Surgical Technique

Pulmonary arterioplasty using video-assisted thoracic surgery mechanical suture technique

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Abstract: Lung cancer invading pulmonary trunk is a locally advanced condition, which may indicate poor prognosis. Surgical resection of the lesion can significantly improve survival for some patients. Lobectomy/Pneumonectomy with pulmonary arterioplasty via thoracotomy were generally accepted and used in the past. As the rapid development of minimally invasive techniques and devices, pulmonary arterioplasty is feasible via video-assisted thoracic surgery (VATS). However, few studies have reported the VATS surgical techniques. In this study, we reported the techniques of pulmonary arterioplasty via VATS.

Keywords: Lung cancer; arterioplasty; video-assisted thoracic surgery (VATS); surgery; pulmonary artery

Submitted Dec 10, 2015. Accepted for publication Jan 18, 2016.
doi: 10.21037/jtd.2016.01.61
View this article at: http://dx.doi.org/10.21037/jtd.2016.01.61

Introduction

Lung cancer invading pulmonary trunk is not uncommon. Traditionally, the removal of the superior vena cava requires occlusion of a part of the sidewall by a clamp or complete occlusion of the pulmonary trunk from the proximal to distal ends. When a video-assisted thoracic surgery (VATS) manual suture technique is applied, more operation ports are required to facilitate the blockage of the pulmonary trunk; or, many surgical devices need to pass through the same port; in addition, the suturing needs to be performed using needle holders. Thus, this technique is highly challenging for most thoracic surgeons. Few articles have reported the application of complete VATS techniques in patients with lung cancer invading the pulmonary trunk. Automatic mechanical suturing enables the direct resection of the lateral wall of pulmonary trunk and avoids the blockage of pulmonary trunk and manual suturing, thus lowering the difficulty of minimally invasive surgery.

Case 1 presentation

Patient

A 60-year-old smoking male patient was admitted due to recurrent cough for over 2 months. Chest CT indicated the presence of right upper lobe carcinoma and obstructive pneumonia (*Figure 1*). Bronchofiberscopy indicated that the lesion was a squamous cell carcinoma. No distant metastasis was detected. In order to achieve satisfactory effectiveness of radical treatment, we further discussed the disease condition and treatment protocol with the patient and his family and with other colleagues in our department and then decided to carry out Preoperative neoadjuvant chemotherapy. After three cycles of treatment, chest CT showed that the tumor remarkably shrank (*Figure 2*). Preoperative assessment showed good heart and lung function. Pulmonary arterioplasty by VATS was then scheduled.

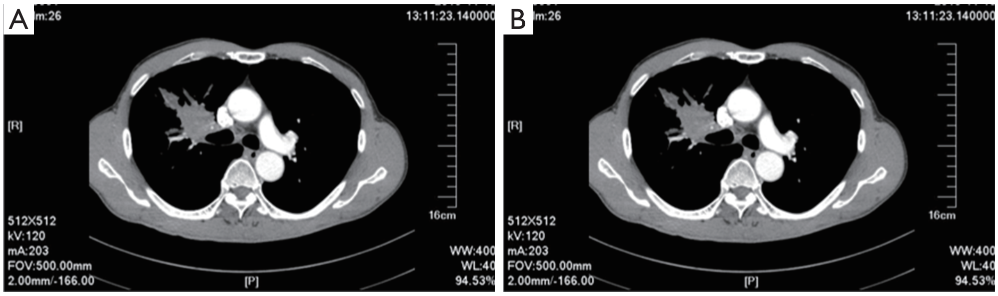

Figure 1 Chest CT at admission showed that the right upper lobe tumor had invaded the right pulmonary trunk, along with obstructive pneumonia in the right upper lobe.

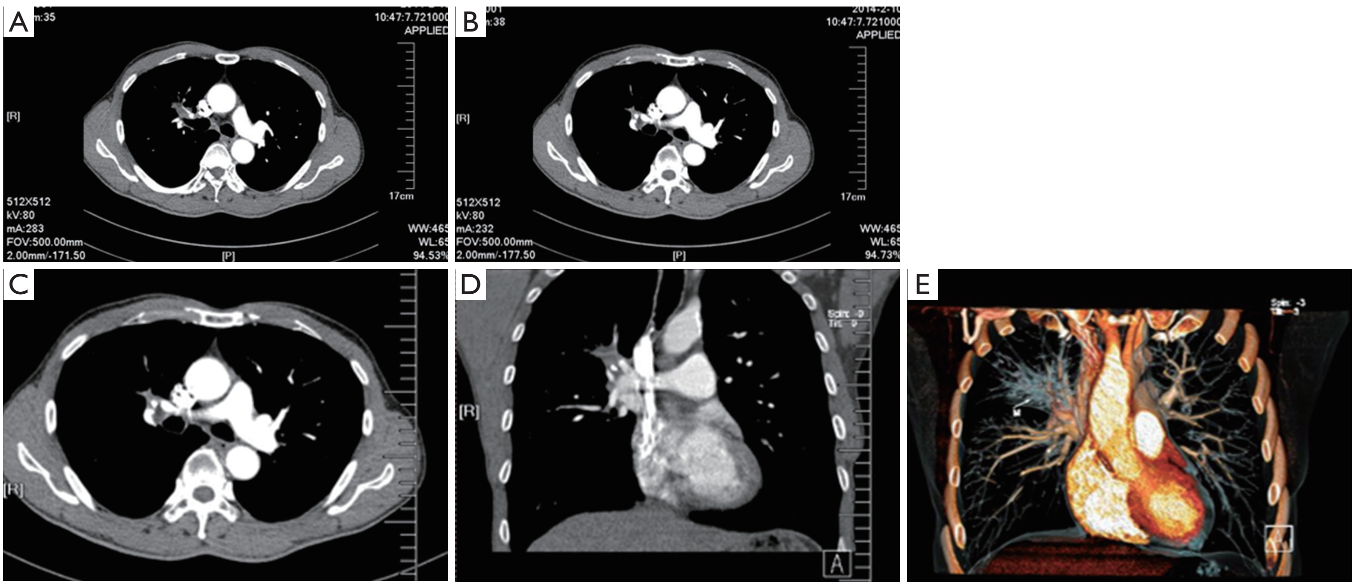

Figure 2 Neoadjuvant chemotherapy was applied before surgery. After three cycles of treatment, chest CT showed that the tumor remarkably shrank.

Anesthesia

After the induction of general anesthesia, the patient was under double-lumen endotracheal intubation.

Body position

The patients were often placed in a lateral decubitus position on the unaffected side (*Figure 3*). The waist bridge is elevated to maximize the intercostal spaces and thus facilitate the operation.

Design of incisions

Typically three incisions will be more feasible (*Figure 4*). Observation port (incision): in the 6^{th} or 7^{th} intercostal space at anterior axillary line, about 1 cm in length. Main operation incision: in the 3^{rd} or 4^{th} intercostal space at anterior axillary line, about 4 cm in length. Auxiliary operation incision: within the same intercostal space with the observation port; in the 6^{th} or 7^{th} intercostal space at posterior axillary line, about 0.5 or 1 cm in length.

Surgical process

The detail of the surgical process was as follow:

(I) Dissect the posterior mediastinal pleura using an electrocautery hook, and then open up the tunnels in and outside the upper oblique fissure of lung;

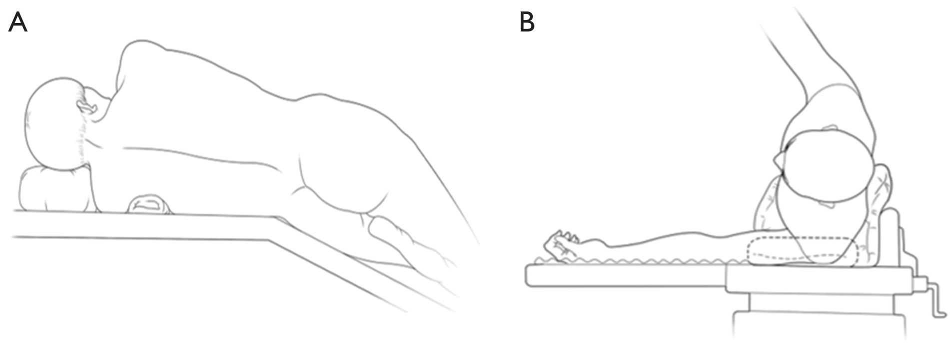

Figure 3 Surgical positions.

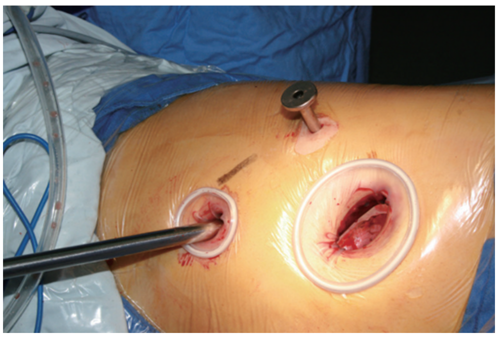

Figure 4 Distribution of incisions.

finally, divide the upper oblique fissure using the endoscopic cutter/stapler (*Figure 5*). Notice:

(i) During the dissection of the posterior mediastinal pleura, the electrocautery hook should be closer to lung till the bronchus;

(ii) The key of the first approach is to free a channel for the creation of an artificial fissure within the lung parenchyma (*Figure 6*). The beginning and end of the channel used for creating artificial lung fissure in right lung were demonstrated in *Table 1*;

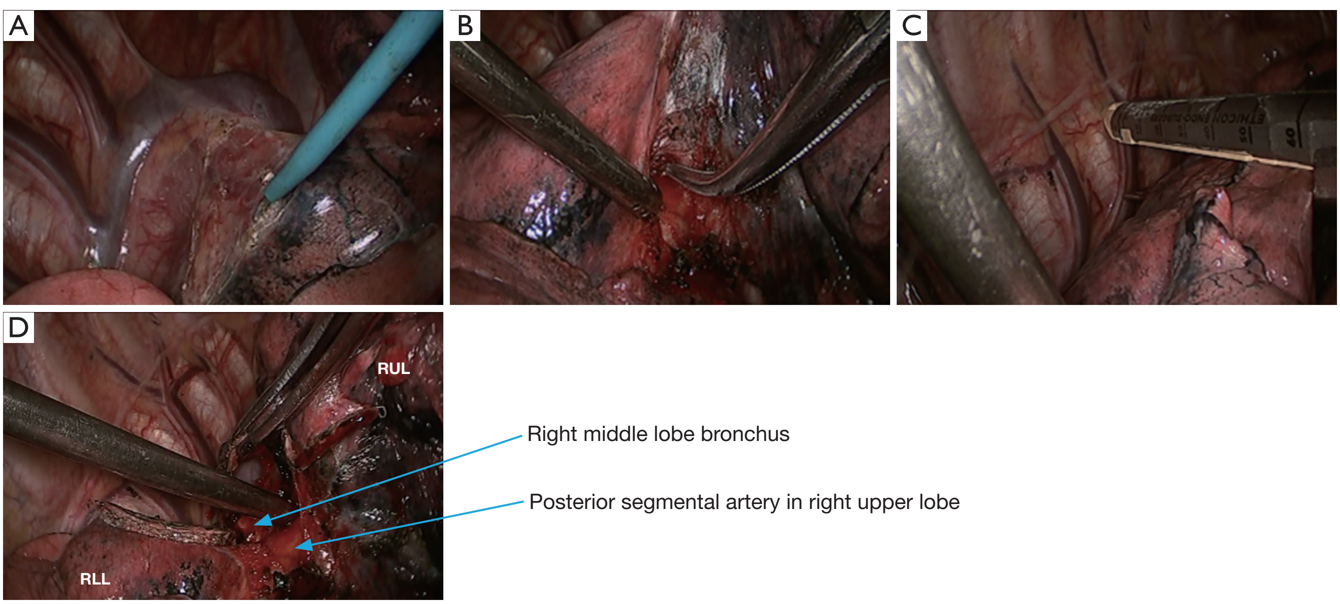

Figure 5 The procedure of dissection of oblique fissure. (A) Dissect the posterior mediastinal pleura using an electrocautery hook; (B) open up the tunnels in and outside the upper oblique fissure of lung using vascular clamp; (C) cut open the pulmonary fissure using the endoscopic cutter/stapler; (D) the dissected upper oblique fissure.

(iii) If the lung fissure is poorly developed and the inter-fissure tissues are basically fused, parts of the tissue can be divided using cutter/stapler at the site of lung fissure before creating the channel.

(II) The gap between right upper lung vein and pulmonary trunk was dissected using an electrocautery hook. The right upper lung vein was dissociated with a right-angle clamp and then suspended with a suture. Under the guidance of a urinary catheter, the right upper lung vein was transected with the endoscopic cutter/stapler (*Figure 7*);

(III) Dissociate the right intermediate bronchus and right main bronchus using the vascular clamp, followed by the transection of right intermediate bronchus and right main bronchus (*Figure 8*);

(IV) Thoroughly dissociate the adjacent tissues. Lift the pulmonary artery, cross the endoscopic cutter/stapler, and then resect the arterial branch and side-wall of part of pulmonary trunk in right upper lung (*Figure 9*). The detail of the surgery was demonstrated in the video (*Figure 10*).

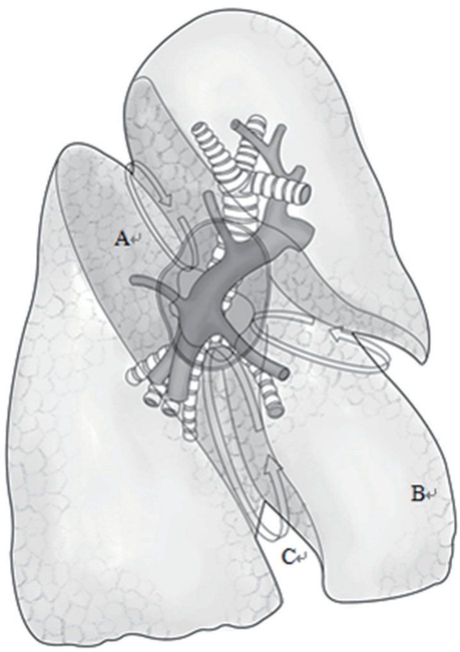

Figure 6 Right lung fissures. A: the upper part of right lung fissure. The arrow crosses the gap between the recurrent branch of the right upper pulmonary artery and the dorsal segment of the right lower pulmonary artery; B: horizontal fissure. The arrow crosses the gap over the intermediate lobe artery; C: lower part of right oblique fissure. The arrow crosses the gap between the intermediate lobe artery and basal artery.

Postoperative diagnosis and follow-up

Pathology: moderately-differentiated squamous cell carcinoma in the right upper lung. The tumor invaded the bronchus, while no cancer was seen in the bronchial stump (*Figure 11*).

Post-operative CT showed that the ventilation was good in both lungs; the right middle bronchus did not become narrow or twisted; the pulmonary artery was patent, and no luminal stricture was observed (*Figure 12*).

Case 2 presentation

Patient

A 57-year-old smoking male patient was admitted due to left chest pain for over 3 months. Chest CT indicated the presence of carcinoma at the apical and posterior segments of the left upper lobe and obstructive pneumonia (*Figure 13*). No distant metastasis was seen in further preoperative examinations. The heart and lung functions were good.

Table 1 The beginning and end of the channel used for creating artificial lung fissure in right lung

Location for creating artificial lung fissure	Beginning	End
Upper part of the right oblique fissure	Gap between the recurrent branch of the right upper pulmonary artery and the dorsal segment of the right lower pulmonary artery	Gap between the right upper lobe bronchus and intermediate bronchus
Horizontal fissure	Gap between right middle lobe artery and arterial trunk	Gap between the upper lobe branch and the intermediate lobe branch of the right upper pulmonary vein
Lower part of the right oblique fissure	Gap between right intermediate lobe artery and basal artery	Gap between the intermediate lobe branch of right upper lung vein and the lower vein of right lung

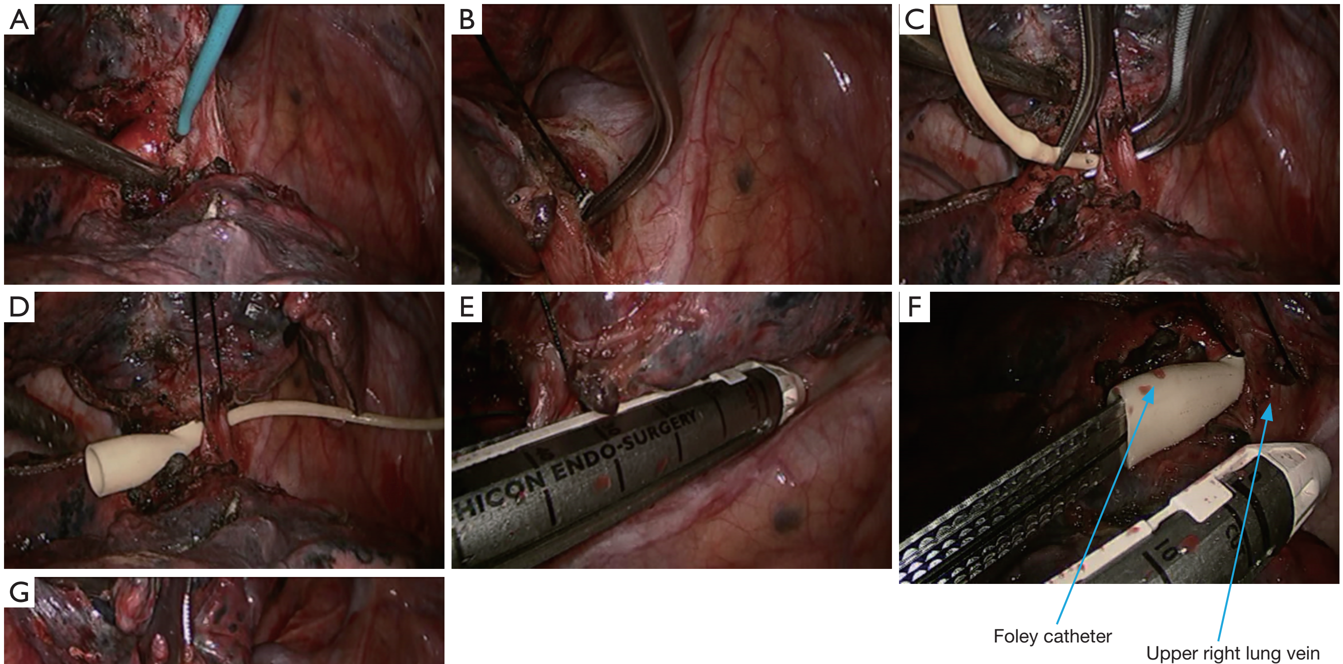

Figure 7 The techniques of dissociation of right upper lung vein. (A-D) Dissociates the right upper lung vein and crosses the Foley catheter; (D-F) under the guidance of the catheter, the endoscopic cutter/stapler crosses the gap in right upper lung vein; (G) the dissected upper right lung vein

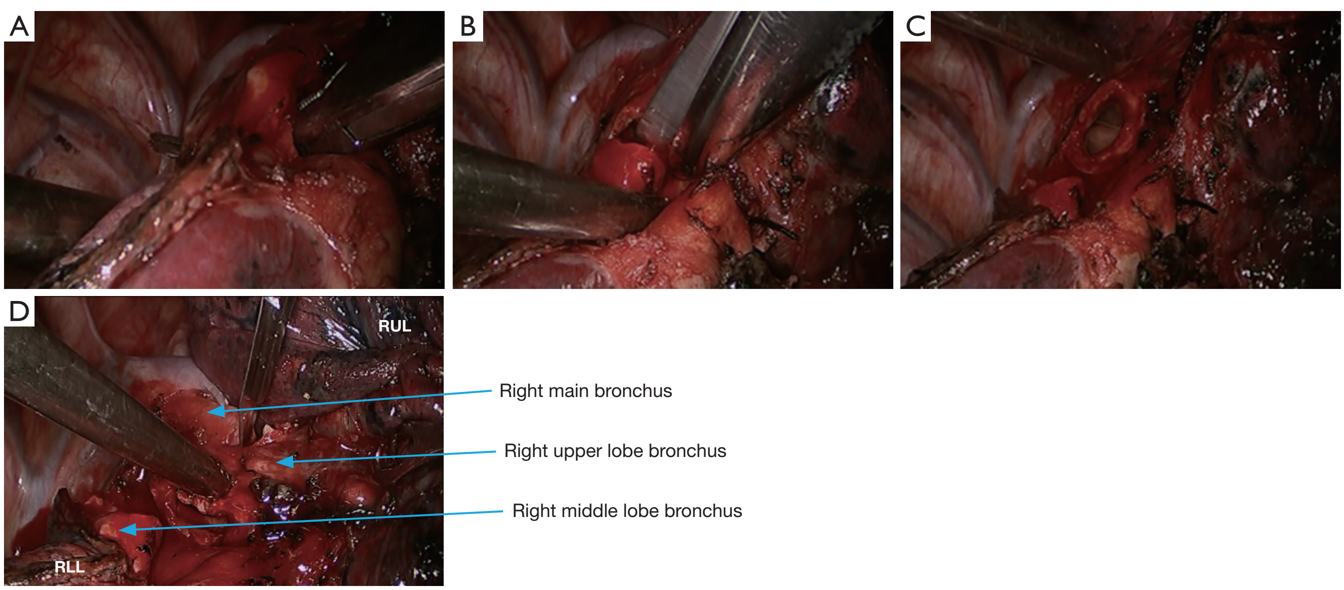

Figure 8 The techniques of dissection of right intermediate bronchus and middle bronchus. (A) Dissect the intermediate bronchus in right lung; (B) transect the right middle bronchus; (C) stump of the right middle lobe bronchus; (D) transect the right main bronchus.

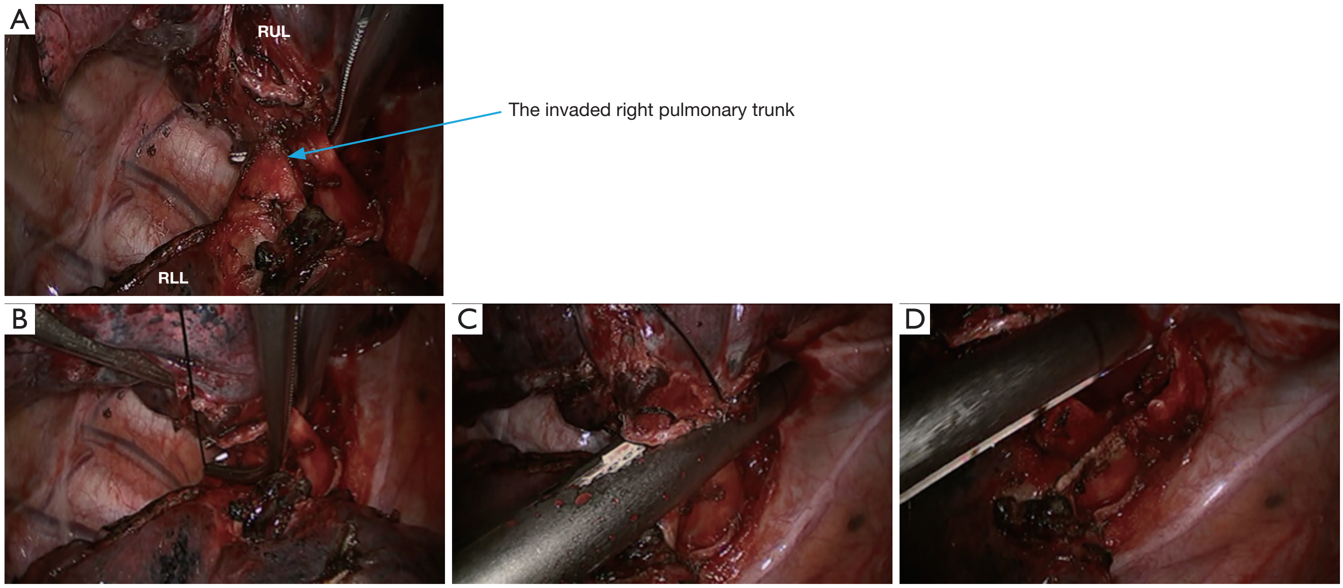

Figure 9 The techniques of resection of arterial branch. (A) Exploration with right-angled clamp confirmed that tissues around the lung artery have thoroughly dissociated; (B) cross the suture to assist retraction; (C) place the endoscopic cutter/stapler; (D) resect the side-wall of part of the pulmonary trunk.

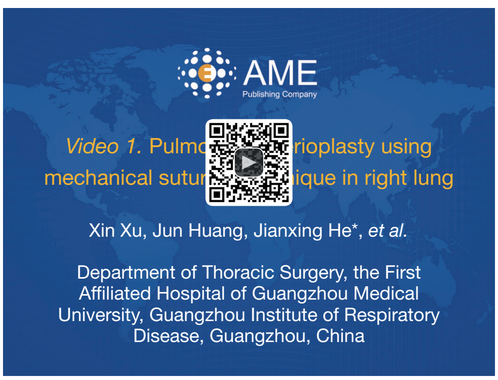

Figure 10 Pulmonary arterioplasty using mechanical suturing technique in right lung (1).
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Pulmonary arterioplasty by VATS was then scheduled.

(I) The mediastinal pleura were dissected using electric surgical knife. Tissues around the left upper pulmonary vein were thoroughly dissociated to achieve nearly skeletonization. The left upper pulmonary vein was dissociated using a right-angled clamp (*Figure 14*) and then transected using the endoscopic cutter/stapler;

(II) After the left upper lobe was lifted upwards, the sheath of pulmonary artery was dissected to expose the pulmonary arterial branch at the lingular segment of left upper lobe, which was blocked with vascular clamps and then transected using ultrasonic scalpel (*Figure 15*). The pulmonary

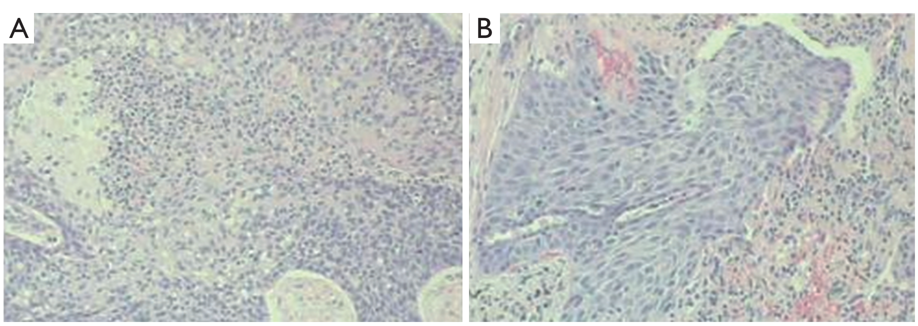

Figure 11 The result of pathology (magnification, ×100).

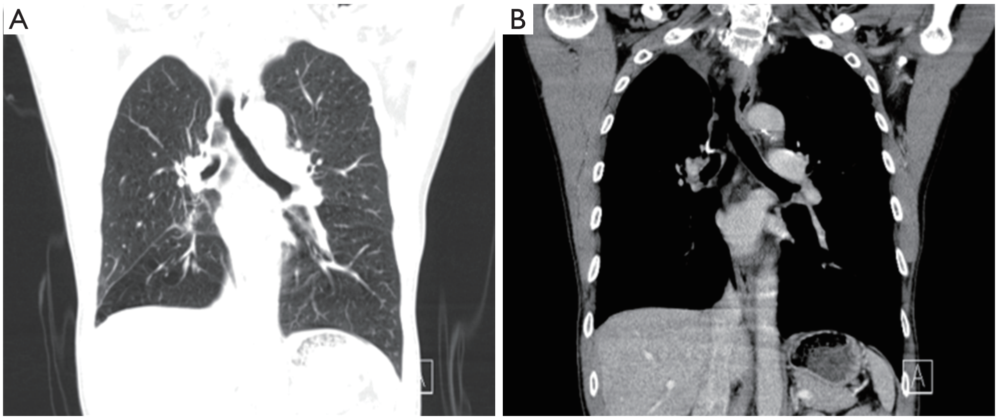

Figure 12 Postoperative CT scan.

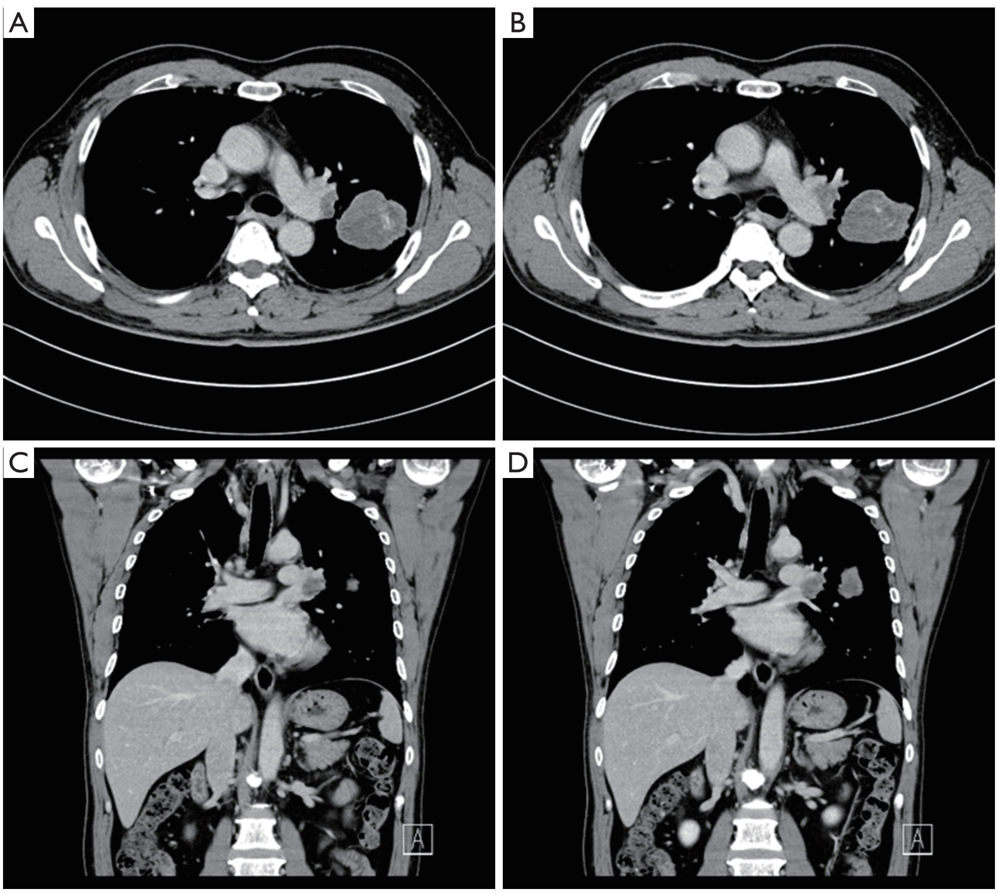

Figure 13 Pre-operative CT scan.

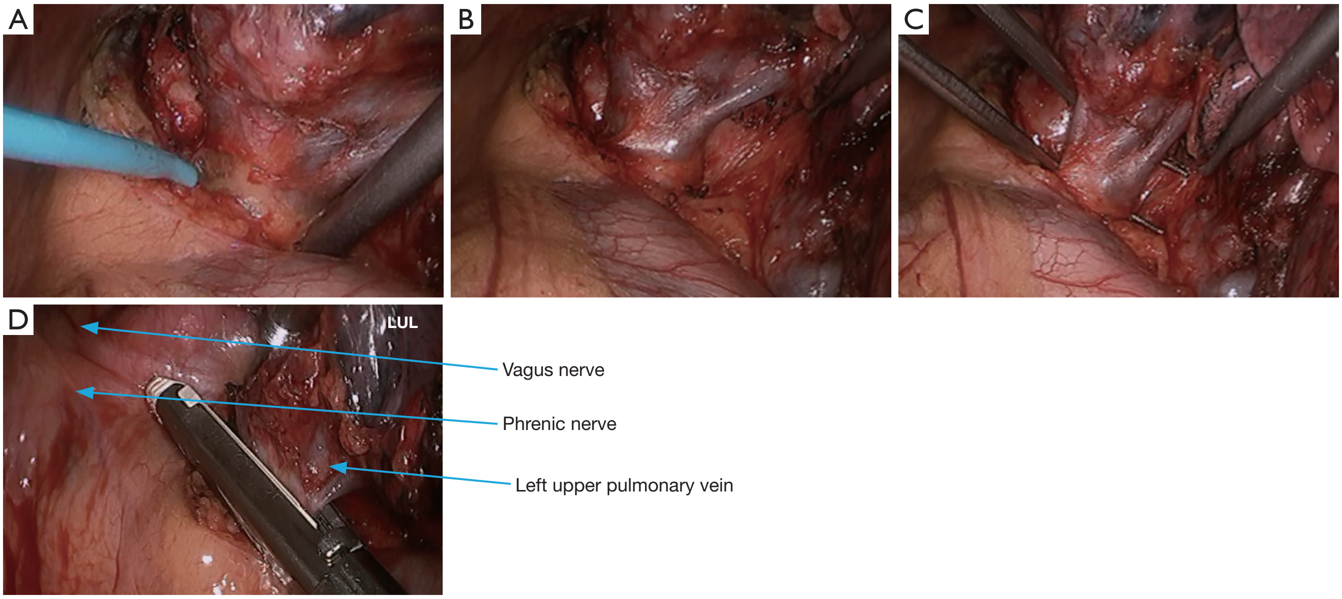

Figure 14 The procedure of dissociation of left upper pulmonary vein. (A) Expose the left upper pulmonary vein; (B) dissociate the gap behind the left upper pulmonary vein; (C) cross the endoscopic cutter/stapler through the gap behind the left upper pulmonary vein; (D) transect the left upper pulmonary vein.

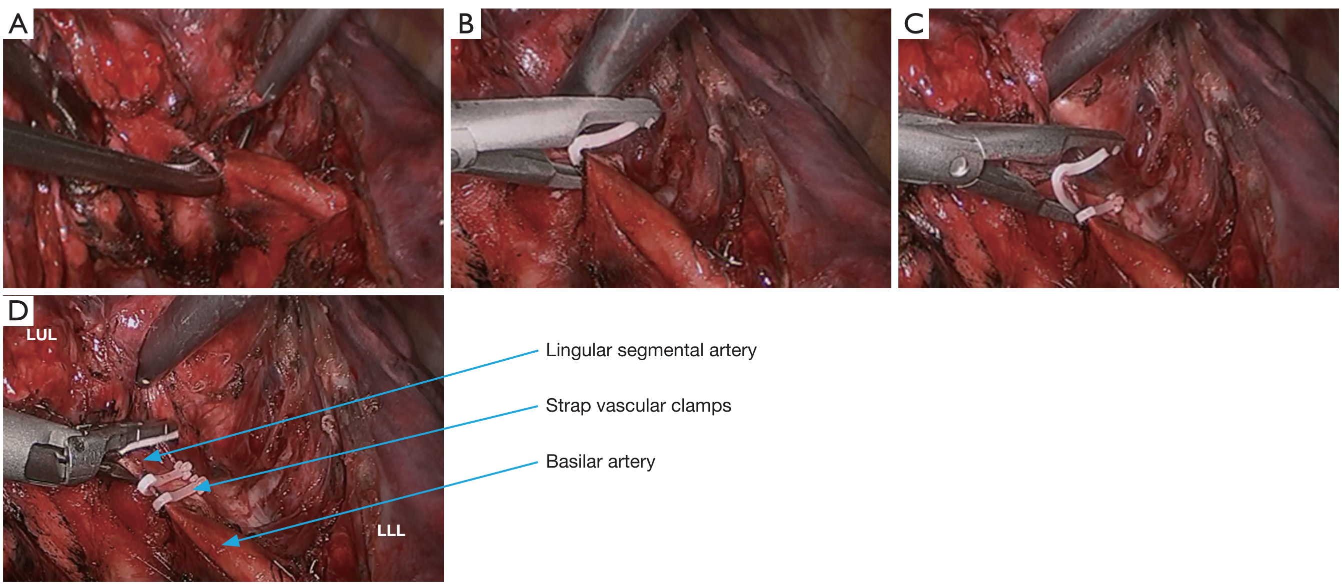

Figure 15 The procedure of dissociation and transection of lingular segmental artery. (A) Dissociate the lingular segmental artery in left upper lobe; (B,C) block the lingular segmental artery using vascular clamps; (D) transect the distal end of lingular segmental artery using ultrasonic scalpel.

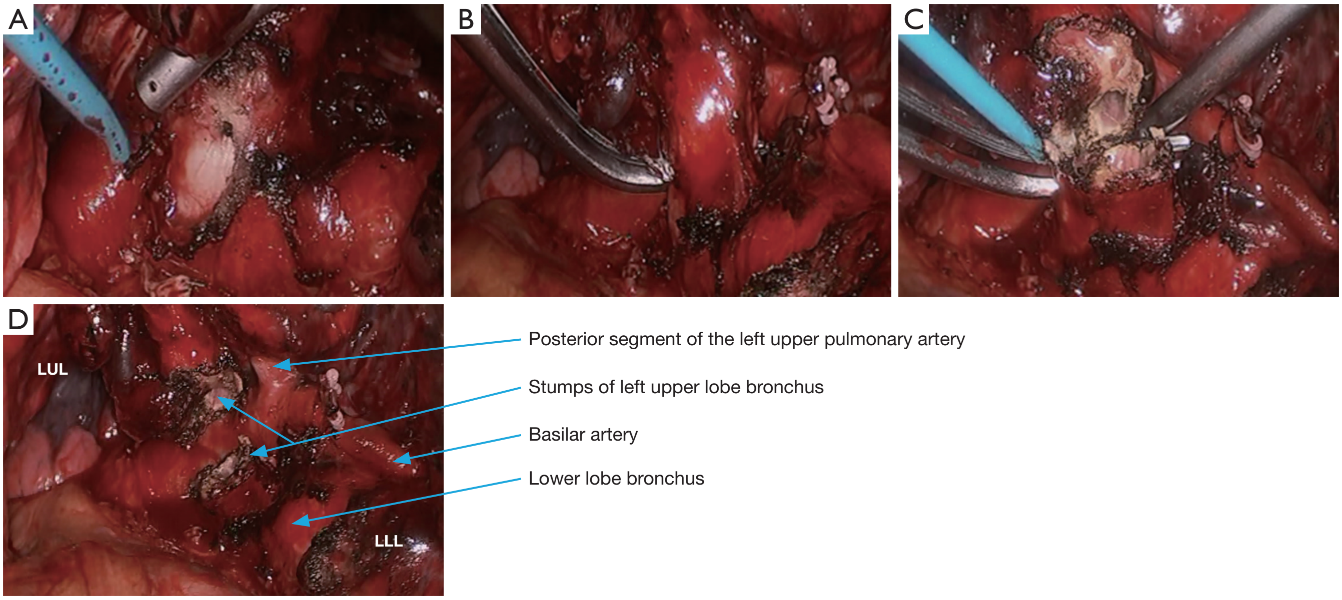

Figure 16 The procedure of dissociation and transection of pulmonary trunk. (A) Dissociate the left upper lobe bronchus; (B) cross the clamps through the gap between bronchus and pulmonary trunk; (C) cut open the left upper lobe bronchus; (D) stump of the transected right upper lobe bronchus.

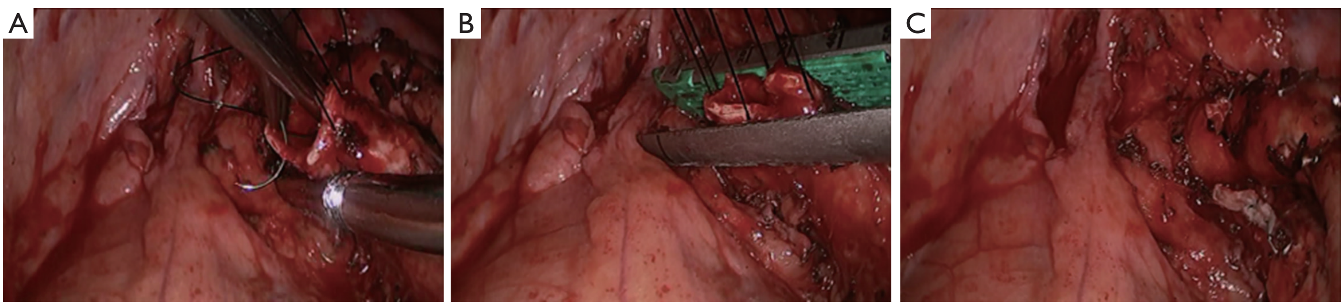

Figure 17 The techniques of suturing of bronchus. (A) Suturing of the traction suture at the stump of left upper lobe bronchus; (B) close the bronchial stump using endoscopic cutter/stapler; (C) the bronchial stump after closure.

arterial branch at the posterior segment of left upper lobe was handled using the same method, followed by the division of the oblique fissure;

(III) After the left upper lung was lifted upwards, the right upper lobe bronchus was dissociated and then transected (*Figures 16,17*);

(IV) After the posterior mediastinal pleura at the pulmonary hilum was cut open and its surrounding tissues were dissociated, the endoscopic cutter/stapler was placed to remove the first branch of left pulmonary artery and the side-wall of part of pulmonary trunk (*Figure 18*). Pulmonary arterioplasty using mechanical suturing technique in left upper lobectomy was performed on June 6th 2013 (*Figure 19*). The pathology result demonstrated that small cell lung cancer (*Figure 20*).

Discussion

The method used in this study has two key technical concerns: first, how to ensure safe resection without bleeding margins of the sidewall, and second, how to ensure thoracoscopic resection with negative margins while maintaining sufficient blood reflux in the residual vessel.

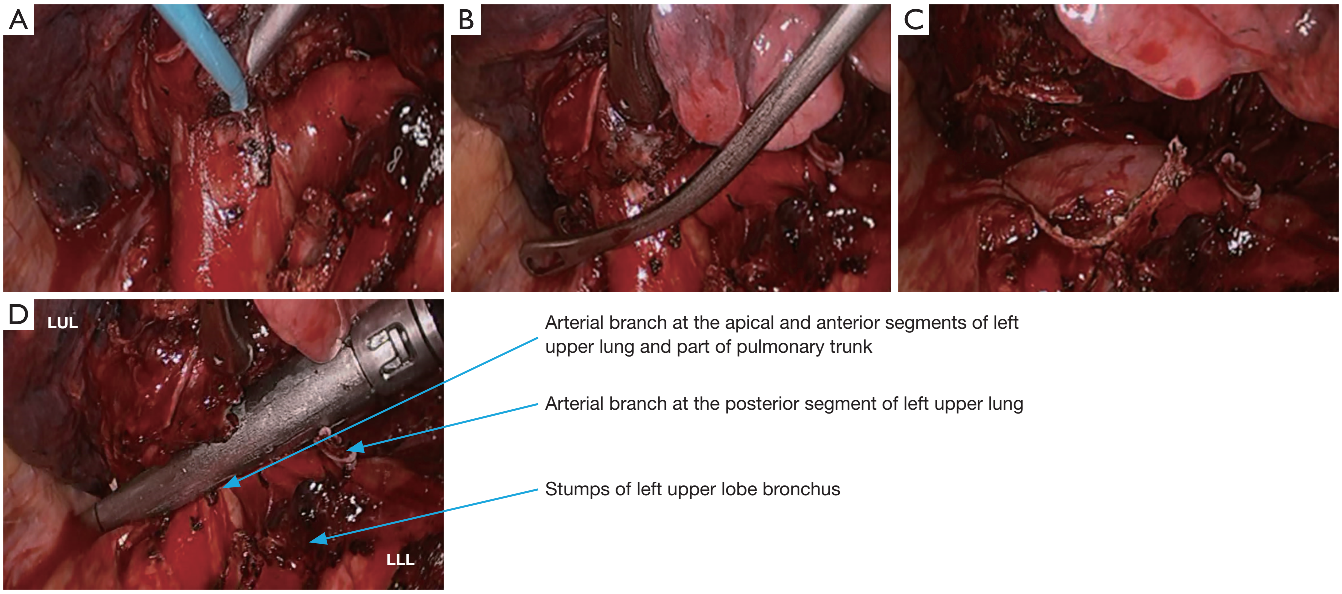

Figure 18 The techniques of partial pulmonary artery and pulmonary trunk resection. (A) The first branch of left pulmonary artery (arterial branches at the lingular and posterior segments had been transected) and the side-wall of part of pulmonary trunk and their surrounding tissues were dissected as possible; (B) explore whether the gap was large enough using an oval clamp; (C) place the endoscopic cutter/stapler (white reloads), which were fired when in the appropriate place; (D) resect the left upper lobe; the resection margin of pulmonary trunk.

Figure 19 Pulmonary arterioplasty using mechanical suturing technique in left upper lobectomy (2).
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Regarding the first technical issue, in thoracoscopic lung surgery, cutting blood vessels of different diameters and thicknesses with a stapler is a common operation (3-5). From a technical point of view, resection of the sidewall of the pulmonary trunk with a stapler is essentially nothing different from transection of handling the pulmonary artery (6). Therefore, we do not worry whether the cutting margin can be properly stapled and if bleed leakage occurs.

Regarding the second technical issue, from the technical view for resection, we are most concerned about the length and the circumference of invasions in the pulmonary trunk, especially the latter. In theory, after one third of the circumference of pulmonary trunk is resected, the area of the channel formed by the remaining sidewall of the

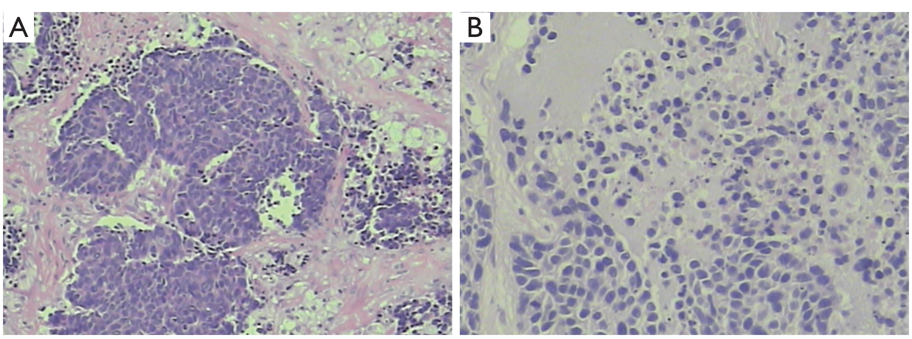

Figure 20 The postoperative pathology result (magnification, ×100).

pulmonary artery is about half of the sectional area of the original pulmonary trunk, which is sufficient to deliver blood to the lower pulmonary lobe. Therefore, after the application of endoscopic cutter/stapler, if the lower margin of the clamped part is no more than one third of the original lumen of pulmonary trunk, the blood supply of the pulmonary artery will not be affected.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Cite this article as: Xu X, Huang J, Yin W, Zhang X, Chen H, Mo L, He J. Pulmonary arterioplasty using video-assisted thoracic surgery mechanical suture technique. J Thorac Dis 2016;8(3):617-627. doi: 10.21037/jtd.2016.01.61