Is Right Sleeve Lower Lobectomy Necessary? Is It Safe?

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Introduction

The bronchial sleeve resection was developed as an alternative to pneumonectomy for patients with lung cancer generally originating from the bronchus lobe. This method is recommended particularly for patients with restricted cardiopulmonary reserves.1 Today, sleeve resections are also used in patients who can tolerate a pneumonectomy.2–6 The survival rate after sleeve resections is similar to or better than that following a pneumonectomy. The right sleeve lower lobectomy is the least used of the bronchial sleeve operations. This technique can be used in patients with non-small cell lung cancer (NSCLC) that originates from the right

Abstract

Objectives  The right sleeve lower lobectomy is the least used of the bronchial sleeve operations. There are only case-based studies in the literature. In this study, we compared this technique to those used in patients who underwent a right lower bilobectomy.

Methods  We retrospectively reviewed the data of patients who had been operated on due to non-small cell lung cancer (NSCLC) from January 2005 to December 2015 from a dataset that was formed prospectively. Of the 4,166 patients who underwent resections due to NSCLC, the files of those who had a right sleeve lower lobectomy (group S) and those who had a right lower bilobectomy (group B) were evaluated. The remaining 25 patients in group B and 18 patients in group S were compared in terms of demographic data, morbidity, hospitalization time, mortality, histopathology, recurrence, and total survival.

Results  No significant differences in the demographic or clinical characteristics were observed between the two groups, except that group S had more female patients. Postoperative complications developed in 52% of the patients in group B and 11.1% of the patients in group S (p = 0.006). Mean hospitalization time was 9.6 ± 3.6 (range, 6–19) days in group B and 6.72 ± 1.5 (range, 4–9) days in group S (p = 0.001). All patients received complete resections. The mean patient follow-up time was 42.9 months. No significant difference was found between local and distant recurrences (p = 1, p = 0.432). Mean survival time was 89.6 months (5-year rate = 73%), which was 90.6 months (5-year rate = 75.3%) in group B and 63.1 months (5-year rate = 69.3%) in group S (p = 0.82).

Conclusion  This technique allows for reduced filling of the thoracic cavity by a prolonged air leak and a reduced prevalence of complications. Additionally, the hospitalization time is shortened. It does not produce any additional mortality burden, and total survival and oncological outcomes are reliable. This technique can be used in selected patients at experienced centers.
lower lobe, invades the intermediary bronchus, and enters
the middle bronchial lobe. Mostly case-based studies are
found in the literature. In this study, we compared a right
sleeve lower lobectomy to patients who underwent a right
lower bilobectomy in terms of morbidity, hospitalization
time, mortality, histopathology, recurrence, and survival.

**Materials and Methods**

Our Institutional Review Board approved this study (version
number 2561).

We retrospectively reviewed the data of patients who had
been operated on due to NSCLC from January 2005 to
December 2015 from a dataset that was formed prospec-
tively. Of the 4,166 patients who had resections due to
NSCLC, the files of those who had a right sleeve lower
lobectomy and those who had a right lower bilobectomy
were evaluated in detail. Preoperative computed tomogra-
phy (CT) scans and bronchoscopies, as well as the surgical
results and postoperative pathology reports, of group B
patients were reviewed. Accordingly, exclusion criteria
included the presence of fissure invasion, middle lobe vas-
cular structure invasion, macroscopic tumor invasion in the
intermediary bronchus, or interlobar lymph node involve-
ment (Fig. 1).

Five surgeons who specialize in thoracic surgery were
present in our clinic during the above-mentioned period and
completed the operations. All surgeons had at least 10 years
of experience in surgical oncology. Two of these surgeons
performed the right sleeve lower lobectomies for the
patients meeting the criteria, and the remaining three per-
formed the right lower bilobectomy. The operations per-
formed and their distributions through the years are shown
in Fig. 2.

The demographic data, morbidity, hospitalization time,
mortality, histopathological characteristics, development of
relapses, and 2- and 5-year survival rates were analyzed.
Morbidities were considered undesired conditions that
developed during hospitalization or within the first
30 days following the operation. Atelectasis, atrial fibrilla-
tion, pneumonia, and prolonged air leakage (>7 days) were
investigated. Mortality was considered death occurring
within the first 30 days postoperatively or during hospitali-
ization. All patients were assessed in the presence of an
oncologist during the postoperative period. The VII TNM
staging was used for staging. Chemotherapy was adminis-
tered if needed. The patients were checked with a physical
examination and CT scan every 6 months within the first
postoperative 5 years and every year thereafter. Fiber optic
bronchoscopy and positron emission tomography CT were
requested for patients who were suspected of relapse.

**Operative Technique**

Anesthesia was administered to all patients using double-
lumen intubation. The patients underwent a thoracotomy in
the left lateral decubitus position. Each patient was staged
intraoperatively. Their fissures were opened and lymph
nodes assessed. The vascular and bronchial structures
were prepared. The intermediary bronchus was cut imme-
diately after the end of the upper lobe and the middle lobe
bronchi were cut in patients who underwent a sleeve
lobectomy (Fig. 3A). After ensuring negative surgical bron-
chial margins with a frozen section examination, an anasto-
mosis was performed continuously with 4/0 propylene
sutures (Fig. 3B). A parietal pleural flap was passed
between the bronchus and the pulmonary artery. The medi-
astinal lymph nodes were sampled systematically in

**Fig. 1** Patient group selection.
patients from both groups, and the operation ended after placing the drain. The patients were awakened in the operating room and taken to the surgical intensive care unit. A parenchymal linear stapler was used for separation when the minor fissure was incomplete on the bilobectomies. After resection, the air leaks were repaired with 3/0 polyglactin. Fibrin glue was used for a persistent air leak.

**Statistical Analysis**
Continuous variables are presented as mean ± standard deviation and discrete variables are presented as frequencies. The demographic and clinical characteristics of the patients and variables, such as age and hospitalization time, were tested for a normal distribution using the Kolmogorov–Smirnov’s test. The t-test was used to calculate the means of these variables in the two groups, and the chi-square test was used to compare morbidity between the two groups. The calculations were performed using SPSS software (SPSS Inc., Chicago, Illinois, United States). A p-value of < 0.05 was considered significant.

**Results**
The patients were divided into two groups: the bilobectomy group (group B; n = 93) and the right sleeve lower lobectomy group (group S; n = 25). Of the 93 patients in group B, 68 were excluded because they did not meet the relevant criteria and could not undergo a right sleeve lobectomy. Seven patients in group S were excluded; five underwent surgery for carcinoid tumors and two had missing data.
Twenty-five patients were included in group B compared with 18 patients in group S. In the end, the cohorts were formed from patients in the two groups who underwent a right sleeve lower lobectomy.

The mean age of group B was 56.8 ± 9.8 (range, 37–77) years and that of group S was 55.8 ± 13.7 (range, 25–79) years (p = 0.784). No females were in group B, whereas 11.1% (n = 2) of group S consisted of females (p = 0.169). No significant differences were found in the demographic characteristics of the patients between the groups (►Table 1).

Complications developed in 13 patients in group B (52%) during the postoperative period (prolonged air leak in 11 patients, pneumonia in 1, and atrial fibrillation in 1). Complications developed in two patients in group S (11.1%) (atelectasis in one patient and granulation in the middle lobe entry in one) (p = 0.006) (►Table 2).

The mean postoperative hospitalization time was 9.6 ± 3.3 (range, 6–19) days in group B and 6.72 ± 1.5 (range, 4–9) days in group S (p = 0.001). No operative mortality was observed in either group. Mean operation time was 155 ± 20 minutes in group B and 176 ± 24 minutes in group S (p = 0.005) (►Table 1).

The groups comprised mostly stage 1B patients (p = 0.443) and the histopathological assessments revealed that squamous cell carcinoma was the most common cancer in both groups (group B: 80% and group S: 83.3%) (►Table 3).

All patients received a complete resection (R0). Mean patient follow-up time was 42.9 (median, 36) months. During this time, local recurrence developed in 8% (n = 2) (postoperative 42 and 66 months) of patients in group B and in 5.6% (n = 1) (postoperative 46 months) of patients in group S (p = 1). The distant recurrence rates in groups B and S were 24% (n = 6) and 11.1% (n = 2), respectively (p = 0.432) (►Table 4).

A Kaplan–Meier’s analysis was performed for 25 patients in group B and 18 patients in group S. Mean survival was 90.6 months (95% confidence interval [CI], 73.2–108). Five-year survival was 75.3% in group B (63.1 months) (95% CI, 52.4–73.8) and 69.3% in group S (p = 0.82) (►Fig. 4).

**Discussion**

Sleeve lobectomy is a surgical technique that can generally be used in patients whose disease originates from the lobed

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### Table 1 Demographic characteristics of patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group B, n (%)</th>
<th>Group S, n (%)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>25 (100)</td>
<td>16 (88.9)</td>
<td>0.169</td>
</tr>
<tr>
<td>Female</td>
<td>0</td>
<td>2 (11.1)</td>
<td></td>
</tr>
<tr>
<td>Comorbidity</td>
<td>18 (72)</td>
<td>12 (66.7)</td>
<td>0.707</td>
</tr>
<tr>
<td>Cardiac problems</td>
<td>8 (32)</td>
<td>5 (27.8)</td>
<td>0.766</td>
</tr>
<tr>
<td>COPD</td>
<td>9 (36)</td>
<td>8 (44.4)</td>
<td>0.576</td>
</tr>
<tr>
<td>CRF</td>
<td>2 (8)</td>
<td>1 (5.6)</td>
<td>1</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>3 (12)</td>
<td>5 (27.8)</td>
<td>0.247</td>
</tr>
<tr>
<td>Hypertension</td>
<td>6 (24)</td>
<td>4 (22.2)</td>
<td>1</td>
</tr>
<tr>
<td>Previous surgery</td>
<td>2 (8)</td>
<td>5 (27.8)</td>
<td>0.112</td>
</tr>
<tr>
<td>Smoking habits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoker</td>
<td>19 (76)</td>
<td>14 (77.8)</td>
<td>1</td>
</tr>
<tr>
<td>Nonsmoker</td>
<td>6 (24)</td>
<td>4 (22.2)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CF, cardiac failure; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure.

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### Table 2 Postoperative complications and hospitalization

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group B</th>
<th>Group S</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation time (min)</td>
<td>155 ± 20</td>
<td>176 ± 24</td>
<td>0.005</td>
</tr>
<tr>
<td>Postoperative complication</td>
<td>Yes, n (%)</td>
<td>13 (52%)</td>
<td>2 (11.1%)</td>
</tr>
<tr>
<td></td>
<td>No, n (%)</td>
<td>12 (48%)</td>
<td>16 (88.9%)</td>
</tr>
<tr>
<td>Hospitalization (d)</td>
<td>9.6 ± 3.3</td>
<td>6.72 ± 1.5</td>
<td></td>
</tr>
</tbody>
</table>

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### Table 3 Histopathological comparisons

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group B, n (%)</th>
<th>Group S, n (%)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tumor histology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squamous cell carcinoma</td>
<td>20 (80%)</td>
<td>15 (83.3%)</td>
<td>1</td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td>5 (20%)</td>
<td>3 (16.7%)</td>
<td></td>
</tr>
<tr>
<td>Pathological stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1A</td>
<td>1 (4%)</td>
<td>1 (5.6%)</td>
<td>0.443</td>
</tr>
<tr>
<td>1B</td>
<td>10 (40%)</td>
<td>9 (50%)</td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td>4 (16%)</td>
<td>2 (8.7%)</td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>9 (36.0%)</td>
<td>4 (22.2%)</td>
<td></td>
</tr>
<tr>
<td>3A</td>
<td>1 (4%)</td>
<td>3 (16%)</td>
<td></td>
</tr>
</tbody>
</table>

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bronchi. This technique allows for better protection of the parenchyma and reduces postoperative complications. This option should be used regardless of the patient’s age or respiratory/cardiac function. Sleeve resections are preferred in all cases where a complete resection is possible. In their meta-analysis, Shi et al.\cite{8} showed that sleeve lobectomies are preferred more than pneumonectomies for early-stage lung cancers.

Fewer complications developed in group S in our study. Fewer incidences of prolonged air leak, in particular, can be explained by the presence of a smaller residual space in the thorax. In their bilobectomy series involving 146 patients, Galetta et al.\cite{9} reported a morbidity rate of 47% and a mortality rate of 1.4%, stating that the most frequently experienced morbidity was prolonged air leak in the thoracic space. In their study where they reviewed 1,831 bilobectomy cases, Thomas et al.\cite{10} reported that a lower bilobectomy has a threefold higher risk for developing a fistula than an upper bilobectomy. Kim et al.\cite{11} reported in their bilobectomy series of 92 patients that mortality rate was 4.3% and morbidity rate was 31%. They stressed that more problems occur in a lower bilobectomy. A retrospective study by Gómez-Caro et al.\cite{12} in which lobectomy and bilobectomy were compared showed that 7.9-fold more cardiopulmonary complications developed in patients who underwent lower lobectomy compared with those who underwent a lower lobectomy. In a study performed by Ludwig et al.,\cite{13} complication rates of bilobectomy and sleeve lobectomy were 53 versus 33%. Respiratory function 3 months postoperatively was not significantly different between the groups.

In our study, the complications that developed in group S were associated with anastomosis-related problems. These complications likely developed due to temporary bronchial edema occurring in the anastomotic line and the difficulty in clearing drainage associated with repositioning of the middle bronchial lobe. All of these complications were treated with fiberoptic bronchoscopy. The hospitalization time of group S patients was shorter due to fewer complications. Postoperative air leaks occurred less frequently due to sleeve resection because the minor fissure did not need to be separated in this group. Our previous study showed that sleeve resection has complications.\cite{14}

No operative mortality was seen in our study. As there are no series related to right sleeve lower lobectomy in the literature, no mortality comparison could be made. However, the absence of any mortality suggests that the sleeve resections had no negative effect on mortality.

No significant difference in recurrence was found between the groups. The prerequisite for performing a sleeve resection is the ability to perform a complete resection. R0 resections were performed in both groups. The absence of any difference between the local recurrences of the groups is promising for a right sleeve lower lobectomy to be performed with an appropriate indication. Similarly, no difference was found between the groups with respect to distant recurrences. Local tumor control, which is the main concern in bronchoplasty, is reportedly acceptable.\cite{2,4,6,15} While the recurrence rate ranges between 8 and 23% after a sleeve

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group B, n (%)</th>
<th>Group S, n (%)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local recurrence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2 (8%)</td>
<td>1 (4.3%)</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>23 (92%)</td>
<td>22 (95.7%)</td>
<td></td>
</tr>
<tr>
<td>Distant recurrence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>6 (24%)</td>
<td>2 (11.1%)</td>
<td>0.432</td>
</tr>
<tr>
<td>No</td>
<td>19 (76%)</td>
<td>16 (88.9%)</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 4 Survival curves of the bilobectomy and the right sleeve lower lobectomy groups.
lobectomy, it has been reported to be 10 to 14% in pneumonec-
tomies. Park et al.16 found no difference in local recurrences
between the two groups.

Parenchymal protective surgery is associated with better
prognosis and survival, particularly for early-stage lung
cancers. The studies of Okada et al,4 Deslauriers et al,5 and
Takeda et al3 reported better survival rates after sleeve
lobectomy administered to stage 1 and stage 2 patients.
Lobectomy and pneumonectomy have been compared for
survival in sleeve studies. No difference was found in our
study between 5-year survival of the bilobectomy group and
survival of the sleeve lower lobectomy group.

Limitations

The limitations of our study are that it was retrospective; the
number of patients was small because a right sleeve lobec-
tomy can only be applied to a relatively limited number of
patients; the operations were performed by different sur-
geons; and general survival was calculated rather than
survival by stages, as the number of patients was small. In
many series, male sex is a risk factor for complications.
However, it was not evaluated in our study because of the
absence of females in group B. The mean age of patients in
our study was lower than in oncological surgery patients in
the literature. The reason for this is that the mean age of
patients with NSCLC treated with surgery between these years
was 56 ± 15.2 years. Therefore, our age-related complication
rate was low. The patients’ postoperative lung function was
not compared between the groups due to missing data.

Conclusion

Our study showed that due to protection of the middle lobe,
it was easier for the lung to fill the thoracic cavity, leading to
reduced rates of prolonged air leakage and other complica-
tions. Consequently, hospitalization time was shortened. The
surgical technique did not bring an additional mortality
burden and the survival rate and oncological outcomes
were reliable. Therefore, we believe that this method should
be preferred for appropriate patients at experienced centers.

Conflict of Interest

The author(s) declare no potential conflict of interest with
respect to the research, authorship, and/or publication of
this article.

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