Bronchopleural Fistula After Pneumonectomy: Mechanical Stapling Versus Hand Suturing

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Abstract
Objectives: Bronchopleural fistula (BPF) after pneumonectomy is a serious complication, occurring in 1-15% of the cases. Study aim was to evaluate the incidence of BPFs between hand sutured and stapled bronchus closure.

Methods: Hospital records of 549 consecutive pneumonectomy patients were reviewed retrospectively. The bronchial stump was closed in 510 patients using a uniform interrupted hand suture technique and in 39 patients by mechanical stapler.

Results: BPF rate was higher in the stapled group (5/39 cases, 12.8%) than (33/510 cases 6.5%) in the hand sutured group but not significant p=0.177. BPFs were significantly associated with right-sided pneumonectomy (p=0.026) and male patients (p=0.03). BPF rate was not influenced by surgeon's experience, suture material, or TMN stage. BPFs could be managed conservatively in 80% (4/5) of the stapled cases compared to only 36.4% (12/33) of the hand sutured cases, therefore survival was significantly prolonged in the stapled group compared to the hand-sutured group (763 ± 165 days SEM vs 260 ± 30 days SEM; p=0.003)

Conclusions: Stapled or hand sutured bronchial closures show no significant difference in BPF rates. Patients at higher risk for BPFs should receive a vascularised flap covering the bronchial stump.

INTRODUCTION
Bronchopleural fistula (BPF) after pneumonectomy represents the most dreaded complication in thoracic surgery. Although the incidence has decreased in the recent years due to new surgical refinements and better understanding of the bronchial healing process [1], diagnosis and therapeutic management remain major problems nevertheless. Mortality rates range from 20-70% in the literature (Table 1) [2,3,4,5,6], with the most common cause of death being aspiration pneumonia and subsequent ARDS.

Figure 1
Table 1: Pneumonectomy bronchopleural fistula, technique associated incidence and mortality in the literature

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>No. pat</th>
<th>Hand suture</th>
<th>Stapler BPF (%)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forester-Wood</td>
<td>1980</td>
<td>150</td>
<td>11.1, interrupted</td>
<td>2.6</td>
<td>50</td>
</tr>
<tr>
<td>Mori et al.</td>
<td>1997</td>
<td>964</td>
<td>1.2</td>
<td>11.2</td>
<td>40</td>
</tr>
<tr>
<td>Halikis et al.</td>
<td>1999</td>
<td>757</td>
<td>2.4, running</td>
<td>12.2</td>
<td>33</td>
</tr>
<tr>
<td>Haubert et al.</td>
<td>2001</td>
<td>209</td>
<td>6.5, interrupted</td>
<td>12.8</td>
<td>34</td>
</tr>
<tr>
<td>Pasch (current report)</td>
<td>2005</td>
<td>175</td>
<td>2.4, running</td>
<td>5.7</td>
<td>33</td>
</tr>
<tr>
<td>Sirtori et al.</td>
<td>2005</td>
<td>949</td>
<td>6.5, interrupted</td>
<td>12.8</td>
<td>34</td>
</tr>
</tbody>
</table>

In a retrospective analysis of 38 cases of BPF occurring after 549 consecutive pneumonectomies, the influence of hand sutured versus stapled bronchus closure and other surgical and demographic co-factors were investigated.

MATERIALS AND METHODS
We studied retrospectively 549 consecutive pneumonectomies performed for bronchogenic cancer
between 1980-1996 at the department of Thoracic and Vascular Surgery, Heidehaus Hospital (Hannover Medical School). The mean age was 56.2 years, with 472 (86%) men and 77 (14%) women treated. Left pneumonectomy was slightly over represented with 53% of the cases.

Over the 16 years of observation, 25 surgeons were involved with a mean of 22 cases per surgeon (range 1-187). The bronchus stump was interrupted hand sutured in 510 cases in an open technique \[1\] and mechanically stapled in 39 cases, randomised by surgeon’s choice.

The histological distribution of the bronchogenic cancers was representative with 61% squamous, 28% adeno, 3% large-anaplastic, 4% small cell carcinoma and 5% other histology. No previous radiation and/or chemotherapy treatments were performed.

Details regarding the type and method of surgery and subsequent treatment were carefully reviewed for each patient by operative note and hospital charts. Particular attention was paid to factors possibly affecting the occurrence of BPFs: technique of bronchial closure, suture material, R0/R1-resection, TNM stage, re-thoracotomy rate and time interval, age, sex, clinical diagnosis and associated conditions.

Data are presented as means and standard deviation. Continuous not normally distributed variables were analysed using the Kruskal-Wallis test and the Mann-Whitney U test. Continuous normally distributed variables were assessed with a one-way analysis of variance and the Student’s t-test. Risk factor correlations were investigated by univariate analysis. Qualitative correlation were analysed by Chi-square or Fischer exact test. Survival data were analysed by Kaplan-Meier and Cox-regression methods using log-rank test. P<0.05 were considered statistically significant. All tests were two-tailed. All statistical analyses were performed on a personal computer using SPSS for Windows (Version 10.0, SPSS, Chicago, USA)

RESULTS

Of the 549 pneumonectomy cases, 510 bronchus closures were hand sutured and 39 mechanically stapled. The overall mortality within the first month was 5.5% including 4 intra-operative deaths. The BPF associated mortality was 34% and occurring only in hand sutured cases. No influence was found for sex, age, operation time, tumor site or surgeon. The combined fistula and non-fistula associated postoperative revision rate was equal between hand and stapled bronchus closures (6.3% vs 5.1%, p=1.0).

The BPF rate for all cases was higher in the stapled group with 5/39 cases (12.8%) versus 33/510 cases (6.5%) in the hand sutured group, but not significantly p=0.177. For patients surviving the first month, a trend for a lower incidence of BPFs was noted in the hand sutured group (p=0.082). BPF case specifics listed in Table 2.

Table 2: Consecutive description of the 38 bronchopleural fistula cases

<table>
<thead>
<tr>
<th>No.</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Histology</th>
<th>Stage</th>
<th>Size</th>
<th>Technique</th>
<th>Histology</th>
<th>Stump</th>
<th>Technique</th>
<th>Size</th>
<th>Eviscerate</th>
<th>Site</th>
<th>Success</th>
<th>Survival (days)</th>
<th>Cause of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Male</td>
<td>62</td>
<td>SCC</td>
<td>IA</td>
<td>4</td>
<td>Hand</td>
<td>SCC</td>
<td>Right</td>
<td>Hand</td>
<td>4</td>
<td>Eviscerate</td>
<td>Right</td>
<td>60</td>
<td>60</td>
<td>No rejection</td>
</tr>
<tr>
<td>27</td>
<td>Male</td>
<td>63</td>
<td>SCC</td>
<td>IA</td>
<td>4</td>
<td>Hand</td>
<td>SCC</td>
<td>Right</td>
<td>Hand</td>
<td>4</td>
<td>Eviscerate</td>
<td>Right</td>
<td>60</td>
<td>60</td>
<td>No rejection</td>
</tr>
<tr>
<td>28</td>
<td>Male</td>
<td>64</td>
<td>SCC</td>
<td>IA</td>
<td>4</td>
<td>Hand</td>
<td>SCC</td>
<td>Right</td>
<td>Hand</td>
<td>4</td>
<td>Eviscerate</td>
<td>Right</td>
<td>60</td>
<td>60</td>
<td>No rejection</td>
</tr>
<tr>
<td>29</td>
<td>Male</td>
<td>65</td>
<td>SCC</td>
<td>IA</td>
<td>4</td>
<td>Hand</td>
<td>SCC</td>
<td>Right</td>
<td>Hand</td>
<td>4</td>
<td>Eviscerate</td>
<td>Right</td>
<td>60</td>
<td>60</td>
<td>No rejection</td>
</tr>
</tbody>
</table>

Surgeon experience had no influence on occurrence of BPFs, although 81% of the cases were performed by high volume surgeons (over 50 cases), 10.8% by moderate volume surgeons (10-50 cases) and 8.2% by low volume surgeons (less than 10 cases). Interestingly the low volume surgeons showed the lowest rate of BPFs (2.2%, 1/45), followed by the high volume surgeons (6.7%, 30/445). The moderate volume surgeons had the highest rate of BPFs (11.9%, 7/59), but not significantly compared to the other surgeon groups and/or bronchus closure technique. None of the four high volume surgeons (11/187, 8/94, 2/66, 6/63 cases respectively) had a significantly higher rate of BPFs for either bronchus closure technique. The suture material (absorbable/non-absorbable, braided/non-braided) and flap covering of the stump had no statistical influence on
occurrence of BPFs.

BPFs were not associated with a single TNM stage (pT1=8.3%, pT2=4.7%, pT3a=8.2%, pT3b=5.7%), whereas squamous cell carcinoma cases developed significantly more BPFs compared to other histologies (9.1% vs 4.1%, p=0.026). Right-sided pneumonectomy cases showed a significantly higher rate of BPFs (12.0% vs 2.4%, p=0.000). Men developed BPFs more frequently (7.8% vs 1.3%, p=0.03). The operation time was shorter in the stapled than in hand sutured BPF group (113±51 min. vs 147±36 min., statistical trend p=0.075).

BPFs could be managed conservatively (chest tube drainage, bronchoscopic intervention) in 80% (4/5) of the stapled cases compared to only 36.4% (12/33) of the hand sutured cases. The remaining 22 cases were operatively treated, with a significantly higher mortality rate than conservatively treated cases (52% vs 7%; p=0.01), therefore survival was significantly prolonged in the stapled group compared to the hand-sutured group (76±165 days SEM, CI 440-1086 vs 260±30 days SEM, CI 201-318; p=0.003).

DISCUSSION

BPFs after pneumonectomy show the highest mortality in thoracic surgery cases [1,5,8]. Risk factors for BPF such as male sex [1,5,8], right-sided pneumonectomy [1,5,8], squamous cell carcinoma, pneumonia leading to ARDS [3,5,8] and prolonged postoperative mechanical ventilation [5,8,9] are known and supported by this study.

Probably due to the smaller number of stapled bronchial closures in this study, only a statistical trend could be found towards a higher rate of BPF in the stapler group (12.8%) compared with hand suturing group (6.4%). The literature review is undecided regarding this discussion (Table 1)[1,5,8,9]. Only single surgeon reports [1] are able to report below average BPFs, whereas in our study the high volume surgeons could not duplicate these results, although individual suturing techniques were not investigated in this study.

Interestingly, BPFs after stapled closure are more often conservatively treatable in our experience and in addition associated with a longer survival.

The operative revision of the BPFs is the surgical gold-standard using different flap techniques to seal and reinforce the debrided and resutured bronchus stump with vascularised tissue (pericard, thymus, muscle, etc.) [5,8,9]. Several authors, including us, recommend initial flap covering of the stump [5,8] especially for right-sided pneumonectomies and bronchus diameters larger than 25mm.

SCC: squamous cell carcinoma; D: debridement; R: reclosure; PFF: pericardial fat flap; TP: thoracoplasty; Met: Metastatic disease; OMF: omentum majus flap; CBPF: chronic bronchopleural fistula; CBPF+E: chronic bronchopleural fistula with empyema.

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