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EFFECT OF INFERIOR PULMONARY LIGAMENT DISSECTION ON PROLONGED AIR LEAK AND OTHER COMPLICATIONS AFTER UPPER LOBECTOMY: A RETROSPECTIVE COHORT STUDY

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ABSTRACT

Aim: To investigate the effect of inferior pulmonary ligament dissection (PLD) on the development of residual pleural space and other complicationsafter upper lobectomy.

Methods: We retrospectively analyzed the data of patients who underwent upper lobectomy in our clinic between January23, 2011, and February26, 2013. Patients with a history of pulmonary tuberculosis, ipsilateral lung surgery, those that received neoadjuvant radiotherapy, those with a FEV1 value below 50%and those with two drains were excluded. Forty patients were included in the study and divided into two groups according to whether PLD was performed (Group I, n=20) or not performed (Group II, n=20). Complications that developed, negative aspiration requirement, additional thoracic drain requirement, duration of drain in place, hospital stay, and percentage of the pleural space on chest X-ray were recorded. The results were statistically compared between the groups.

Results: Of the patients, 34(85%) were male, and the mean age was 60.5 (38-78) years. Right upper lobectomy was performed in 24(60%) patients (55% Group I, 45% Group II). Postoperative complications were detected in 16(40%) patients (45% Group I, 35% Group II). The most common complication was prolonged air leak seen in eight (20%) patients (15% Group I, 2.25% Group II). The mean duration of drain in place was 8 days (7days Group I, 9 days Group II, p=0.62).

Conclusion: From the results of our study, PLD had no positive or negative effect on pleural space or complications in patients who underwent upper lobectomy.

Keywords: Pleural space; Postoperative complications; Thoracic surgical procedures

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INTRODUCTION

In patients undergoing anatomic lung resection, complications related to the respiratory system (10-50%) are the most common [1,2]. When patients who have undergone pneumonectomy are excluded, the most frequently seen respiratory system complications are prolonged air leak and expansion defects (e.g., residual pleural space). Especially in the early period, apically located pleural space is one of the most common problems [3,4]. Prolonged air leak and pleural space defects prolong hospital stay and cause additional problems, such as infection. Therefore, in an attempt to reduce the incidence of these complications, many applications are used, such as dissection of the inferior pulmonary ligament (PLD), pneumoperitoneum, pleural tent, etc. in the perioperative period. There are very few studies in the literature showing the effects of PLD, and the benefits of this application have not yet been proven [5]. In this study, we aimed to show the effect of PLD on postoperative lung expansion, residual pleural space, and other complications in lung upper lobectomy operations.

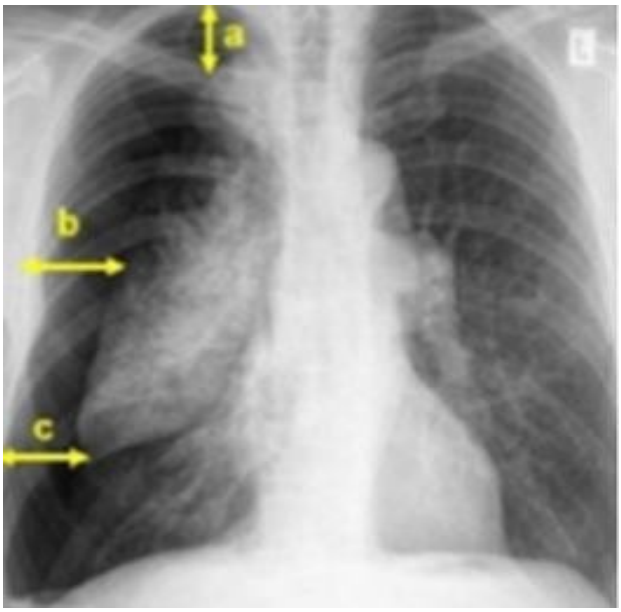
METHODS

After obtaining necessary permissions and approval from the Clinical Research Ethics Committee of Uludag University Faculty of Medicine (decision number: 2012-23/5), we accessed the anatomical lung resection data, which we had prospectively recorded in our clinic since 1996, and retrospectively analyzed the data of patients who had undergone upper lobectomy since February 23, 2013, using the electronic data bank of our hospital. The study was conducted in compliance with the tenets of the Declaration of Helsinki and ethical principles. After 2010, lobectomy operations were performed by the same surgical team in our clinic using the standard muscle sparing mini-thoracotomy or videothoracoscopy technique. As a clinical approach, PLD was routinely performed in all lung resections until June 8, 2012, but after this date, it was no longer used as a routine procedure during these operations. After lung resection was completed, one or two thoracic drains were placed for postoperative air and fluid drainage according to the intraoperative findings, and these drains were connected to the closed underwater drainage system. All the patients were extubated in the intraoperative operating room and followed up in the intensive care unit for one day. In order to reduce the development of postoperative pain, an epidural catheter was placed preoperatively, and narcotic and nonsteroidal anti-inflammatory drugs were given postoperatively.

The following exclusion criteria were used: history of pulmonary tuberculosis, history of ipsilateral lung surgery, presence of preoperative neoadjuvant radiotherapy, presence of advanced emphysematous lung diseaseand a FEV1 value below 50% in pulmonary function tests, videothoracoscopybeing used as the surgical approach, and use of two drains for the monitoring of postoperative air leak and drainage.

The cases included in the study were divided into two groups as those in which PLD was performed (Group I) and those in which this procedure was not used (Group II). Patient recruitment was terminated on January 23, 2011, when 20 patients were reached in both groups.

Residual pleural space was defined as an air gap of greater than 3 centimeters or more than 20% on postoperative chest X-ray, and prolonged air leak as air leak from the drain lasting longer than five days [1]. Air leak evaluation was performed as suggested by Macchiarini et al. [6]. Negative aspiration from the drain bottle (-20 cmH2O) was performed in cases of high-volume air leak, large pleural space on chest X-ray, and massive subcutaneous emphysema. In the patients with insufficient negative aspiration, an additional thoracic drain was applied. Complications that developed, duration of drain in place and hospital stay, negative aspiration requirement, and additional thoracic drain requirement were recorded. If an additional thoracic drain was used, the time to the withdrawal of all the drains was considered when evaluating duration of the drain in place. Chest X-rays obtained on days 1, 3, 5, 7, 30, and 90 after the operation were examined. For the calculation of the pleural spacepercentage, the formula shown in Figure 1 was used, and the results were recorded [7].



PNEUMOTHORAX PERCENTAGE

CALCULATION = 4.2 + [4.7 X (A+B+C)]

A: DISTANCE BETWEEN CHEST WALL APEX AND LUNG APEX
B: LUNG UPPER MIDDLE LEVEL, DISTANCE BETWEEN CHEST WALL AND LUNG
C:LUNG UPPER LOWER LEVEL, DISTANCE BETWEEN CHEST WALL AND LUNG

Figure 1. Calculation of pleural space percentage value on chest X-ray

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) software was used for statistical analysis of the data. The Shapiro-Wilk test was used to testthe normality of data distribution, and the Mann-Whitney U test was conducted to compare groups with non-normally distributed data. Relationships between variables were examined with the Pearson and Spearman correlation coefficients. Pearson chi-square and Fisher's exact chi-square tests were used to analyze categorical data. In the analysis of repeated measurements, the percent change values of the following measurements were calculated with respect to the initial measurements and statistically compared between the two groups. The significance level was taken as $p<0.05$.

RESULTS

Of the 40 patients included in the study, 34 (85%) were male and six (15%) were female. The mean age of the patients was 60.5 (38-78) years. Left upper lobectomy was performed in 16 (40%) patients, and right upper lobectomy in 24 (60%). Lung cancer was the most common indication for upper lobectomy (n=35, 87.5%). The most common tumor cell types in the patients were adenocarcinoma (n=14, 35%) and squamous cell carcinoma (n=14, 35%). Table 1 shows the demographic characteristics of the patients. When the variables were compared between the two groups, the differenceswere not statistically significant, except that the patients in Group I had a significantly higher age (p=0.03).

Table1. Demographic characteristics of the patient

	Total (n=40)	Group I (n=20)	Group II (n=20)	Pvalue
Mean age	60.5 (38-77)	64 (51-78)	58.5 (38-68)	0.035
Gender(male-female)	34-6 (85-15%)	14-6 (70-30%)	20-0 (100-0%)	-
FEV 1 % value	79.1%	78.8%	80.2%	0.782
Lobectomy side (right)	20 (50%)	11 (55%)	9 (45%)	0.527
Reason for lobectomy (malignancy)	35 (87.5%)	19 (95%)	16 (80%)	
Neoadjuvant chemotherapy	12 (30%)	7 (35%)	5 (25%)	0.490

Postoperative complications were detected in 16 patients (40%) (Group I, n=9, 45%; Group II, n=7, 35%). Prolonged air leak was seen in eight patients (Group I, n=3; Group II, n=5), respiratory distress in three (Group I, n=3; Group II, n=0), atelectasis in four (Group I, n=3; Group II, n =1); pneumonia in two (Group I, n=1; Group II, n=1), arrhythmia in one (Group I, n=1, Group II, n=0), pleural effusion in one (Group I, n=1; Group II, n =0), acute renal failure in one (Group I, n=1; Group II, n=0), and empyema in one (Group I, n=0; Group II, n=1). The most common complication in both groups was prolonged air leak (20%). Six patients with prolonged air leak had undergone right upper lobectomy and two had

undergone left upper lobectomy. The reason for this operation was benign only in one patient. Negative aspiration was applied to 17 (42%) patients (Group I, n=8, 40%; Group II, n=9, 45%). Additional thoracic drains were required in seven patients (17.5%) (Group I, n=3, 15%; Group II, n=4, 20%). The mean duration of drain in place was 8 (2-32) days; 7 (3-14) days in Group I and 9 (2-32) days in Group II, indicating no statistically significant difference between the two groups (p=0.62). The distribution of complications according to the groups is given in Table 2.

Table2. Complications that developed in the patients

	Total (n=40)	Group I (n=20)	Group II (n=20)
Complication	16 (40%)	9 (45%)	7 (35%)
Prolonged air leak (into the pleural space)	8	3	5
Dyspnea	3	3	-
Atelectasis	4	3	1
Pneumonia	2	1	1
Pleuraleffusion	1	1	-
Empyema	1	-	1
Arrhythmia	1	1	-
Acute renal insufficiency	1	1	-
Suction drain	17(42.5%)	8 (40%)	9 (45%)
Additional drain requirement	7 (17.5%)	3 (15%)	4(20%)
Duration of drain in place	8 (2-32)	7 (3-14)	9 (2-32)
Duration of hospital stay		7.25	6.5

On the chest X-ray taken on the seventh postoperative day, expansion defects were observed in 17 patients (43%) (Group I, n = 10, 50%; Group II, n = 7, 35%), while no expansion defect was observed in any of the cases after 90 days. The pleural space volumes with percent (%) change values calculated on postoperative days 0, 1, 3, 5, 7, 30, and 90 were as follows: In Group I; 19.48 (8.90;34.75), -0.34 (-1;1.56), -0.44 (-1;0.86), -0.65 (-1;0.46), -1 (-1;1.03), -1 (-1; 0.17), and 0, respectively in Group I and 23.00 (0; 79.40), -0.34 (-1;0.61), -0.34 (-1;0.61), -1 (-1;-0.20), -1 (-1; -0.35), -1 (-1;-0.68), and 0, respectively in Group II.

DISCUSSION

The human body tries to fill the space formed in the thorax after lung resections through compensatory mechanisms, such as the displacement of mediastinal structures, elevation of the diaphragm, narrowing of the intercostal space, and expansion of the remaining lung [3]. However, these mechanisms are often insufficient to fill the gap in the early postoperative period. Residual pleural space is commonly seen in the apical region, especially after upper lobectomy. In order to prevent this complication, many techniques such as pleural tent, temporary phrenic nerve damage, and pneumoperitoneum applications have been described [3,8]. One of these techniques is PLD, which is applied by many surgeons. Theoretically, PLD aims to reduce the pleural space volume by separating the lower lobe from its mediastinal adhesions and increasing its mobility. In the literature, a limited number of studies have been conducted to test this hypothesis. In a meta-analysis that compiled these studies, Lv et al. [5] concluded that PLD did not make a significant contribution to the reduction of pleural space volume. In another study, Soek et al. compared the presence of apical pleural space in the chest X-rays taken one month after surgery, but they did not find a significant difference between the groups with and without PLD for both the right and left upper lobectomy operations [9]. In another study, Matsuoka et al. [10] determined that PLD had no benefit in eliminating the dead space after upper lobectomy. They even suggested that PLD could have a negative effect. In the current study, we aimed to investigate the accuracy of this theory. We excluded patients who underwent lung resection other than upper lobectomy due to the routine use of PLD during lower lobectomy and lower incidence of pleural space problems in other operations. In addition, we excluded patients with restrictive lung disease, those with a history of thoracic surgery, and those that had received radiotherapy treatment, since these factors may adversely affect the above-mentioned compensatory mechanisms. Unlike other studies in the literature, we also analyzed the percent change values by calculating the pleural space volumes in the postoperative chest X-rays of the patients. On the completion of the study, we determined that residual pleural space was a common problem in patients that had undergoneupper lobectomy, but PLD had no positive or negative contribution to the development of this complication. In addition, we found that age, gender, pulmonary function test results, operation indication, and operation side had no effect on the development of prolonged air leak and residual pleural space. However, prolonged air leak, which was the most common complication in both groups, was higher in the group in which PLD had not been used,

although this difference was not statistically significant. In addition to negative aspiration and additional thoracic drain requirements, the longer drain duration of the non-PLD group may be due to the higher incidence of prolonged air leak in this group. In a study conducted in Turkey, the authors found that residual pleural space developed in 41% of patients who had undergone lung resection, and it persisted in 10% of patients at 12 weeks after surgery [12]. In contrast, in our study, residual pleural space and prolonged air leak detected in 20% of our patients completely disappeared by the end of the postoperative 12th week.

Some authors have suggested that, contrary to the possible benefits of PLD in upper lobectomy cases, it may also cause certain complications due to the increased movement of the remaining lung tissue. Usada et al.[4] published the results of a survey study they conducted among Japanese thoracic surgeons. The authors reported that 69% of the centers surveyed in Japan did not perform PLD, and only 11% regularly performed this procedure.According to 30 centers, the most important reason for this was complications such as bronchial stenosis, atelectasis, and bronchial obstruction, which were considered to be associated with PLD.In another study, Bu et al. [12] reported that preservation of the inferior pulmonary ligament corrected the re-expanded lung after surgery, reduced bronchial distortion, and prevented excessive lung movement and pulmonary torsion. Narita et al. [13] obtained similar results in their study. However, there are also studies concluding that PLD has no effect on bronchial stenosis and obstruction [14,15]. Kim et al. [15] evaluated the narrowest angle between the bronchi in PLD and non-PLD groups after lobectomy and showed no significant difference between the groups. In our clinic, we do not routinely perform bronchoscopy unless there are any complications in the early postoperative period. Therefore, we were not able to evaluate whether there was postoperative bronchial stenosis in our study. In addition, the patients who underwent lobectomy for lung carcinoma at the third month postoperatively were evaluated with thorax computed tomography (CT) for control purposes, but we did not include the changes in the bronchial angle in our study, since CT was not performed in the presence of benign conditions.

Since the inferior ligament is formed by the fusion of pleural leaves, studies investigating how pleural drainage is affected by dissection in this region have reached different results.Seok et al. [9] examined the drainage time, duration of drain in place, and presence of pleural effusion on postoperative chest X-rays to evaluate the accumulation of pleural effusion.They found no significant difference between the groups that had and had not undergone inferior PLD.When all the patients were examined, the duration of drain in place was longer in the PLD group ($p > 0.05$). Lv et al. [5] considered that PLD might increase the amount of drainage in the early postoperative period, but they did not find a significant difference between the two groups. Similarly, Kim et al. [15] reported that there was no significant difference between the PLD and non-PLD groups in terms of delayed pleural effusion development. Our results also indicated no significant difference between the two groups in terms of pleural effusion development and drain duration.

Although PLD is performed to reduce dead space, Khanbhai et al. [16] reviewed relevant articles in their database considering the possibility that this procedure could lead to additional problems, as well as causing bronchial deformation and pleural drainage changes related to lung mobilization. The authors found no convincing evidence that PLD during upper lobectomy significantly improved outcomes and reduced complications. Lv et al. [5] also evaluated complications such as postoperative atelectasis, arrhythmia, pulmonary infection, empyema, and prolonged air leak in patients who had undergone upper lobectomy and did not find any differences between the groups, similar tothe above-mentioned studies. Consistent with the literature, Kim et al. [16] found no significant difference in the prevalence of complications requiring prolonged hospitalization, such as delayed pleural effusion and apparent atelectasis.

CONCLUSION

In light of the studies in the literature, it is not possible to conclude that PLD has a positive or negative effect on the pleural space. Our results also support this idea. Although a small number of studies suggest that protecting the inferior pulmonary ligament increases pleural effusion, most studies did not show any difference. In conclusion, all these evaluations show that there is not sufficient evidence indicating the positive or negative effect of PLD on the development of postoperative complications. Therefore, randomized controlled studies are warranted.

Conflict of Interest: The authors declare that they have no conflict of interest.

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