Efficacy of anterior fissureless technique for right upper lobectomies: a case-matched analysis

Majed Refai*, Alessandro Brunelli, Michele Salati, Cecilia Pompili, Francesco Xiume `, Armando Sabbatini

Division of Thoracic Surgery, Ospedali Riuniti Ancona, Ancona, Italy

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Abstract

Objective: In pulmonary lobectomy, the dissection through the fissure to gain access to the pulmonary artery may increase the risk of postoperative air leak. For several anatomic reasons, this risk is especially high after right upper lobectomies (RULs). The objective of this investigation was to verify the efficacy of an anterior fissureless lobectomy (FL) technique in reducing the incidence and duration of air leak after RUL.

Methods: An observational analysis was performed of 206 consecutive patients (2002—2009) submitted to RUL for non-small-cell lung cancer. Operations were performed through a muscle-sparing lateral thoracotomy. Patients with completely developed fissures were excluded. No sealants or buttressing material were used. For group TR (traditional resection, 146 patients), RUL was performed by traditional intra-fissure dissection of the pulmonary artery; for group FL (60 patients), RUL was carried out by fissureless division of all hilar vascular structures. Several perioperative variables were used in identifying propensity score-matched pairs of patients undergoing traditional and fissureless lobectomies. The matched groups were then compared in terms of incidence of prolonged air leak, air leak duration, operation time, chest tubes duration, hospital stay and costs.

Results: Propensity score analysis yielded 58 well-matched pairs of patients operated by traditional or fissureless RUL. Compared to those in the traditional group, patients in group FL had a mean reduction in air leak duration, duration of chest tube and postoperative stay of 1.1, 1.4 and 1.2 days, respectively. This translated into an average hospital cost saving of 569 € per patient.

Conclusions: The use of an anterior fissureless technique during RUL reduced the duration of air leak and hospital costs without increasing the surgical time. Given its simplicity and efficacy, we regard it as a useful tool for implementing fast-tracking policies and cutting hospital costs.

Keywords: Pulmonary resections; Right upper lobectomy; Anterior fissureless technique; Air leak; Hospital costs

1. Introduction

Prolonged air leak (PAL) after major lung resections remains a frequent and challenging complication for general thoracic surgeons in their daily practice [1,2]. It has been reported that this complication may occur in about 12% of patients after pulmonary lobectomy (European Society of Thoracic Surgeons (ESTS) Database Annual Report 2010). Previous studies have also shown that PAL is a major factor that may influence length of stay [3–5], negatively impact on hospital costs [5] and increase the risk of other complications such as empyema [6].

Right upper lobectomy (RUL) is at the highest risk of prolonged air leak, maybe due to the incomplete nature of the minor fissure [7,8]. However, this event may be influenced by the surgical technique that we adopt. In performing conventional lobectomy, the access to the pulmonary artery is gained by the dissection through the fissure which may increase air leak. Conversely, by performing an anterior fissureless lobectomy (FL), this manoeuvre is obviated by the division of all lung parenchyma by stapler.

The objective of our investigation was to verify whether the use of the anterior FL technique could reduce the incidence and duration of air leak and shorten hospital stay after RUL.

2. Methods

Our study is an observational analysis performed on prospectively collected data in a periodically audited electronic database of a single dedicated thoracic surgery unit. This study was approved by the local Institutional Review Board and all patients gave their consent to use their data in the data set for clinical research.

A total of 225 consecutive patients were submitted to RUL for non-small-cell lung cancer from 2002 through 2009.
Nineteen patients were excluded from the analysis for extended resections (chest wall, diaphragm, etc.) (10 patients), need for postoperative mechanical ventilation (three patients) and completely developed fissures found at operation (six patients).

The remaining 206 patients were divided in to two groups:

- group TR (traditional resection): 146 patients who underwent RUL by the traditional intra-fissure dissection of the pulmonary artery;
- group FL: 60 patients who underwent RUL by the anterior fissureless technique.

Briefly, this technique involves a preliminary division of the upper branches of the superior pulmonary vein followed by the division of the anterior pulmonary artery trunk to the upper lobe. Then, the upper lobe parenchyma was retracted dorsally to expose the posterior ascending artery that was ligated and divided. The fissures were finally completed by stapling the parenchyma [8, 10].

All operations were performed though a muscle-sparing lateral thoracotomy. For the purpose of this study, all patients with complete fissures (in both groups) were excluded. No sealants, pleural tents or buttressing material were used in this series.

The bronchus was divided using a stapling device. At the end of the procedure, the presence of air leak was always tested by submerging the lung in sterile saline and inflating it to a pressure of 25—30 cm H2O. In case of bubbling, every attempt was made to minimise the air leak by applying sutures.

One or two chest tubes were left at the end of the operation. Chest tubes were left on suction (−15 cm H2O) until the morning of the first postoperative day and then switched to alternate suction according to institutional protocol [9].

Postoperative chest pain was assessed at least twice a day during the morning and evening rounds. Treatment was titrated to achieve a pain score below 4 (range 0—10) during the first 72 postoperative hours by means of continuous intravenous infusion of non-opioid analgesics. Chest physiotherapy was performed in all patients starting from the first postoperative day by qualified and dedicated physiotherapists, according to standardised protocols.

Air leak was assessed twice daily (during the morning and evening rounds) by the attending physician. Patients were instructed to perform standardised repeated forced expiratory manoeuvres (coughing and blowing). Chest tubes were removed if no air leak was detectable in the chest drain unit and the pleural effusion was less than 400 ml in the last 24 h, after a chest X-ray was obtained to show satisfactory lung expansion.

Fixed and variable costs were retrieved from the hospital’s accounting and pharmacy departments’ data systems. Costs are expressed in euro and adjusted for inflation rate as of December 2009.

Fixed costs included capital, employee salaries, building maintenance and utilities. Variable costs included patient-care supplies, food, radiographic film, laboratory reagents and medications, with their delivery systems (such as intravenous catheters or bottles) and the cost of other postoperative therapeutic procedures such as cardioversion, bronchoscopy and blood transfusions. Surgical costs include operating room occupancy and surgical material (i.e., staplers). For reference, the average daily cost of hospital stay in our setting is 400 € in the ward and 1100 € in the intensive care unit (ICU). The operating room occupational cost is about 3.5 € per min.

2.1. Statistical analysis

This is an observational analysis performed on prospectively collected data. Definitions of variables and outcomes were standardised. For the purpose of this study, PAL was defined as an air leak lasting longer than 5 days.

To minimise selection bias and the influence of several clinical confounders on outcomes, propensity score methodology was used to match patients submitted to traditional lobectomy and anterior FL [11, 12]. The aim of the analysis was to match patients submitted to TR and FL according to baseline characteristics and compare outcomes (incidence of prolonged air leak, air leak duration operation time, chest tubes duration, operation time, hospital stay and costs) between the matched groups. The conditional probability to be treated (propensity score) was estimated by logistic regression analysis incorporating the following variables: age, gender, forced expiratory volume in 1 s (FEV1), FEV1/ forced vital capacity (FVC) ratio, diffusion lung capacity for carbon monoxide (DLCO), predicted postoperative DLCO (pDLCO), residual volume/totall lung capacity (RV/TLC), arterial oxygen tension (PaO2), arterial carbon dioxide tension (PaCO2), coronary artery disease (CAD), diabetes, body mass index (BMI), intra-operative adhesions, stapler type and length, pack-years, American Society of Anesthesiologists (ASA) score, Charlson comorbidity index (CCI) score and Eastern Cooperative Oncology Group (ECOG) score.

Before matching patients, a parsimonious explanatory model was developed by logistic regression analysis and bootstrap bagging. Bootstrap analysis was used to assess the reliability of the variables included in the model.

All variables were at least 95% complete; sporadic missing values were imputed by taking the most frequent response category or averaging non-missing values for continuous variables. Greedy matching techniques were then used to select patients who underwent TR treatment with counterparts who underwent FL treatment by choosing the patient with the nearest propensity score [11, 13]. The procedure yielded 58 well-matched pairs of patients operated by traditional or fissureless RUL. Normality of distribution of numeric variables was assessed by the Shapiro—Wilk test. Continuous variables of the two groups of propensity score-matched patients were compared by the Wilcoxon rank test (non-parametric distribution) or by the Student’s t-test (normal distribution). Categorical variables were compared by the chi-square or the Fisher’s exact tests as appropriate. All the statistical tests were two-tailed, with a significance level of 0.05, and were performed on the statistical software Stata 9.0 (Stata Corp, College Station, TX, USA).

3. Results

Propensity score analysis yielded 58 well-matched pairs of patients operated on by traditional or fissureless RUL as shown in Table 1.
Table 1. Characteristics of the patients in the two matched groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Fissureless</th>
<th>Traditional</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>68.8 (7.8)</td>
<td>66.9 (9.1)</td>
<td>0.2</td>
</tr>
<tr>
<td>FEV1%</td>
<td>82.3 (15.5)</td>
<td>82.3 (18.4)</td>
<td>0.9</td>
</tr>
<tr>
<td>FEV1/FVC ratio</td>
<td>0.69 (1.1)</td>
<td>0.68 (1.3)</td>
<td>0.5</td>
</tr>
<tr>
<td>DLC0%</td>
<td>78.8 (17.3)</td>
<td>76.3 (19.3)</td>
<td>0.5</td>
</tr>
<tr>
<td>Pl. adhesions (n, %)</td>
<td>12 (21%)</td>
<td>11 (19%)</td>
<td>0.8</td>
</tr>
<tr>
<td>Stapler length (mm)</td>
<td>225.2 (85.2)</td>
<td>153.2 (51.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BMI</td>
<td>27.1 (5.7)</td>
<td>26.3 (4)</td>
<td>0.4</td>
</tr>
<tr>
<td>COPD (n, %)</td>
<td>14 (24%)</td>
<td>19 (33%)</td>
<td>0.3</td>
</tr>
<tr>
<td>RV/TLC</td>
<td>0.45 (0.07)</td>
<td>0.44 (0.1)</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Results are expressed as means ± standard deviation unless otherwise indicated. Pl. adhesions: pleural adhesions; BMI: body mass index; FEV1: forced expiratory volume within the first second; FVC: forced vital capacity; DLC0: diffusion lung capacity for carbon monoxide; COPD: chronic obstructive pulmonary disease; RV: residual volume; and TLC: total lung capacity.

Table 2. Comparison of the operative and postoperative outcomes in the two groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Traditional</th>
<th>Fissureless</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation time (min)</td>
<td>180 (44)</td>
<td>183 (51)</td>
<td>0.81</td>
</tr>
<tr>
<td>Postoperative stay (days)</td>
<td>7.7 (4.2)</td>
<td>6.5 (4.1)</td>
<td>0.04</td>
</tr>
<tr>
<td>Air leak duration (days)</td>
<td>2.5 (3)</td>
<td>1.4 (2.8)</td>
<td>0.15</td>
</tr>
<tr>
<td>Duration of chest tube (days)</td>
<td>6.7 (6.4)</td>
<td>5.3 (6.3)</td>
<td>0.004</td>
</tr>
<tr>
<td>Pleural effusion 48 h (ml)</td>
<td>810 (392)</td>
<td>679 (374)</td>
<td>0.004</td>
</tr>
<tr>
<td>Postoperative hospital costs (€)</td>
<td>3436 (2216)</td>
<td>2867 (2307)</td>
<td>0.046</td>
</tr>
<tr>
<td>Perioperative costs (€)</td>
<td>5336 (2373)</td>
<td>4767 (2332)</td>
<td>0.07*</td>
</tr>
<tr>
<td>(including surgical costs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolonged air leak &gt; 5 days (n)</td>
<td>4</td>
<td>2</td>
<td>0.7**</td>
</tr>
</tbody>
</table>

Results are expressed as means ± standard deviation unless otherwise indicated.

Mann–Whitney test.

Fisher’s exact test.

The total cardiopulmonary morbidity was almost identical in the two groups TR and FL (11 vs 12 cases, respectively, p = 1).

Compared to those in the traditional group, patients in the FL group had a statistically significant reduction in chest tube duration (5.3 vs 6.7 days, p = 0.004), postoperative hospital stay (6.5 vs 7.7 days, p = 0.04), postoperative hospital costs (2867 € vs 3436 €, p = 0.046) and perioperative costs, inclusive of surgical costs (4767 € vs 5336 €, p = 0.07). This translated into an average total hospital cost saving of 569 € per patient (Table 2). Moreover, we did not find significant increase in operation time (180 min (TR) vs 183 min (FL), p = 0.8) and found lower pleural effusion after FL (810 ml (TR) vs 679 ml (FL), p = 0.04).

4. Discussion

PAL is a frequent and common complication after major lung resections, with an incidence after RUL as high as 26% [7].

Because this complication has been shown to be closely related to hospital stay and costs [3–5], several preventative measures have been attempted to minimise its occurrence [14–17]. Among these measures, the application of surgical techniques that limit parenchymal dissection and the creation of raw surfaces have been explored [15].

We believe that the best way to reduce air leak begins in the operating theatre with careful and meticulous surgical technique. The presence of incomplete or fused fissures increases the risk of PAL and surgical technique is determinant in reducing air leak [18].

In this context, the use of a fissureless technique that spares parenchymal dissection appears to add to conventional procedure in reducing injury to the lung, with the theoretical advantage to minimise the incidence of air leak.

By using a propensity score case-matched analysis, we found that this technique was superior to the traditional intra-fissure dissection of the pulmonary artery, in shortening the duration of chest tubes and the postoperative stay. This translated into a cost saving of approximately 500 € per patient, including surgical costs.

In fact, although the length of stapled parenchyma was longer with this technique (due to the absence of an intra-fissure dissection with cautery), the similar operative time and shortened hospital stay offset this factor.

To our knowledge, only two studies in the literature have assessed the efficacy of the anterior fissureless RUL. Gomez-Caro and colleagues [18] performed a randomised trial by including all the lobar and bilobar resections. They found that the use of the fissureless technique reduced significantly the incidence and duration of air leak. Similarly, Ng and colleagues [8], in an observational study including only RUL, found that the use of the fissureless technique resulted in fewer chest tube days and shorter hospital stay.

In our series, we found similar results with a reduced duration of air leak and hospital costs, without increasing the surgical time. Although our study is not a randomised trial, we opine it adds to the current scant literature addressing this technique, inasmuch as it is a sizeable case-matched analysis specific to RUL performed in a relatively short period of activity without variation in clinical practice and in a unit with standardised perioperative pathways of care.

Our study may have potential limitations.

First of all, this is an observational retrospective study. It is not a randomised trial. Although propensity score analysis remains the most rigorous method for investigating causal effects in a non-randomised setting, it cannot completely account for unknown variables affecting the outcome that are not correlated strongly with the measured variables [12].

Second, although both techniques were performed during the entire period of the study, there was a distinct time trend. In fact, fissureless procedures were most commonly performed in the most recent period. The influence of this factor on the results of the analysis remains unclear, but must be taken into consideration in the interpretation of our findings, as other unknown or uncontrolled factors associated with air leak or postoperative stay may have varied as well.

In conclusion, RUL performed through a fissureless technique appears to decrease duration of air leak, shorten hospital stay and lower hospital costs. We regard it as a useful tool for implementing fast-tracking policies and cutting hospital costs. Based on the present results, we started to systematically perform this technique in all RULs and to explore and assess this procedure even for other types of lobectomies. Yet, the generalisation of our results requires a confirmatory large independent randomised trial.
References

[8] Ng T, Ryder BA, Machan JT, Cioffi WG. Decreasing the incidence of prolonged air leak after right upper lobectomy with the anterior fissureless technique. J Thorac Cardiovasc Surg 2010;139:1007—11.