Wedge resection of the bronchus:
an alternative bronchoplastic technique for preservation of lung tissue☆

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Abstract

Objectives: We present a modified wedge resection of the bronchus, as an alternative bronchoplastic technique for lung resection, in cases of patients with or without adequate pulmonary reserve to undergo a pneumonectomy, in order to preserve lung tissue. Methods: Seventeen patients underwent a major lung resection with wedge resection of the bronchus for non-small cell lung cancer (NSCLC) in our department, from March 1995 to October 1999. A right-sided NSCLC were diagnosed in 17 males, with a mean age 62.5 ± 6.6 (range 51–72) years. Further workup was free of metastatic disease. All patients underwent a right posterolateral thoracotomy, under general anesthesia with a double lumen endotracheal tube. Twelve right upper lobectomies, four right upper and middle lobectomies and one carinal resection were performed. The wedge resection of the bronchus carried out longitudinally, along the bronchial tree, and the bronchial defect was reaproximated transversely, in a single-layer, with interrupted non-absorbable suture. The frozen section of the distal margin of the resected bronchus was negative for malignancy in all patients. Extended mediastinal lymph node dissection followed each lung resection. Results: The pathology report showed 12 squamous-cell carcinomas, three adenocarcinomas, one adenosquamous carcinoma and one neuroendocrine carcinoma. The differentiation of the carcinomas was well in two cases, moderate in ten and poor in five. The pTNM stage was IB in four patients (23.5%), IIA in one (5.9%), IIB in eight (47.1%) and IIIA in four (23.5%). The median disease-free distal margin of the bronchus was 5 mm (range 2–15 mm). The average postoperative hospital stay was 15 days (range 12–28 days). The morbidity and mortality rate was 11.8 and 5.9%, respectively. Postoperative follow-up was every 6 months. The average survival is 20.0 ± 15.2 months (range 1–54 months). There are 12 patients alive, and their follow-up is negative for locoregional recurrence or distant metastasis. The survival study showed no significantly statistic relation to the histologic type, cancer differentiation, pTNM stage, and disease-free distal margin of resection larger or less than 0.5 cm (Kaplan–Meier study log rank method). Conclusions: The wedge resection of the bronchus as a bronchoplastic procedure is an easy, fast and safe technique of reparation of the bronchial tree. It presents not only a low rate of morbidity and mortality, but also a satisfactory survival. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Lung cancer; Wedge resection; Bronchoplastic technique

1. Introduction

Therapeutic resection for lung cancer is considered any resection of the lung parenchyma within disease-free margins. In cases where cancer has already infiltrated the main bronchus, several types of bronchoplastic procedures are used to save as much disease-free parenchyma as possible and to avoid proceeding to a pneumonectomy. The latter procedure is accompanied by more serious complications sooner or later. The bronchoplastic procedures are applied not only in patients with poor respiratory reserve, but also in all those patients, that it is technically possible.

In this study we present our experience in performing wedge bronchoplasty analyzing the advantages of the surgical technique, the postoperative course of the patients, their survival and any factors affecting it.

2. Material and methods

2.1. Patients

During the period March 1995–October 1999, 17 patients underwent a major lung resection with wedge resection of the main bronchus. All patients were male with a mean age 62.5 ± 6.6 years (range 51–72 years) and presented a right

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lung tumor. The preoperative workup included complete physical examination, laboratory tests, bronchoscopy and cardiological evaluation (Fig. 1). In patients with an FEV₁ < 2000 ml, a perfusion scanning of the lungs was performed in order to estimate the postoperative FEV₁. Further workup for metastatic disease included computed tomography of the chest, brain and upper abdomen, and also a bone scan. No patient had distant metastasis. Because of improvements in imaging techniques, including high-resolution computed tomography, we have not routinely performed mediastinoscopy in our department. Characteristics of the patients can be seen in Table 1.

2.2. Operation

Twelve right upper lobectomies, four right upper and middle lobectomies and one wedge carinal resection were performed. In 11 patients the bronchoplastic procedure was performed due to marginal respiratory reserve (expected postoperative FEV₁ < 800–1000 ml), while in six patients we performed it electively. All patients underwent a right posterolateral thoracotomy, under general anesthesia with a left-sided double-lumen endotracheal tube. After opening the pleural cavity, we performed an examination of the hilum pulmonis. After the decision for bronchoplasty was taken, we dissected the inferior pulmonary ligament, dissected and ligated the appropriate vessels, dissected and transected the interlobar fissures. The wedge resection of the bronchus carried out longitudinally along the bronchial tree, and the bronchial defect was reapproximated transversely, in a single layer, with interrupted non-absorbable suture No 3.0 or 4.0, such as Ethibond® or Prolene®. The frozen section of the distal margin of the resected bronchus was negative for malignancy in all patients. In six patients the bronchial stump was covered with a pleural flap. Extended mediastinal lymph node dissection followed each lung resection. A single lumen endotracheal tube was substituted for the double lumen tube. We used a 3-mm pediatric fiberoptic bronchoscope in order to clean the bronchial tree and check the anastomosis. Two chest tubes were inserted in the pleural cavity and the thoracotomy incision was closed according to standard procedures. The patients remained in the intensive care unit for the first 48 h postoperatively.

The primary tumor and lymph nodes status was classified according to the international staging system reported by Mountain [1]. The histologic type of the tumors was determined by applying the WHO classification [2].

2.3. Statistics

Survival estimates were made with the Kaplan–Meier model and compared with the log-rank test. Statistical significance was admitted for any value of \( P \) less than 0.05 [3].

3. Results

3.1. Postoperative period

The average postoperative hospital stay was 15 days (range 12–28 days). There was no atelectasis, bronchopleural fistula or empyema. There was no air leak lasting for more than 7 days. The morbidity was 11.8%: two patients with obstruction of the small intestine due to adhesions from previous abdominal operation and cardiac dysrhythmia. The mortality was 5.9%: one patient died due to cardiac arrest.

Table 1
Characteristics of the patient population

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
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<tbody>
<tr>
<td><strong>Age</strong></td>
<td>62.5 ± 6.6 years (51–72)</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td></td>
</tr>
<tr>
<td>Right upper lobectomy</td>
<td>12</td>
</tr>
<tr>
<td>Right upper and middle lobectomy</td>
<td>4</td>
</tr>
<tr>
<td>Wedge carinectomy</td>
<td>1</td>
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<tr>
<td><strong>Histologic type</strong></td>
<td></td>
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<tr>
<td>Squamous-cell carcinoma</td>
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</tr>
<tr>
<td>Adenocarcinoma</td>
<td>3</td>
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<tr>
<td>Adenosquamous carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Neuroendocrine carcinoma</td>
<td>1</td>
</tr>
<tr>
<td><strong>Cancer differentiation</strong></td>
<td></td>
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<tr>
<td>Well</td>
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<tr>
<td>Moderate</td>
<td>10</td>
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<tr>
<td>Poor</td>
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<tr>
<td><strong>TNM stage</strong></td>
<td></td>
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<tr>
<td>IB (T2N0M0)</td>
<td>4</td>
</tr>
<tr>
<td>IIa (T1N1M0)</td>
<td>1</td>
</tr>
<tr>
<td>IIb (T2N1M0)</td>
<td>7</td>
</tr>
<tr>
<td>IIb (T3N0M0)</td>
<td>1</td>
</tr>
<tr>
<td>IIia (T3N1M0)</td>
<td>2</td>
</tr>
<tr>
<td>IIia (T2N2M0)</td>
<td>2</td>
</tr>
</tbody>
</table>

Fig. 1. Tumor of the carina: preoperative flexible bronchoscopy.
3.2. Histology

All resections were performed within a disease-free distal margin. The average distal margin of the bronchial ring was 5 mm (range 2–15 mm). There were 12 squamous cell carcinomas, three adenocarcinomas, one adenosquamous and one neuroendocrine carcinoma. The tumor differentiation was well in two patients, moderate in ten patients and poor in five patients. The pTNM stage was IB in four patients, IIA in one patient, IIB (T2N1M0) in seven patients, IIB (T3N0M0) in one patient, IIIA (T3N1M0) in two patients and IIIA (T2N2M0) in two patients (Table 1).

3.3. Survival

Patients with N2 disease were treated either with chemotherapy or/and radiation. Postoperative follow-up took place every 6 months including physical examination and laboratory tests, computed tomography of the chest, brain and upper abdomen, and a bone scan. Flexible bronchoscopy was performed to any patient presenting with respiratory symptoms (e.g. dyspnea).

The average survival is $20.0 \pm 15.2$ months (range 1–54 months). The patient who died on the 28th postoperative day was not excluded from the survival study. Regarding the other patients who died, one had a recurrence at the suture line, one recurrence at the suture line and at the remaining ipsilateral lung tissue along with distant metastases, and two patients only with distant metastases. There are 12 patients alive up to date, and their follow-up is negative for locoregional recurrence or distant metastasis (Fig. 2).

The survival study showed no statistically significant relation to age, larger or less than 65 years ($p = 0.061$ – borderline), histologic type ($p = 0.95$), cancer differentiation ($p = 0.40$), pTNM stage ($p = 0.62$), and disease-free distal margin of resection, larger or less than 5 mm ($p = 0.77$), level of N ($p = 0.62$), level of T ($p = 0.31$) and selective operation ($p = 0.39$). Cumulative survival of the patients is presented in Fig. 3.

4. Discussion

Since the first introduction of sleeve resection for a bronchial carcinoma in, 1947 by Price-Thomas, this procedure has become a therapeutic option also for the treatment of bronchogenic carcinoma [4]. Three types of bronchoplastic procedures have been described: sleeve, flap and wedge. Wedge bronchoplastic procedures were done for lobar tumors with local infiltration of the cranial and the caudal parts of the adjoining bronchus, and the flap bronchoplasties were done for lobar tumors with only local involvement of either the cranial or caudal part of the adjacent main bronchus [5].

We applied the wedge technique in 3.03% of all patients and their majority had poor respiratory reserve (64.70%). In the rest, the infiltration of the main bronchus by the tumor allowed the wedge technique. While this type of bronchoplasty can be done on either lung, we performed randomly lobectomies or bilobectomies only in the right lung (Figs. 4 and 5). There is no doubt though that the right upper lobe is the most appropriate for bronchoplasty due to anatomical reasons [6].

The success of the procedure and the lack of postoperative complications depend mainly on proper lung mobilization, use of proper sutures and recognition of the need to use pedicled flaps or not. We believe that after initial examination of the hilum pulmonis and tumor invasion, the mobilization of the inferior pulmonary ligament and the main bronchus or the trachea at a length of 1–2 cm are necessary, especially in cases of bilobectomy. The ligation of pulmonary vessels comes first, while at the phase of bronchial

Fig. 2. Tumor of the carina: postoperative flexible bronchoscopy.

Fig. 3. Cumulative survival of patients. The points on the curve represent the patients at risk on a certain time. There are two patients with the same survival of 20 months.
stump closure, the sutures should be put beginning from the sides (area of lower tension) towards the middle (area of greater tension). We prefer using non-absorbable sutures, such as Ethibond or Prolene, in order to achieve a smaller chance of creating a granuloma. Nevertheless some authors prefer using absorbable sutures [7,8]. Finally, we believe that we should cover the stump only when there is extensive resection of the bronchus, resulting in devascularization of the stump. Although omentum was considered the ideal pedicled flap in order to cover and provide hemotasis to the stump, we used a pleural flap, with excellent results in avoiding opening the peritoneal cavity [9].

Utmost care must be taken to perform the anastomosis on disease-free margins. Kayser et al. report that when the distal margin is at least 10 mm, the tumor infiltration rate is less than 5% [10]. The frozen section of the resected bronchus stump secures the disease-free bronchoplasty [10]. We used it before anastomosing all patients and the disease-free margin ranged from 2 to 15 mm.

Sleeve resection or pneumonectomy is indicated in cases of evidence of tumor infiltration of the bronchial stump and improper anastomosis due to technical errors (kinking and stenosis of the anastomosis). Sleeve resection is the only alternative procedure for patients with poor respiratory reserve, whereas pneumonectomy may be performed in those with adequate reserve.

Local recurrence seems to be the more serious complication after bronchoplasty, with a rate of 5.4–25% [5–7]. Although the suture line is the most usual site of recurrence, most authors do not clarify whether recurrence takes place at the suture line, the remaining parenchyma, the lymph nodes or the pleural cavity. When recurrence occurs, pneumonectomy or sleeve resection are the only options, as indicated. We had two patients (11.76%) with locoregional recurrence, with a disease-free margin of 4 and 7 mm. Since their respiratory reserve was poor, we did not perform any kind of further resection.

Atelectasis has been reported to be the most common complication after bronchoplasty procedures (2–20%). Technical errors in bronchial approximation, lymphatic interruption, local postoperative edema, and partial or complete denervation of the remaining lung may potentially contribute to atelectasis [7,11]. Other common postoperative complications are stenosis (3–9%) and dehiscence (3–5%) of the anastomosis. Finally, postoperative pneumonia (4–6%) and empyema (2%) may be the result of stenosis or dehiscence of the anastomosis, respectively [6,7,12]. There is no reference to a bronchovascular fistula complicating wedge bronchoplasty. None of our patients presented any of those major complications. We believe that the careful mobilization without devascularization of the bronchus and the completion of the anastomosis taking care not to cause kinking are crucial steps in order to avoid major complications.

Flexible bronchoscopy is the ideal technique to check the anastomosis intra- or postoperatively. When performed during operation with a 3-mm pediatric flexible bronchoscope, bronchial secretions can be suctioned and the suture line can be checked. We believe that patients should be submitted to postoperative bronchoscopy only in the presence of major complications.

As for statistical analysis, we are not able to find signifi-
cant relations between pTNM stage, T and N level, and length of disease-free distal margin with survival, probably due to our small number of patients. However, according to our results, we support that a resection in clear margins is the crucial point for survival.

A dilemma for the surgeon is the case of patients with adequate respiratory reserve, who can withstand either pneumonectomy or bronchoplasty. The advantages of the latter are the lower morbidity and mortality, the higher postoperative quality of life without the late complications following pneumonectomy, the possibility to be followed by completion pneumonectomy or contralateral lobectomy in cases of recurrence, with fair expectations for long-term survival [6]. Nevertheless, N2 disease and infiltration of a pulmonary vessel should be considered as indications for pneumonectomy, due to higher rate of local recurrence [8,13].

As a conclusion, we believe that wedge bronchoplasty is an easy, fast and safe technique of restoring the bronchial tree architecture. It is indicated in all patients that it is technically possible, especially in patients with marginal respiratory reserve. It seems that resection in clear margins results in satisfactory survival.

References


Appendix A. Conference discussion

Dr P. Fuentes (Marseille, France): When performing what you called wedge bronchoplasty, did you observe a plication of the mediastinal wall of the remaining bronchus, which results sometimes in a kind of valve which allows the air to enter to the lower lobe but not to go outside?

Dr Kotoulas: No. We had no major complications, such as stenosis or valve type mechanism. After the end of wedge bronchoplasty, we checked the suture line using a pediatric bronchoscope in order to re-perform it, if it was necessary.

Dr V. Porhanov (Krasnodar, Russia): I have just one remark. Many surgeons in Russia don’t use a bronchoplastic procedure to do wedge resection.

Dr V.V. Sokolov (Kiev, Ukraine): What was the primary location of tumors in your cases? If you had T2 peripheral tumors, probably wedge resections were justified, but if you had T2 segmental cancer, in our opinion, a sleeve resection is more safe. The second question is, if you have segmental cancer, in our opinion, also the sleeve resection is preferable without compromise to ventilatory functions postoperatively. The third question is, what was the mean time to local recurrence in the 2 patients?

Dr Kotoulas: I will begin with the third question. The mean time was 1 year for the first patient, and 14 months for the second patient. As for sleeve or wedge resection, we prefer in these cases the wedge resection, because we can prevent the skeletonization of the bronchial tree, and with this procedure we have less possibility of fistula as a complication.

Dr Sokolov: If you have segmental cancer, it is impossible to achieve quite good negative margins with wedge resection and sleeve resection is preferable. Certainly wedge resection is possible in lung cancer, but probably not in T2 segmental cancers.

Dr Kotoulas: Yes. If we have a case of no disease-free distal margin, we prefer the sleeve resection. In other cases we prefer the wedge resection.

Dr F. Rea (Padova, Italy): Just a comment regarding the problem of the kinking of the mediastinum bronchial wall; you can avoid it maybe with a deep wedge on the bronchus. I believe. My question is: how many sleeve resections do you have in your group? And what is your policy? Do you believe that the wedge or sleeve resection is just for patients with a poor pulmonary function test or even for patients with good health and pulmonary function test?

Dr Kotoulas: We believe that wedge resection must be performed in all patients, when it is technically possible. Until now, we performed wedge resection in 25 patients, and sleeve resection in 13.