Management of the bronchial stump in pulmonary resections: a review of 533 consecutive recent bronchial closures

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Abstract

Objective: The method used to achieve bronchial closure, especially the relative merits of sutured versus stapled closure, remains an important topic among thoracic surgeons who seek the best way to prevent postoperative bronchopleural fistula (BPF) formation. Methods: Bronchial closure in 533 consecutive stumps in pulmonary resection from 1995 to 1997 at the National Cancer Center Hospital, Tokyo, was reviewed in terms of the incidence of troubles related to mechanical stapling (stapling failure) and to BPF formation. Fifty stumps (9%) were closed by manual suturing and 483 (91%) by mechanical stapling. For stapling, endostaplers were used for 313 stumps (65%), and other types of conventional staplers for 170 stumps (35%). Results: There were 18 stapling failures (a 3.7% overall incidence, 4.8% for endostaplers, 1.8% for other types of staplers). However, of these 18 patients only one developed BPF after surgery. Seven BPFs developed postoperatively among the 533 closures (overall incidence, 1.3%): two after manual suturing (4%) and five after stapling (1%), and this difference was not statistically significant. Of seven patients with BPF, four died of BPF-related complications. Conclusions: Although bronchial closure by stapling was accompanied by failure, its incidence was acceptable and was not directly associated with the development of BPF postoperatively, as long as properly repaired. Newly developed endostaplers had similar incidence of stapling failure and BPF formation compared with other types of conventional staplers. These results suggest endostaplers can be used safely for various types of bronchial closure. The advantage of such devices could be the least chance of pollution of the operative field, simultaneous performance of stapling and division by one motion, and subsequently great saving of time.

Keywords: Lung resection; Bronchus; Stapling; Bronchopleural fistula; Lung cancer

1. Introduction

The method used to achieve bronchial closure is one of the most important topics in thoracic surgical community. The controversy regarding the superiority of suturing or stapling of the bronchial end continues among surgeons who seek the best way to prevent postoperative bronchopleural fistula (BPF) [1–4]. In a previous study in 1992, we reported a 2.1% incidence of BPF in 2359 pulmonary resections for lung cancer during a 28-year period in which closure had mainly been achieved by manual suturing [5]. The recent evolution of surgical staplers, their stability, and excellent characteristics have been remarkable, despite previous speculation that the type of jaws used in staplers (parallel versus hinged) was responsible for BPF formation [6,7]. Furthermore, with the advent of endoscopic (thoracoscopic) surgery, new types of endostaplers have become available for bronchial and vascular closure in pulmonary resection. In our institute, we now routinely close the bronchial stump not only with conventional staplers but also with recently developed endoscopic staplers. In cases where tumors are located close to the scheduled line for bronchial division and intraoperative microscopic evaluation of a frozen section is indicated, or in cases in which the bronchial wall is stone hard with calcified cartilage, manual suturing has been indicated. Especially for endoscopic staplers, little information is currently available regarding stapling failures or the incidence of the postoperative formation of BPF.

In this retrospective review, we analyzed the type and incidence of stapling failures which occurred at the time of the operation according to the type of stapler, the incidence of BPF, and the clinical outcome for 533 consecutive bronchial closures over the past three years at the National Cancer Center Hospital, Tokyo.

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2. Materials and methods

2.1. Patients

For the 3-year period from January 1995 through December 1997, 533 bronchial stumps were closed in 527 consecutive patients who underwent major pulmonary resections for various diseases of the thorax at the National Cancer Center Hospital, Tokyo. The patients ranged in age from 23 to 88 years (median, 64 years). Three hundred and twenty-eight patients were male, and 199 were female. These pulmonary resections consisted of pneumonectomy, bilobectomy, lobectomy, and segmentectomy (Table 1). Non-anatomical pulmonary resections (wedge resection) and bronchoplastic procedures which did not include closure of the bronchial stump were excluded from this study. Six patients underwent right upper and middle bilobectomy, which included two separate closures of the upper and middle bronchial stumps. Therefore, there were 533 bronchial stumps to be closed for 527 patients. Pulmonary resections were performed for the following diseases: lung carcinoma in 477 patients, metastatic lung tumor in 41, mediastinal tumor in one, and other diseases in eight.

The patients’ medical and operative records were critically reviewed in terms of the method of bronchial closure, troubles related to closure, and the postoperative formation of BPF. The incidence of closure failure and BPF formation was calculated according to the operative mode and method of closure. Values were compared by a chi-square test in which a P value less than 0.05 was considered statistically significant. In case expected cell frequencies are less than 5, Fisher’s exact test was employed.

Table 1

<table>
<thead>
<tr>
<th>Mode</th>
<th>Total</th>
<th>Side</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lobectomy</td>
<td>431 (397)</td>
<td>268 (246)</td>
<td>163 (151)</td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>281 (257)</td>
<td>171 (153)</td>
<td>110 (104)</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>23 (21)</td>
<td>23 (21)</td>
<td>53 (47)</td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>127 (119)</td>
<td>74 (72)</td>
<td>53 (47)</td>
<td></td>
</tr>
<tr>
<td>Bilobectomy</td>
<td>38 (33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper and middle</td>
<td>12 (9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle and lower</td>
<td>26 (24)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumonectomy</td>
<td>42 (36)</td>
<td>11 (10)</td>
<td>31 (26)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>533 (483)</td>
<td>326 (296)</td>
<td>207 (187)</td>
<td></td>
</tr>
</tbody>
</table>

Numbers in parentheses indicate numbers of closures by mechanical stapling.

2.2. Bronchial closure

In our institute, mechanical stapling was routinely used to close stumps. However, manual suturing with 3-0 prolene or 3-0 ti-cron strings was used for the following lesions or conditions: lesions located close to the pulmonary hilum, hilar (peribronchial) or mediastinal adenopathy which made it difficult to apply staplers, and/or bony hard (calcified) bronchus. Therefore, this study is a retrospective and non-randomized analysis on the outcome after bronchial closure with different types of technique.

Of the 533 bronchial stumps, 50 (9%) were closed by manual suturing and 483 (91%) were closed by mechanical stapling. For mechanical closure, various types of staplers were used. Recently, endostaplers (ENDO GIA®, ENDO GIA II®, ENDO TA®, US Surgical, Norwalk, CN, Endopath Endocutter ETS 35®, Endopath Endocutter ETS-Flex 35®, Endopath Endocutter Shield 45®, Cincinnati, OH), which were originally designed for endoscopic surgery, were most frequently used in 314 closures. Other types of conventional staplers (Roticulator®, Premium TA®, US Surgical, Norwalk, CN, Proximate Linear stapler II 30®, Cincinnati, OH) were used in 169 closures. There was no distinct criteria as to which type of staplers (endostaplers versus other conventional staplers) was chosen. However, since the endostaplers were newly advocated for routine use in this period, TA-type staplers was gradually replaced by endostaplers. However, for bronchi where endostaplers, which is a straight and non-articulated shape, were difficult for their application in a limited space, TA-type staplers continued to be used.

The bronchial stump was reinforced in 45 closures, in which risk factors for the development of BPF such as pneumonectomy, preoperative radiation, and predisposing conditions such as diabetes and liver dysfunction, were recognized. For this purpose, pedicled pericardial fat pad was used most often in 41 closures, followed by omentum in two and muscle in two. As for type of pulmonary resection, stump coverage was performed for 14 pneumonectomies, eight bilobectomies, and 23 lobectomies.

We have evaluated the outcome of bronchial closures by both stapling failure and occurrence of BPF. ‘Stapling failure’ was defined as the trouble at the time of firing the staples during the surgery which included the following: incorrect formation of staples, falling-off of staple line, incomplete division by knife, massive air leakage along the staple line, and bleeding.

3. Results

3.1. Stapling failures

Of the 483 mechanical closures, stapling failures occurred in 18 (incidence, 3.7%). The following types of stapling failures were identified: incorrect formation of
staples in 12 patients, falling-off of staple line in three, incomplete division in four, and air leakage in two. They occurred either independently or in combination. The most common failure was a problem with staple formation, in which each staple was fired but did not enfold to grasp the tissue. In such cases, the staples remained in a rectangular shape. Most of these events were the result of malocclusion between the cartridge and anvil. All of the failures were recognized during the surgery, and appropriate surgical repair was attempted at that time. Especially for those with apparent air leakage, the stapled stump was further reinforced by a manual suture and the absence of air leakage was confirmed. Although stapling failures were analyzed according to the operative mode (Table 2), no particular preference for operative mode, side, or location for the resection was observed. There was no statistical difference in incidence of stapling failure between endostaplers (4.8%) and other types of staplers (1.8%). Of the 18 patients with stapling failures, only one patient (5.6%), who underwent right pneumonectomy and in whom air leakage was found after stapling, developed BPF despite appropriate repair, while the other failure cases were uneventful.

3.2. Bronchopleural fistulas

BPFs developed in seven of 533 bronchial closures or 527 patients after surgery (incidence, 1.3%). Two BPFs developed after resection with manual suturing ($n=50$, incidence, 4%), whereas five developed in 483 mechanical closures (1%, Table 3). The difference in the incidence between manual suturing and mechanical stapling was not statistically significant. The onset of BPF ranged 5–16 days after surgery, with most cases around 10–14 days. The incidence of BPFs according to the type of stapler was also studied (Table 4): there was no difference between endostaplers and other types of stapler. Among the five BPFs after mechanical closure, only one case (20%) was associated with a stapling failure. Reinforcement was performed in 45 bronchial stumps (8%). In this group, BPFs did not occur after surgery. On the other hand, seven BPFs occurred in 488 bare bronchial stumps (1.4%).

3.3. Outcome of patients with BPF

Of the seven patients with BPFs, four died of fistula-related complications such as pneumonia and sepsis. The overall fistula-related mortality in this series was 0.7%. Three patients were cured by the fenestration and subsequent thoracoplasty with/without omentopexy.

4. Discussion

The method used to achieve bronchial closure with the lowest incidence of BPF is an important topic in the thoracic surgical community. Controversy continues regarding the relative merits of sutured versus stapled closure of the bronchus, with many advocating the superiority of stapling [1–3]. On the other hand, hand-sewn closure is still a preferred technique in some institutions [4]. In our institute, stapled closure has been routinely used. A sutured closure was considered when the tumor was located close to the
The first advantage is especially important for pulmonary resection where the bronchial closures were performed by mechanical stapling in our institute. The superiority of stapling to suturing or their equivalence cannot be concluded from the present retrospective study due to differences in backgrounds of the patients and the retrospective nature of the study. However, the incidence of BPF for stapling (1%) was within the acceptable range reported previously [6–8], and therefore, stapling can be reasonably accepted as the method of choice. For pneumonectomies, which are thought to be most likely to develop BPF among the different types of resection [5], the incidence of BPF in stapled stumps was as low as 2.8% in this series.

For this series of patients, several kinds of staplers were used. Interestingly, endostaplers were used in more than half of the patients in whom stapling was performed. Endostaplers were originally designed for use in endoscopic (thoracoscopic) procedures. Therefore, endoscopic staplers have two major differences compared to conventional TA-type staplers: both stapling and division can be performed simultaneously in only one firing motion; and both sides of the stapled ends (proximal and distal) can be closed. These features are useful even for open procedures. The possible advantages of using endostaplers in pulmonary resection are as follows: (1) Contamination of the operative field can be minimized, since both proximal and distal ends of bronchi are simultaneously and tightly closed, and therefore no discharge (which is sometimes purulent or contaminated) can leak out; (2) the time required for closure can be greatly reduced, especially compared to TA-type staplers, for which closure of the distal end of the bronchus and division are required; and (3) endostaplers can also be used safely in vascular division by selecting the appropriate cartridges. The first advantage is especially important for pulmonary resections with infectious lung diseases and tumors with extensive necrosis and abscess formation, in which early division and closure of both sides of the bronchus is preferable.

Little information is currently available concerning the reliability of endostaplers in pulmonary resections. The present results showed that endostaplers could be safely used for bronchial closure with only a 1% incidence of postoperative BPF formation, although stapling failures occurred in 4.8%. Furthermore, stapling failures were not directly related to BPF formation if such failures were properly managed intraoperatively. In fact, despite these failures, the incidence of postoperative BPF was essentially the same for both types of staplers.

Slightly higher incidence of stapling failure for endostaplers may be in part attributed to the learning curve for surgeons regarding new instruments. However, other important issues might also play a role in these stapling failures. When the cartridge is inadequately positioned, it can lead to malocclusion between cartridge and anvil, and to the subsequent failure of staples to form properly. During the operation, cartridges may be slightly shifted by strongly pushing against a hard surface such as a rib or retractor. The hard and less- flexible nature of the bronchus also play a role. Especially for endostaplers, the resistance and friction of the transecting knife is greatly increased, which subsequently induces both sides of the bronchial tissue to be enfolded. This results in the falling-off of staple lines, incomplete division, and air leakage at the point of staple penetration. Finally, a surgeons’ reckless application of staplers where the entire structure of the bronchus is not stapled may happen. However, this can be easily prevented by checking the tip of cartridge before firing. The important message here is that many stapling failures can be prevented with careful attention and knowledge about staplers.

Endostapler-type devices seem to be useful even for open pulmonary resections due to their stability and characteristics.

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References


