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Original Article

Right Lower Sleeve Lobectomy: Detailed Technique and Perioperative Patient Management

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Purpose: This report reviews our experience with right lower sleeve lobectomy and describes our technique and approach to perioperative patient management.
Methods: We retrospectively reviewed 11 patients who underwent right lower sleeve lobectomy for lung cancer. Surgical techniques and perioperative management were also investigated.
Results: Bronchoplasty was performed using 4-0 absorbable monofilament sutures. The deepest portion was anastomosed using continuous sutures; interrupted sutures were used for the more superficial portions. The truncus intermedius and right middle lobe bronchus should be anastomosed in a natural position. Anastomosis patency was confirmed using intraoperative bronchoscopy. Separation of the right upper and middle lobes and pericardiotomy at the inferior edge of the superior pulmonary vein are useful for mobilizing the right middle lobe. Death during hospitalization and treatment-related death did not occur. One patient developed pneumonia, and another developed a bronchopleural fistula.
Conclusion: We reported our technique of right lower sleeve lobectomy and our approach to perioperative patient management. Sharing knowledge is essential to completing this rare surgery.

Keywords: primary lung cancer, right lower sleeve lobectomy, technique, perioperative management

Introduction

Right lower sleeve lobectomy is commonly used to treat right lower lobe lung cancer which infiltrates the truncus intermedius or has metastasized to the hilar lymph nodes. The procedure partially preserves lung parenchyma and therefore respiratory function.[1,2] This report reviews our experience with right lower sleeve lobectomy and describes our technique and approach to perioperative patient management.

Materials and Methods

We retrospectively reviewed 11 patients with lung cancer who underwent right lower lobe sleeve lobectomy in our institution from January 2017 to December 2022. Patients who had undergone preoperative treatment were excluded. All patients provided written informed consent for the operation and the use of their data in a clinical study. Institutional ethics committee approval was obtained (approval no. 4403; date, October 3, 2019).

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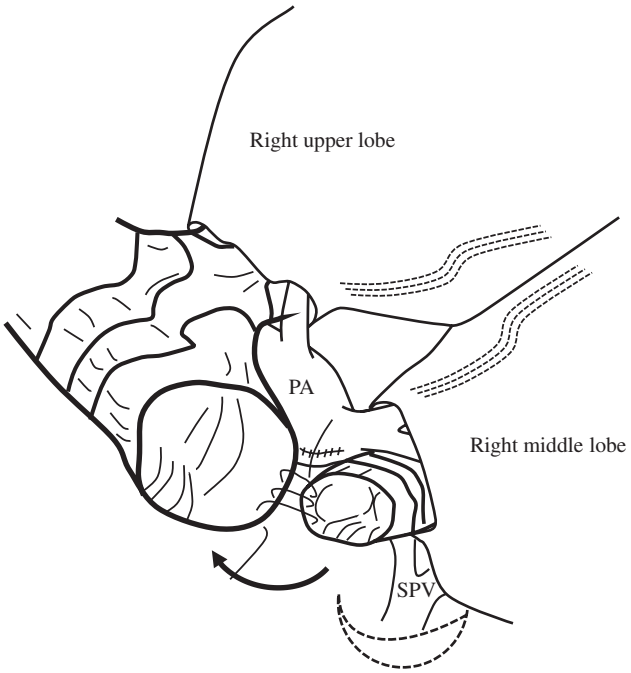

Fig. 1 Separation of the right upper and middle lobes and pericardiotomy at the inferior edge of the superior pulmonary vein assist with mobilization of the right middle lobe. PA: pulmonary artery; SPV: superior pulmonary vein

Clinical and pathological staging was performed according to the eighth edition of the TMN Classification of Malignant Tumors.[3] Mediastinal lymph nodes with a short axis >10 mm on computed tomography were diagnosed as metastases. The criteria for surgical resection were as follows: absence of distant metastasis, absence of malignant pleural or pericardial effusion, absence of N2 disease at two or more mediastinal levels, absence of bulky N2 disease, absence of N3 disease, and predicted postoperative vital capacity >40%.

Adjuvant chemotherapy was initiated at the discretion of the treating physician. Patients with pathological stage II and III lung cancer received adjuvant platinum-based doublet chemotherapy; those with stage I disease received adjuvant oral tegafur.

Our technique for right lower sleeve lobectomy and approach to perioperative management are described below. After thoracotomy, pulmonary resection and airway reconstruction are performed. **Figure 1** shows the technique for middle lobe mobilization. Separation of the right upper and middle lobes is essential. In addition, the pericardium is cut at the inferior edge of the superior pulmonary vein to complete mobilization.[4] The axes of the right middle lobe bronchus and truncus intermedius are irregular because the middle lobe is rotated dorsally after the sleeve right lower lobectomy. Both bronchi should be anastomosed in a natural position. A separation between the upper and middle lobes should be provided in all cases, although there is no excessive tension. An insufficient separation between the right and middle lobes may inhibit the anastomosis in a natural position and increase the risk of bronchial kinking. We recommended two to three rings of cartilage as the appropriate length for the truncus intermedius and 5–10 mm from the bifurcation of the middle lobe segmental bronchus as the appropriate length for the right middle bronchus. Bronchoplasty is performed using 4-0 absorbable monofilament sutures. The deepest portion is anastomosed using continuous sutures; interrupted sutures are used to anastomose the more superficial portion. To correct caliber mismatch, large-caliber bronchial stumps are sewed with a wide pitch, and small-caliber bronchial stumps are sewed with a narrow pitch; no other special methods are used. Because the middle lobe bronchus is fragile, we should grasp it gently. Layer-to-layer bronchial anastomosis is a standard, but not strictly so, technique. Because of caliber mismatch, a distal stump often enters a proximal stump, as in a telescopic anastomosis. Intraoperative pathological examination is used to confirm the absence of cancer cell infiltration in the bronchial stumps. Anastomosis patency is confirmed using intraoperative bronchoscopy. A sealing test (pressure, 15 cmH_2O) is then performed at the end of the operation. Anastomosis sites are circumferentially covered with

a pedicle pericardial fat pad. Lymph node dissection at inferior mediastinal, superior mediastinal, and subcarinal zones is routinely performed before pulmonary resection. One or two drainage tubes are placed in the surgical cavity.

Chest computed tomography and bronchoscopy are routinely performed 1 week after surgery. Bronchoscopy is repeated as needed until the anastomosis has completely healed. After discharge, all patients undergo follow-up chest radiography and measurement of tumor markers every 2 to 4 months. Computed tomography is performed at 6 months and then yearly. We do not measure respiratory function routinely after the operation.

Results

Patient characteristics are shown in **Table 1**. The most common histological subtype was squamous cell carcinoma. **Figure 2** shows the bronchial anastomosis in two patients. Both anastomoses were performed with both bronchi in their natural position. However, the axes between the truncus intermedius and middle lobe bronchus were different in each case.

The median follow-up was 34 months. Death during hospitalization and treatment-related death did not occur. A curve of overall survival is shown in **Fig. 3**. Three- and five-year survival rates are 90 and 72%, respectively. One patient developed pneumonia, which may have been caused by sputum retention at a narrow anastomosis. This patient's bronchi were anastomosed in an unnatural position and the middle lobe bronchus became kinked and constricted. A length of middle lobe bronchus was too long, which might be one of the reasons for kinking. The patient was treated using antibiotics and repeated bronchoscopy. In addition, another patient developed a bronchopleural fistula (BPF). In this patient, bronchoscopy revealed ischemic changes in the proximal mucosa at anastomosis. An excessive length of the trunk intermedius may be a reason for BPF. He then underwent a middle lobe lobectomy.

Discussion

Right lower sleeve lobectomy is rarely performed and has not been well studied. Sufficient clinical courses of right sleeve lower lobectomy were reported.[1] Operation time and length of hospital stay were shorter in their study than ours; however, their patients were younger and many had earlier-stage cancer. The 5-year survival rate after right lower sleeve lobectomy was reported to be 69.3%.[1] The prognoses of our patients were better than those of previous reports. We cannot show pulmonary function after the right lower sleeve lobectomy due to missing data. However, the beneficial effect of right middle lobe preservation on respiratory function was previously reported.[2] One patient had BPF and another had pneumonia. Incidences of BPF and pneumonia after sleeve lobectomy were reported to be 6% and 10%, respectively.[5,6] The incidence of pneumonia in this study is similar to that of previous reports. Excessive length and ischemia of the trunk intermedius might be a cause of BPF in our patient. We will be able to avoid BPF by the appropriate length of trunks intermedius and perioperative managements, which are described in this article. Right lower sleeve lobectomy may be a feasible method for lung cancer patients.

It is easy to recognize the correct bronchial axis at the anastomosis site when the peripheral bronchus has a membranous portion or when both bronchi can be connected by horizontal movement alone. When performing a right lower sleeve lobectomy, the right middle lobe bronchus is connected to the truncus intermedius using both horizontal and rotatory movements. The degree of rotatory movement required depends on the number and direction of the middle lobe vessels and the volume and form of the preserved middle lobe. The middle lobe bronchus is soft and can become kinked and constricted when the bronchial axis is irregular. When performing the anastomosis, visualization of the narrow lumen of the right middle bronchus is difficult. We suggest using intraoperative bronchoscopy to confirm its patency once the anastomosis has been completed.

Adequate mobilization of the right middle lobe avoids tension at the anastomosis site and requires separation of the upper and middle lobes. One patient in our study developed a BPF, which may have been caused by ischemia at the proximal edge of the anastomosis. An excessively long proximal stump can decrease blood flow at the truncus intermedius. We recommend using two to three rings of cartilage as the length for the truncus intermedius. This enables easy suturing and avoids ischemia at the proximal stump. However, limiting the proximal stump length can generate more tension at the anastomosis site. Pericardiotomy at the inferior edge of the superior pulmonary vein is also useful for mobilizing the right middle lobe.[4] This technique enables horizontal movement and overcomes any tension at the anastomosis site in most cases. We previously reported that low

Table 1 Characteristics of patients in the study

	n = 11
Age (in years)	70 (38–84)*
Gender	
Male/female	6/5
Smoking history	
Yes/no	9/2
Clinical T factor	
1/2/3	6/4/1
Clinical N factor	
0/1/2	3/2/6
Clinical stage	
I/II/III	2/3/6
Histological subtypes	
Squamous cell carcinoma	6
Adenocarcinoma	3
Others	2
Operation time (min)	341 (238–526)*
Hospitalizations (days)	13 (8–33)*
Pathological T factor	
1/2/3	4/5/2
Pathological N factor	
0/1/2	2/4/5
Pathological stage	
I/II/III	1/5/5
Adjuvant chemotherapy	5 (45%)

*Values given are median (range).

body mass index (BMI) was a significant risk factor for respiratory complications after bronchoplasty with caliber mismatch.[7] A patient with BPF in this study had a relatively low BMI (19.8 kg/m^2). BMI before surgery may be an important criterion for surgical indication of the right lower sleeve lobectomy. The appropriate length of the middle lobe bronchus may be 5–10 mm from the bifurcation of the middle lobe segmental bronchus. This length prevents the anastomosis line from covering the cartilage between the middle lobe segmental bronchus. Because the right middle bronchus does not have a cartilaginous ring, it is expanded to fit the trunk intermedius. However, the cartilage between the segmental bronchus is hard. When the anastomosis line covers the cartilage between the segmental bronchus, the right middle bronchus cannot enough dilate, which may cause BPF or stenosis. We should avoid the preservation of the right middle lobe when the appropriate length of the middle lobe bronchus cannot be kept due to tumor or metastatic lymph node infiltrations.

It was previously reported that the use of a bronchial flap was very beneficial in adjusting this caliber mismatch.[8] However, we considered that the long stump of the right middle bronchus could be easily kinked because of the absence of a cartilaginous ring. One patient developed pneumonia owing to the kinking of the distal bronchus. We suggest a special technique is not required to correct the caliber mismatch between the middle bronchus and trunk intermedius.

Air leakage after lobectomy usually originates from the cut edges of interlobar formation. In the right lower sleeve lobectomy, we need up to three interlobar formations. Because the preserved middle lobe rotates dorsally to different degrees after lower sleeve lobectomy, the size, and location of the residual thoracic cavity differ between individual patients. Placement of a single drain is generally recommended after pulmonary resection.[9,10] It is sometimes difficult to expect effective placement of a drainage tube during the operation. We recommend placing two drains after right lower sleeve lobectomy, especially in patients with an emphysematous lung because pulmonary emphysema is a risk factor for prolonged air leakage after pulmonary resection.[11]

Complications of a BPF include infection in the pleural cavity and bronchopulmonary artery fistula, which is potentially catastrophic. Surgically, the bronchial anastomosis is isolated from the pleural cavity by covering it with a pericardial fat pad, which may help to avoid both pleural cavity infection and bronchopulmonary artery fistula after BPF.[12] It was reported that BPF developed 180 days after anatomical lung resection.[13] A bronchovascular fistula developing 163 days after bronchoplasty has been reported.[14] It is important that the pedicle flap intervenes for a long term between the bronchial anastomotic site and the pulmonary artery. We usually use a pedicle pericardial fat pad because their volumes are preserved sufficiently after 6 months.[15] After bronchial sleeve resection, there is a length difference between the shortened bronchus and the pulmonary artery. Horizontal movement of the lung parenchyma may cause pulmonary artery kinking.[16] The presence of the pericardial fat pad around the anastomosis site may warp the pulmonary artery and prevent this. We have never experienced a patient with a vascular complication.

Video-assisted thoracoscopic (VATS) lobectomy can be safely taught to surgeon trainees. Surgical outcomes after VATS lobectomy are similar between trainees and attending surgeons.[17] We suggest that the sleeve lobectomy technique and perioperative patient management differ from those of simple lobectomy. In our institution, procedures are performed using thoracotomy rather than VATS to share the technique among team members.

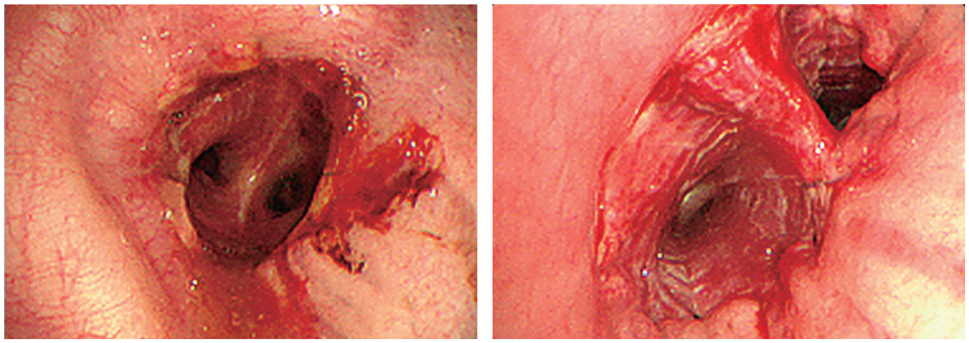

Fig. 2 The right middle lobe rotates dorsally after the right lower sleeve lobectomy. The degree of rotation differs among individual patients. When the middle lobe bronchus and the truncus intermedius are anastomosed in a natural position, the axes of both bronchi differ between patients.

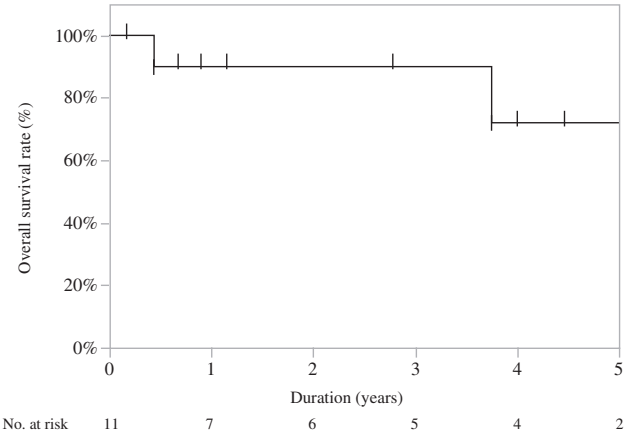

Fig. 3 Curve of overall survival among 11 patients who underwent right lower sleeve lobectomy for right lower lobe lung cancer.

Accordingly, both trainee and attending surgeons are allowed to perform sleeve lobectomy. The reliability of VATS[18] or robotic sleeve lobectomy[19] has been reported. However, these procedures are usually performed by experienced surgeons. How to teach complex thoracoscopic surgical techniques remains a clinical question.

This study has several limitations. First, it was small in scale and retrospective in design. Data from postoperative respiratory function tests are especially essential to investigate the beneficial effect of this surgical method on respiratory function preservation. The accumulation of data from more patients and further analyses are currently underway. Second, the follow-up period was short. Our future studies will report long-term outcomes. Finally, we could not evaluate the validity of right lower sleeve lobectomy compared with right middle and lower bilobectomy because the right middle and lower bilobectomy was a rare method in our institute. Although our patients had relatively advanced lung cancer, they had favorable prognoses. We investigated clinical courses and surgical techniques strictly and showed appropriate perioperative management of the right lower sleeve lobectomy. We will be able to decrease surgical complications and establish the validity of this surgical method after the accumulation of patients' data.

Conclusion

We reported our technique of right lower sleeve lobectomy and our approach to perioperative patient management. Sharing of knowledge is essential to complete a rare surgery.

Declarations

Ethics approval and consent to participate

Institutional ethics committee approval was obtained (approval no. 4403; October 3, 2019). All patients

provided written informed consent for the operation and the use of their data in a clinical study.

Consent for publication

We obtained written informed consent from the patient for publication.

Data availability

Not applicable.

Author contributions

Hidetoshi Inoue and Takuma Tsukioka designed this study, analyzed the data, prepared the figures, and wrote the original draft. Nobuhiro Izumi and Noritoshi Nishiyama oversaw the study and revised the article. All authors reviewed the article.

Disclosure statement

The authors have no conflicts of interest to declare.

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