

Advanced Lung Cancer Invading the Left Atrium Wall Treated with Pneumonectomy and Combined Resection of the Left Atrium Using Stapling Devices: Report of Two Cases

Junzo Shimizu, MD,¹ Yasumitsu Hirano, MD,¹ Yoshinori Ishida, MD,¹
Seiichi Kinoshita, MD,¹ Yasuhiko Tatsuzawa, MD,¹ Yukimitsu Kawaura, MD,¹
and Shiro Takahashi, MD²

In chest surgery, stapling devices are primarily used to close bronchi. However, they are also used for dissection and suturing between lung lobes, resection and plication of lung tissue (including bullae), combined resection of the superior vena cava, closure of the pulmonary great vessels, closure of the left atrium following combined resection of the left atrium, and so on. We recently treated two cases of advanced lung cancer, which had invaded the left atrial wall, with pneumonectomy and combined resection of the left atrium using stapling devices, and obtained favorable results. For combined resection of the left atrium, it is safer to use stapling devices than vascular clamps, since the latter involve the risk of dislocation during use. Furthermore, since stapling devices require no margin for suturing, the left atrium can be resected at a point sufficiently distant from the cancer, thus allowing for highly radical resection. Stapling devices are also useful because they can be manipulated even within narrow operative fields. When dealing with lung cancer requiring combined resection of the left atrium, pneumonectomy is needed in most cases. When performing surgery for these cases, it is essential to first close and divide the bronchi and pulmonary arteries and veins as far as possible so that adequate adherence around the left atrium can be developed and the entire lung can be lifted up, followed by resection of the left atrium with a stapling device applied to the left atrium without any tension. (Ann Thorac Cardiovasc Surg 2004; 10: 113–7)

Key words: advanced lung cancer, left atrial invasion, combined resection of left atrium, stapling device

Introduction

Patients undergoing extended surgery for T4 lung cancer often have a poor prognosis, so that it is controversial which cases of T4 lung cancer should be treated by surgery.¹⁾ Of organs which are resected together with the lung for treatment of T4 lung cancer, the left atrium and superior vena cava (SVC) are considered to be indicated for resection at many facilities.²⁾ This is because these

From Departments of ¹Surgery and ²Radiology, Saiseikai Kanazawa Hospital, Kanazawa, Japan

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Address reprint requests to Junzo Shimizu, MD: Department of Surgery, Saiseikai Kanazawa Hospital, Ni 13-6, Akatsuchi-machi, Kanazawa 920-0353, Japan.

two organs are adjacent to the lung and are more prone to tumor invasion (although this possibility can vary depending on the location of the primary tumor) and because the operative technique is relatively simple when the left atrium and/or the SVC is resected together with the lung. We recently treated two cases of advanced lung cancer, which had invaded the left atrial wall, with pneumonectomy and combined resection of the left atrium using stapling devices. Since little information is available regarding use of staplers for the closure and division of the left atrium during pulmonary resection, this paper presents the two cases in detail and discusses the possible advantages, necessary precautions, and so on, when using stapling devices for combined resection of the left atrium.

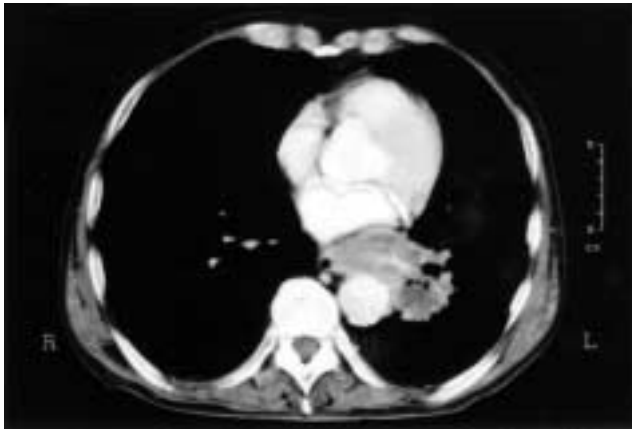


Fig. 1. Chest CT scan (Case 1).

The bronchi of the left lower lobe are obstructed by the tumor, and atelectasis is visible in the lower lobe. Tumor invasion of the left atrium and esophagus is also visible.



Fig. 2. Intraoperative finding 1 (Case 1).

After closure and division of the bronchi and pulmonary arteries and veins, the left atrium has been pulled out and the entire lung has been lifted up, followed by use of a stapling device.

Case Reports

Case 1

The patient was a 78-year-old man with chief complaints of cough and fever. In November 2002, he began to complain of these symptoms and consulted a nearby clinic, where chest X-ray showed an abnormal shadow in the left lung field. He was referred to the internal medicine clinic of our hospital, where bronchoscopy indicated obstruction of the bronchi of the left lower lobe. Squamous cell carcinoma (SCC) was diagnosed on the basis of forceps biopsy by means of bronchoscopy. The patient was then referred to our department to undergo surgery. Blood biochemistry showed signs of anemia and inflammation. Of the serum tumor markers tested, SCC antigen was 0.6 ng/ml (range, 0-1.5 ng/ml), carcinoembryonic antigen (CEA) 1.1 ng/ml (range, 0-2.5 ng/ml), neuron-specific enolase (NSE) 6.1 ng/ml (range, 0-10 ng/ml), and cytokeratin 19 fragment (CYFRA 21-1) 3.7 ng/ml (range, 0-3.5 ng/ml). Only CYFRA 21-1 was thus slightly higher than normal. Chest computed tomographic (CT) scans demonstrated obstruction of the left lower lobe bronchi by the tumor and atelectasis in the lower lobe. The cancer appeared to have invaded the left atrium, esophagus and descending aorta (Fig. 1). Respiratory function test results suggested obstructive disorder because vital capacity (VC) was 3.20 L, %VC 105.3%, forced expiratory volume in 1 second (FEV_{1.0}) 2.00 L, and FEV_{1.0}% 63.5%. Arterial blood gas analysis yielded the following favorable results: pH, 7.441; arterial partial pressure of carbon diox-

ide (PaCO₂), 43.2 mmHg; arterial partial pressure of oxygen (PaO₂), 87.8 mmHg; base excess (BE), 3.8 mmol/L.

On the basis of these results and findings, the patient was diagnosed as having SCC originating from the lower lobe of the left lung and tumor invasion of the left atrium and esophagus was strongly suspected. Left pneumonectomy with combined resection of the tumor-invaded organs was considered indicated for this case. On December 6, 2000, the patient underwent surgery. The tumor, 8 cm in diameter, was located in the hilar region of the lower lobe of the lung and had invaded the pericardium. No tumor invasion of the aorta was visible. Since the esophagus showed adhesion but appeared to be free of tumor invasion, the tunica adventitia of the esophagus was only partially resected. The left main pulmonary artery (PA) was manipulated with TX30V® (Johnson & Johnson Co., Cincinnati, OH), the superior pulmonary vein (PV) ligated and cut, and the left main bronchus manipulated with TA30-4.8® (U.S. Surgical Co., Norwalk, CT). The inferior PV was difficult to expose due to presence of the tumor. The pericardium was therefore opened from the point of tumor invasion with a sufficient margin to keep the entire left lung lifted up. Finally, the tumor-invaded left atrium was drawn out and stapled with a TX60-3.5® (Johnson & Johnson Co.) with an adequate margin (Fig. 2), followed by resection (Fig. 3). Left pneumonectomy was thus completed without bleeding from the left atrial stump. The pericardial defect was closed with an expanded polytetrafluoroethylene (ePTFE) patch. The operation was completed with the placement of a thoracic drain.

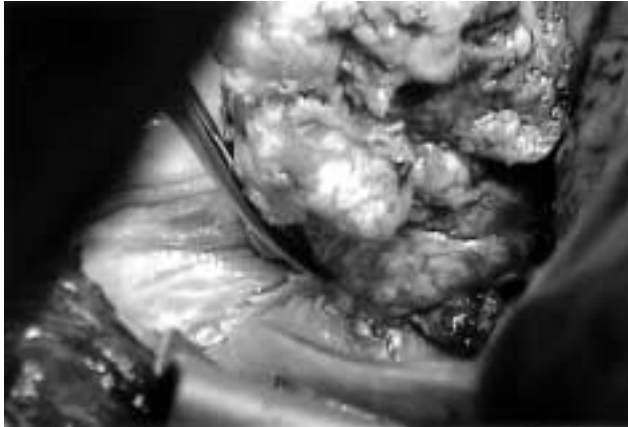


Fig. 3. Intraoperative finding 2 (Case 1).
The left atrium is divided with scissors after stapling.

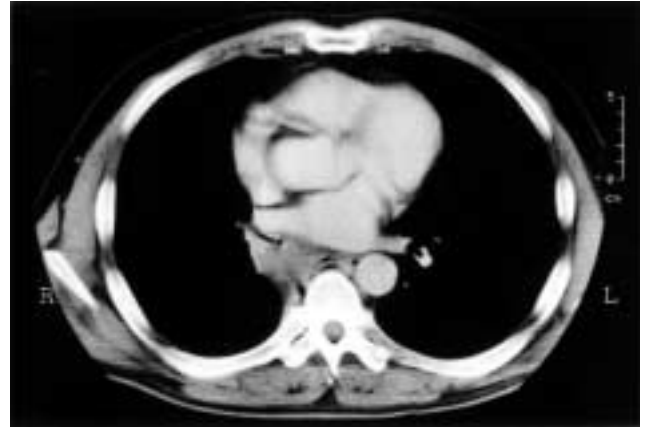


Fig. 4. Chest CT scan (Case 2).
The bronchi of the right lower lobe are obstructed by the tumor, and atelectasis is visible in the lower lobe. Tumor invasion of the left atrium and esophagus is also visible.

The resected tumor was histopathologically rated as a well-differentiated SCC, 7.5 cm in diameter. Tumor invasion of the left atrium, pericardium and fat tissue of the hilar region of the lung was noted. No tumor metastasis was detected in the excised lymph nodes.

The postoperative course was uneventful. Administration of an oral anti-cancer drug [UFT® (Taiho Pharmaceutical Co., Ltd., Tokyo, Japan)] was started and continued as adjuvant therapy. The patient was discharged from the hospital on the 28th hospital day. He died of contralateral pulmonary metastases 1 year and 10 months after surgery.

Case 2

The patient was a 52-year-old man with chief complaints of coughing and bloody sputum. On April 4, 2000, the patient began to complain of coughing, which exacerbated gradually and was later accompanied by bloody sputum. In October of the same year, he consulted a nearby clinic, where an abnormal shadow was detected in the right hilar region. He was referred and admitted to our department where he received a detailed examination followed by treatment. Blood biochemistry results showed nothing noteworthy. Of the tumor markers, SCC (0.6 ng/ml) and NSE (9.0 ng/ml) were normal, but CEA (4.1 ng/ml) was higher than normal (range, 0-2.5 ng/ml). Chest CT scans indicated atelectasis in the right lower lobe due to obstruction of the lower lobe bronchi by the tumor, and showed signs of tumor invasion of the left atrium and esophagus (Fig. 4). Bronchoscopy demonstrated that the intermediate bronchial trunk had an irregular epithelium, the middle lobe bronchi were patent, but the lower lobe

bronchi had been completely obstructed by the tumor and were hemorrhagic. Brushing of the lower lobe bronchi led to a diagnosis of class V (SCC), and the respiratory function test detected signs of obstructive disorder (VC, 3.84 L; %VC, 103.5%; FEV_{1.0}, 2.13 L; FEV_{1.0}%, 54.8%). The arterial blood gas analysis showed that pH (7.451), PaCO₂ (41.1 mmHg), PaO₂ (87.3 mmHg) and BE (5.0) were approximately normal.

On the basis of these results and findings, the patient was diagnosed as having SCC originating from the lower lobe of the right lung with a strong suspicion of tumor invasion of the left atrium and esophagus. Right pneumonectomy with combined resection of the tumor-invaded organs was considered indicated for this case. On November 29, 2000, the patient underwent surgery. The tumor was 5 cm in diameter, located in the hilar region of the lower lobe of the right lung, and had invaded the pericardium. Since the esophagus showed adhesion but appeared to be free of tumor invasion, the tunica adventitia of the esophagus was only partially resected. The right main PA was manipulated with TX30V®, and the superior PV was ligated and cut, followed by manipulation of the right main bronchus with TA30-4.8®. The inferior PV was difficult to expose due to presence of the tumor. The pericardium was therefore opened from the point of tumor invasion with a sufficient margin, to keep the entire right lung lifted up. Finally, the tumor-invaded left atrium was drawn out and stapled with a TA55-3.5® (U.S. Surgical Co.) with adequate margin, followed by resection. Right pneumonectomy was thus completed without bleed-

ing from the left atrial stump. The pericardial defect was closed with an ePTFE patch. The operation was completed with the placement of a thoracic drain.

The resected tumor was histopathologically rated as a well-differentiated SCC, 5.0 cm in diameter. Tumor invasion of the left atrium, pericardium and fat tissue of the hilar region of the lung was noted, as well as tumor metastasis in the excised hilar lymph nodes.

The postoperative course was uneventful. Administration of an oral anti-cancer drug (UFT®) was started and continued as adjuvant therapy. The patient was discharged from the hospital on the 24th hospital day. When metastasis to lymph nodes of the right neck and mediastinum was detected two years after surgery, the patient received 60 Gy radiotherapy and two courses of chemotherapy with cis-platinum and vinorelbine. At present, 2 years and 11 months after surgery, the patient is alive with disease.

Discussion

Anatomically, the left atrium is contiguous, via the pulmonary vein, to the lung hilus. For this reason, direct invasion by lung cancer of an origin near the lung hilus is more likely to occur in the left atrium than in the right atrium and the two ventricles. The pattern in which lung cancer invades the left atrium can be morphologically divided into two types. In the first, the tumor invasion occurs contiguously from the base of the pulmonary vein affected by the primary tumor, and in the second the posterior wall of the left atrium is directly invaded by the primary tumor or metastatic lymph nodes. The first seems to be treated more frequently with combined resection of the left atrium, while the second seems to be frequently an outcome of perinodal invasion by the tumor which has metastasized to the lymph nodes at the tracheal bifurcation.³⁾

Extended surgery for the treatment of lung cancer invading the left atrium has a long history. Combined resection of the left atrium was started in 1946 when Allison⁴⁾ performed surgery for lung cancer which involved removal of pulmonary vessels within the pericardium. Later, extended radical surgery, including combined resection of the left atrium, was performed for cases of lung cancer invading the left atrium.⁵⁾ However, most of the previous reports on this surgery pertained to combined resection of the left atrium involving the use of vascular clamps, and the results were not always satisfactory.³⁾ However, there were patients who survived for long peri-

ods of time after complete resection of SCC combined with resection of the left atrium, although the number of such cases was small.¹⁾ Therefore, the significance of surgery has been recognized for cases of SCC where combined resection of the left atrium using vascular clamps is possible.⁶⁾

In cases of severe tumor invasion of the left atrium, combined resection of the left atrium using vascular clamps is not possible. For this reason, recent reports have dealt with combined resection of the left atrium using cardiopulmonary bypass (CPB).⁵⁻⁸⁾ However, this procedure has not led to long-term survival of the patients because of problems such as increased blood loss during or after surgery due to the effects of heparin and the risk of systemic dissemination of cancer cells due to cell-mediated immunity impairment following CPB. Consequently, the prevailing view is against the use of CPB for this kind of surgery.⁹⁾ Most cases of lung cancer, which has invaded the left atrium, judged to be indicated for surgery, are therefore cases where vascular clamps can be applied deep inside the left atrium for subsequent resection while the lung is kept lifted up.

When performing this type of surgery, it must be borne in mind that massive bleeding can be caused by dislocation of the vascular clamps. In cases where adequate exposure of the left atrium is difficult due to tumor invasion and the left atrium needs to be manipulated in a restricted operative field, highly reliable vascular clamps are needed to make it possible to close the left atrium by suturing after combined resection of the left atrium with partial clamps. In such cases, stapling devices provide a much more reliable means of closing the left atrium by suturing. We therefore adopted such devices many years ago.

Cases indicated for combined resection of the left atrium using stapling devices or vascular clamps are exactly the same, so that resection using stapling is possible in all cases where resection using vascular clamps is possible. Combined resection of the left atrium with stapling has the following advantages: (1) extensive resection of the left atrium, with the cut edge placed sufficiently distant from the tumor, is possible because this resection requires no margin for suturing; (2) suturing can be done uniformly, reliably, simply and rapidly; and (3) manipulation is possible even in a restricted operative field and stapling is clearly more reliable than manual suturing.

In the field of chest surgery, stapling devices were first introduced for bronchus closing,¹⁰⁾ which, as a result, has become easier and more reliable. This means that the sur-

geon can spend more energy to ensure complete resection of the cancer and complete dissection of regional lymph nodes when performing lung cancer surgery. The introduction of stapling devices into clinical practice can thus be considered an epoch-making event. Later, stapling devices began to be used for various other purposes, such as closing the stump of lung tissue (including bullae), dissecting and suturing between lung lobes, and closing the great vessels^{11,12} (SVC, main PA, and superior and inferior PV) and left atrium. However, little information is available regarding the closure and division of the left atrium with staplers during pulmonary resection. We are aware of only one paper in English by Asamura et al.¹³ reporting that pulmonary vascular structures, both PAs and PVs, can be closed and divided safely with the aid of stapling devices with a very low incidence of stapling failure.

In cases where tumor invasion of the left atrium is not extensive, the unresected part of the left atrial wall can be sutured and closed with three staple lines if a vascular stapling device with a staple line of 30 mm [TA30V_s[®] (U.S. Surgical Co.) or TX30V[®]] is used. These stapling devices seem to be highly reliable as a means of closing the left atrium. In cases where tumor invasion of the left atrium is extensive, stapling devices with a longer staple line, such as TA55[®] (U.S. Surgical Co.) and TX60[®] (Johnson & Johnson Co.), are needed. When using both types of stapling devices, care must be paid to the fact that they have two staple lines. To date, however, we have experienced no instances of bleeding from the atrium after closure and division of the left atrium with the aid of these stapling devices.

In most cases of lung cancer which require combined resection of the left atrium, the cancer is an advanced disease involving pneumonectomy. For such surgery, it is essential to first close and divide the bronchi, PA and PV as far as possible so that adequate adherence around the left atrium can be developed and the entire lung can be lifted up, followed by resection of the left atrium with a stapling device applied to the left atrium without any tension. A TA or TX type stapling device, which allows for separate suturing and division, is safer. Endostaplers designed for minimum invasive surgery should be avoided for combined resection of the left atrium, because this type of device performs suturing and division at the same time and miss-firing can have fatal results.

In conclusion, this paper has presented two cases of advanced lung cancer with invasion of the left atrium, where favorable results were obtained with pneumonectomy and combined resection of the left atrium using stapling devices. Possible advantages and necessary precautions when using stapling devices for combined resection of the left atrium were also discussed.

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