Impact of different coverage techniques on incidence of postpneumonectomy stump fistula

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Abstract

Objective: Postpneumonectomy bronchial stump fistula (PBSF) is a serious complication with a reported incidence between 0 and 12%. The aim of this retrospective study was to investigate the effectiveness of different coverage techniques of the bronchial stump applied in a consecutive series of pneumonectomies in avoiding this particular problem. Methods: Between 1/87 and 10/97, 129 patients (90 male, 39 female, mean age 57.8 years, range: 15–78 years) underwent pneumonectomy by one surgeon (W.K.). In 14 patients, additional resection procedures were performed (aorta n = 6, vena cava n = 5, thoracic wall n = 3). In all patients with malignancies (n = 123), mediastinal lymphadenectomy was routinely added to the procedure. Bronchial stump closure was performed by means of stapling devices in all patients. Coverage of the bronchial stump was performed with a generous pedicled pericardial flap and concomitant reconstruction of the pericardium with Vicryl mesh (n = 50), with a portion of the posterior pericardium (n = 16), with the azygos vein (n = 12), with surrounding mediastinal tissue (n = 25), with pleura (n = 16), or with intercostal muscle flap (n = 3); no coverage at all was performed in seven patients. In all patients with high risk for development of PBSF, i.e. patients who received any form of neoadjuvant therapy or had extended resections, the pericardial flap technique was used. Results: Perioperative mortality was 5.4% (n = 7) and five patients (3.9%) experienced significant perioperative complications, with one of them directly related to the method of bronchial stump coverage (cardiac tamponade due to the use of a too small Vicryl mesh for reconstruction of the pericardium). Follow-up was 96.1% complete (five patients were lost to follow-up). Forty-seven patients (36.4%) died late after operation (mean 19 ± 13 months, median 17 months), mainly due to recurrence of their underlying malignant disease. PBSF occurred in one patient only (0.8%), 2 weeks after operation (coverage with pleura). No PBSF was seen in the long term follow-up period. Conclusion: Coverage of the bronchial stump contributes to a low incidence of PBSF. In view of the fact, that this serious complication was completely avoided in the pericardial flap group (used in patients with expected higher risk for PBSF), this particular technique seems to offer the best results. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Pneumonecomy; Bronchial stump fistula; Stump coverage; Pedicled flap; Pericardial flap; Postpneumonectomy empyema

1. Introduction

Postpneumonectomy bronchial stump fistula (PBSF) has been reported to occur with an incidence of 0–12% (Table 1). It represents a typical and serious problem in thoracic surgery. Its development is attributed to the surgical technique of closure of the bronchial stump, and several authors have made different suggestions with regard to the optimal handling method [1–4]. Besides the different attempts to optimise the technique of bronchial stump closure, it has been emphasised that additional coverage with surrounding tissue decreases the incidence of PBSF [5,2]. Different materials, such as pleura [6], intercostal muscle [7], pericardial fat pad [5,8], diaphragm [9], vena azygos in cases of right side pneumonectomy [6], and pericardiophreric plicates [5] have been used as flaps for prophylaxis or closure of already established PBSF. However, it still remains unclear what role these different flaps can have for prevention of PBSF. In addition, it is unclear whether coverage of the bronchial stump is mandatory in every patient, and if so, what coverage technique can offer the best results.

The aim of this retrospective study was therefore: (1) to investigate the incidence of PBSF in a consecutive series of pneumonectomies performed by one surgeon; (2) to analyse the different coverage techniques used over a period of 10 years; (3) to compare the results obtained with these different techniques and their efficacy for prevention of PBSF.
2. Materials and methods

All consecutive patients undergoing pneumonectomy with closure of the bronchial stump by mechanical stapling by one surgeon (WK) over a period of 10 years (1987–1997) were included in this retrospective study. Patients were excluded from analysis, if they had other than a standard resection procedure of the main bronchus (i.e. patients who had sleeve pneumonectomies or patients with an additional tangential resection of the distal portion of the trachea who needed a special bronchoplastic closure of the resulting defect), underwent concomitant pleuropericardophrenectomy, or the closure of the bronchial stump had been performed by hand suture. Additional resection procedures besides the pneumonectomy such as resection of the thoracic wall or resection of the greater vessels did not exclude patients from the study.

A total of 129 patients (90 male, 39 female, mean age 57.8 years, range 15–78 years) fulfilled the inclusion criteria. The indications for pneumonectomy were primary lung cancer (n = 115), other malignancies (n = 8), and benign infectious diseases (n = 6, bronchiectasis in three cases and obliterative bronchiolitis in the contralateral lung after unilateral lung retransplantation in three other cases, respectively, Table 2).

Operative reports and postoperative courses with regard to major events and complications were recorded. For patients with malignancies, TNM stage for primary lung cancers, underlying histology (Table 3), and pre-or post-operative chemo-and/or irradiation therapy were documented.

All patients discharged from hospital were followed up by office records, written questionnaires or direct telephone contact. Follow-up ranged from 1 to 78 months (mean 16 months) and was 96.1% complete (five patients lost to follow-up).

2.1. Surgical technique

2.1.1. Closure of the bronchus

Bronchial stump closure was performed with commercial mechanical staplers (Ethicon® and Auto Suture®) in all patients. Stapling was performed by approximation of the membranous and the cartilaginous portion of the bronchus as suggested before [10]. Tumor negativity of resection margins was ensured by histological examination of frozen sections. The bronchial stump was then checked for air leakage with 30–40 cm H₂O sustained airway pressure.

2.1.2. Lymph node dissection

In all patients with primary lung cancer, a complete mediastinal lymphadenectomy was routinely added to the resection procedure. Typically, the subcarinal and tracheobronchial lymph nodes were resected en-bloc with the lung. This was followed by complete dissection of the other remaining mediastinal lymph node compartments.

2.1.3. Additional resection procedures

In 14 patients (10.8%), additional resection procedures were performed (aorta n = 6, vena cava n = 5, thoracic wall n = 3). Resection of the aorta was performed with cardiopulmonary bypass and details about these complex procedures have been published elsewhere [11]. Reconstruction of the thoracic wall was performed with PTFE (Gore®).

2.1.4. Coverage of the bronchus

Coverage of the bronchial stump was performed with

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Table 1

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Reference</th>
<th>Number of patients</th>
<th>Incidence of PBSF (%)</th>
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<td>H. Dienemann (1990)</td>
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<td>261</td>
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<tr>
<td>A.V. Protsenko (1991)</td>
<td>[23]</td>
<td>542</td>
<td>5.4</td>
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<td>D. Weissberg (1992)</td>
<td>[17]</td>
<td>75</td>
<td>2.6</td>
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<tr>
<td>Present series (1999)</td>
<td>–</td>
<td>129</td>
<td>0.8</td>
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Table 2

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<td></td>
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<tr>
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<td>Infectious diseases</td>
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<td>4.7</td>
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Table 3

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<td>IIIb</td>
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<td>IV</td>
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different materials (Fig. 1). Sixty-six patients had a stump coverage with pericardium. In 16 of them, a portion of the posterior pericardium behind the entrance of the pulmonary veins was pedicled and attached to the stump. In the other 50 patients, a generous pedicled flap of the anterior pericardium with or without the phrenic vessels was used. This technique was applied irrespectively whether the pericardium had been opened during the resection procedure, and in general was chosen in all patients considered to be at a high risk for development of PBSF, i.e. patients with any form of neoadjuvant therapy or extended resections. The flap was attached caplike over the bronchial stump with single stitches of 4-0 PDS (Fig. 2). In all patients, the resulting defect in the pericardium was reconstructed with Vicryl mesh (Johnson and Johnson™).

A pedicled flap of parietal pleura was used in 16 patients operated on the right side. Usually, the pleura cranial or dorsolateral to the azygos vein was used for this procedure. In 12 patients, the azygos vein was double ligated at its confluence with the superior vena cava and at the beginning of its arch. The resulting non perfused segment was attached over the bronchial stump with single stitches. Three patients had their bronchial stump covered with a pedicled intercostal muscle flap which was harvested prior to the resection procedure. In 25 patients coverage of the bronchial stump was performed with adjacent mediastinal tissue. No coverage at all was performed in seven patients.

2.2. Preoperative and postoperative adjuvant treatment

Neoadjuvant and adjuvant treatment strategies and protocols for patients with malignancies varied widely. This was due not only to the long period of time that was investigated, but also to the large number of different referring and treating institutions prior to and after the operation itself. Of the total of 123 patients with malignancies, 70 (56.9%) received some form of additional therapy with irradiation or chemotherapy, either alone or in various combinations. In all these patients the bronchial stump had been covered using some type of tissue. In three patients, adjuvant therapy

![Fig. 1. Type of coverage of the bronchial stump in 129 patients.](image)

![Fig. 2. A pedicled pericardial flap is attached cap-like to the bronchial stump with single stitches of 4-0 PDS.](image)
was given only preoperatively; the remaining 67 patients had postoperative treatment with or without preoperative treatment. Preoperative irradiation was given to seven patients (four patients in combination with chemotherapy). Postoperative irradiation was given to 46 patients (in 13 in combination with chemotherapy). Preoperative chemotherapy was given to seven patients (to four in combination with irradiation). Postoperative chemotherapy was given to 34 patients.

3. Results

3.1. Perioperative period

Perioperative mortality was 5.4%, with seven patients dying within 30 days from surgery. The causes of death were bronchopneumonia and respiratory failure in four, pulmonary embolism in two, and sepsis due to PBSF in one patient, respectively.

Significant perioperative complications occurred in five patients (3.9%). One patient had renal failure and paraplegia after additional resection of the aorta, one patient had bronchopneumonia and two patients adult respiratory distress syndrome, respectively. One patient experienced cardiac tamponade after bronchial stump closure with a large pericardial flap and reconstruction of the pericardium with Vicryl mesh and required reoperation.

Overall reoperation rate was 1.5% (n = 2). Reasons for reoperation were closure of PBSF and re-exploration for cardiac tamponade. Both patients have been mentioned above.

The incidence of postoperative problems related to the bronchial stump and its method of closure and coverage was 1.5% (n = 2). Cardiac tamponade in the first patient was overcome by reconstruction of the pericardium with a larger Vicryl mesh. Postoperative recovery of this patient was uneventful. In the patient with PBSF, which occurred 2 weeks after the initial pneumonectomy and coverage of the bronchial stump with a pleural flap, debridement and relosure of the stump with single stitches of 3-0 PDS (Ethicon®) was performed. Additionally, the bronchial stump was covered with a pedicled flap of omentum. Despite these measures, the patient died 7 days later due to sepsis.

3.2. Long term follow-up

Forty-seven patients (36.4%) died late after operation (mean 19 ± 13 months, median 17 months). The overwhelming cause of death was tumor recurrence. No case of PBSF occurred during the whole out-patient follow-up period. In three patients, tumor recurrence was located at the bronchial stump; however, this did not result in stump insufficiency. None of these three patients was reoperated, since other systemic metastases were present at the same time in all of them.

4. Discussion

PBSF remains a significant problem in thoracic surgery despite major technical improvements within the last years. The reported incidence for this threatening complication ranges widely between a surprisingly low rate of 0% [3,12] and an extremely high rate of 12.0% [13]. Although the here reported incidence is one of the lowest published, this has to be interpreted carefully. The major difference to other reports lies in the fact, that this paper summarises the results of a personal series of operations by one surgeon. Almost all other reports addressing this problem comprise the data of several surgeons [13], of institutions with a high number of operations performed by residents [4], or even collective reviews of different institutions. It is therefore not surprising, that these circumstances can result in a higher rate of surgical problems, and that a personal series of operations should have a lower incidence of PBSF. In one large series of 374 pneumonectomies performed by one experienced surgeon, only two fistula (0.5%) have been reported [14].

A second factor of importance is the method of bronchial stump closure. All patients of this study had their stump closed with a mechanical stapler. This too might have resulted in a decreased incidence of PBSF. Although no large prospectively randomised study exists, which compares modern mechanical stapling devices to hand closure of the bronchus, there is evidence that mechanical stapling is superior to the method of suturing [15–17]. Only in early reports about staplers which had not reached modern standards, a clearly elevated rate of PBSF was documented [18]. To the contrary, in the only reported series of pneumonectomies where no PBSF at all was observed [3], bronchial closure was performed with hand suturing. This was done with a special technique of creating a flap from the membranous portion of the main bronchus, resecting the cartilaginous part back into the carina and suturing the mucosal flap over the resulting defect [12]. Finally, and this addresses the goal of this paper, it has to be considered, that a high percentage (89%) of the here reported patients had an additional coverage of the bronchial stump after its closure. However, it can only be speculated that this has contributed to a low PBSF rate, since no clear data about the value of bronchial stump coverage can be found in literature.

In opposition to these factors, which are favourable to a low PBSF rate, some other circumstances have to be considered, which might elevate the risk for PBSF [19]. In the patients operated in this study, a high percentage of advanced tumor stages, of patients with extended operations and of patients with some form of adjuvant treatment can be found. All three factors have been identified as significantly contributing to occurrence of PBSF in several studies [2,19,20]. In addition, routine en-bloc lymphadenectomy, which was performed in all patients with primary bronchial cancers, is known as a factor that adds to an elevated risk for
PBSF. It therefore seems even more justified to interpretate the low PBSF rate in this study as directly related to the surgical technique applied, and especially to the rigorous use of stump coverage.

As mentioned before, controversy exists about the need for and the benefit from coverage of the bronchial stump. Asamura concluded in his review of more than 2300 patients after lung resection, that further investigation should be performed to answer whether prevention of PBSF by tissue coverage is of benefit [2]. Wright and colleagues [4], attributed the low incidence of 3.1% PBSF to their coverage technique in the discussion of their results with 256 patients after pneumonectomy, in whom the bronchial stump was routinely covered with autologous tissue. They used pleural flaps and pericardial fat pad flaps in the vast majority of their patients. However, out of the 8 cases of PBSF they have observed, three had been covered with pleura, two with omentum, two with pericardial fat pad and 1 with intercostal muscle, respectively. This gives some evidence that none of the methods applied, not even the technique of omentum pull-up, can offer complete protection against development of PBSF. Choice of the autologous tissue for coverage seems therefore to be of crucial importance for optimal results. However, the major problem in surgery for advanced tumors is the complete resection of all tissue surrounding the main bronchus and sometimes even further away. In this situation it can become difficult to find adequately preserved autologous tissue that can be used for coverage. Pleural flaps, although being the most frequently used structure [6], usually have the disadvantage that they are extremely thin and sometimes lack adequate blood supply. Not surprisingly, the only fistula in this report was observed after use of a pleural flap on the right side. Intercostal muscle flaps have been used preferentially in some institutions [4]. It was not described that harvesting of this type of flap would result in any disadvantage. However, vascularisation at the end of operation sometimes can be poor, despite careful dissection before introduction of the rib retractor. Pedicled omental flaps have widely been used for coverage of complex tracheobronchial defects [21]. This technique implies an additional incision, which clearly extends the thoracic operation into the abdomen. It must be questioned, whether this extension of the operation in a prophylactic situation is justified.

The first large series of patients in whom a consequent coverage of the bronchial stump was performed derives from Brewer and colleagues [8]. After investigating the value of pericardial fat pad grafts experimentally, they introduced the method clinically and were able to demonstrate a reduction of early PBSF from 8.0 to 0%. Pericardial fat pad has been suggested for the same purpose by Anderson and Miller [5] in a later publication. The authors used this technique together with pericardiophrenic grafts in 54 different cases of pneumonectomies and carinal or tracheal resections. Their rate of fistula in this mixed collective was 5.5% (3/54). It is especially the thickness of such a pericardiophrenic flap, which is well vascularized, that gives this tissue an optimal quality for use as coverage. In the here reported series, different pericardial flaps were applied. Initially, pericardiophrenic flaps were used only in patients who had an intrapericardial pneumonectomy with sacrifice of the phrenic nerve. After satisfying experience without negative side-effects, this method was applied in other patients too, in whom the pericardium was opened for that purpose. Later on, pericardial flaps without the phrenic vascular pedicle were used as well. Although vascularisation of these flaps is clearly inferior to those including the phrenic vessels, it turned out to be still adequate for the purpose of coverage. All these flaps were attached to the bronchial stump cap-like with single stitches of 4-0 PDS, in a way that covered the stump completely, without necessarily decreasing its blood supply. Since this method was so convincing, we decided to use it in all patients, who were considered to be at an elevated risk for PBSF. This included especially patients with any form of neoadjuvant therapy and patients with extended resections. For instance in the six patients, who had a resection of the thoracic aorta and were operated with cardiopulmonary bypass and had the implantation of a vascular prosthesis close to the left main bronchial stump [11], the lack of any infectious complication gives evidence about the beneficial effect of this technique.

One disadvantage of the use of pericardium for a pediced flap is the necessity to reconstruct it in order to prevent cardiac herniation. We have routinely applied Vicryl meshes for that purpose. The only complication directly related to this technique that was observed in this series, occurred in a patient who had a resection of the left lung together with a large area of pericardium. Additional harvesting of a pedicled pericardial graft resulted in a large defect which was reconstructed with Vicryl mesh. Postoperatively, the patient had symptoms of cardiac tamponade and required re-exploration. After exchange of the narrow Vicryl mesh with a larger one, all symptoms disappeared.

In summary, the here described results suggest that mechanical closure of the bronchial stump together with generous use of coverage of the bronchial stump with autologous tissue contribute to a low incidence of PBSF. Choice of the optimal coverage tissue seems to be of importance. In our hands, the use of pedicled pericardial flaps, either with or without the phrenic vessels, has resulted in complete avoidance of this problem. However, reconstruction of the resulting pericardial defect has to be performed carefully, to avoid any negative impact on cardiac function.

References

[2] Asamura H, Naruke T, Tsujiya R. Bronchopleural fistulas associated...