superior in treatment of air-leak management. In a prospective study performed on 101 patients from 1966 to 1977 in the University of Alabama at Birmingham, he demonstrated that most cases of air- leak after pulmonary resection were expiratory only and mostly forced expiratory. He also showed the low ratio of forced expiratory volume in 1 second to forced vital capacity (FEV1/FVC) and increased age (especially more than 70 yrs) as the significant predictive factors in prolonged air-leak after pulmonary resection. He also showed that most patients with air-leak on postoperative day 4 still had air-leak on postoperative day 7 (4).

This research recommended forming an algorithm for the management of air-leak after pulmonary resection. We used this algorithm in our prospective study comparing the water seal versus suction for management of air-leak (4).

In another prospective study by Ayed performed in a chest diseases hospital in Kuwait (1955-1999), a comparison was carried out whether to receive suction or water seal after thoracoscopy for treatment of spontaneous pneumothorax (5).

Results of this research showed that placing chest tubes on a brief period of suction after thoracoscopy for spontaneous pneumothorax shortens the duration of air-leaks and hence the hospital stay (5).

Cerfolio et al. showed that increased age can increase the duration of air-leak in elective pulmonary resections (4). Also, in another study conducted by Rice et al. it was demonstrated that males more than females suffer from persistent air-leak after surgery (2).

Pulmonary function tests are of the major parts of preoperative evaluations in patients requiring pulmonary resection. These tests can be useful in predicting the risk of prolonged air-leak after surgery (1) as the lower than normal rate of preoperative FEV1 and maximum ventilatory volume (MVV) can

be considered as the important risk factors in predicting persistent air-leak.

In another study the ratio of FEV1 to FVC below 50% was considered as an important predictive factor of postoperative prolonged air-leak (2). Long term use of corticosteroids can also result in continuous air-leak after surgery. Cerfolio showed that use of steroids is an independent risk factor in patients with prolonged air-leak (1). Simultaneous presence of infection and air-leaks can impair the wound healing process. In patients with AIDS air-leakage slightly continues probably as the result of higher prevalence of infection along with reduced inflammatory responses in host (4.5% versus 3.2% in a research) (1).

Diabetes mellitus and acute hyperglycemia are of the known factors in impairing wound healing process. In some studies diabetes is considered as an independent risk factor in persistent air-leak after surgery (1, 6, 7). The conducted studies could not show any significant correlation between the preoperative radiotherapy and chemotherapy (Neoadjuvant) and prolonged air-leak (8).

There is a significant correlation between malnutrition and hypoxia with prolonged air-leak after surgery due to impairment of the tissue healing process (9).

Extension and technique of surgery in pulmonary resection can be effective in rate of air-leak after surgery. Using a precise surgical technique can be the most effective factor in this regard and in fact is considered as the best method of prevention (intraoperative prevention). Upper lobectomy is usually associated with increased rate of air-leaks because there is often a residual space into apical part of the thoracic cavity (10).

Pleural tent will be useful in reducing the residual space in apical part of thoracic cavity, as in two prospective randomized study, use of pleural tent has shown a significant decrease in postoperative air-leak as well as a reduction in total hospitalization days (11,12).

There is a greater risk of prolonged air-leak in patients who undergo surgery due to bullous long disease. This risk ranges from 18% to 55% in open surgery (13).

Use of VATS in treatment of bullous lung disease does not increase the air- leaks related complications, and does not prolong the hospitalization period (14). Use of biologic glue during surgery to reduce air-leak has not shown beneficial effects in human compared with practical models in animals (15). Some recent studies have shown that continuous use of chest tube suction causing a high negative pressure (mostly-20 cmH_2O) can increase the rate of air-leak as well as the duration of chest tube placement (1, 16).

Some researches demonstrated that pulmonary function tests can be useful in predicting prolonged air-leakage after surgery (1), as FEV1 rates lower than normal can be considered as an important risk factor in predicting continuous air-leak. But our study showed no connection between FEV1 rate alone and air-leak from the chest tube.

Considering the analysis of arterial blood gases and rate of $PaCO_2$, risk of air-leak from the chest tube can be brought up, as in patients with higher amounts of this gas, the risk of air-leak from the chest tube increases (fig 2). The reason could be the association of hypercapnia with chronic obstructive pulmonary diseases (COPD). In these patients risk of air-leak and its persistence increases due to hyperinflation and inappropriate repair of lung parenchyma.

Also, higher grades of air-leak on the first day after surgery (inspiratory type or more) will be accompanied by a greater risk of persistent air-leak.

In conclusion, this study showed that use of suction had no effect on reducing the duration of air-leak after surgery.

Clearly, increasing the number of understudy patients as well as considering each of the study variables separately can be effective in increasing the accuracy of variables.

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