Operative Techniques in Thoracic and Cardiovascular Surgery

Technique of Thoracoscopic Segmentectomy

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Pulmonary segmentectomy was first described in 1939 for the treatment of benign lung conditions.[1] Since then, anatomic pulmonary segmentectomy has been demonstrated to be effective in the resection of small primary lung cancers.[2-4] Although a prospective randomized clinical trial conducted by the Lung Cancer Study group demonstrated that limited pulmonary resections resulted in increased locoregional recurrences as compared with lobectomy,[5] a more extended anatomic procedure may not be feasible for some patients. Limited cardiopulmonary functional reserve or extensive comorbidities may preclude aggressive surgical resection for some patients, who may only be candidates for limited pulmonary resection, such as pulmonary segmentectomy. Moreover, more recent data have demonstrated that pulmonary lobectomy offers no survival benefits over segmentectomy in carefully selected patients.[4,6-9]

Compared with conventional approaches, thoracoscopic lobectomy is associated with less postoperative pain, shorter length of stay, less overall complications, and superior compliance with adjuvant therapy, with equivalent oncologic efficacy.[10-15] Recently, thoracoscopic segmentectomy has been demonstrated to be safe and effective for a spectrum of conditions, including primary non-small cell lung cancer (NSCLC), pulmonary metastases, and benign disease.[16] Compared with segmentectomy by thoracotomy, thoracoscopic segmentectomy was associated with a shorter length of stay and with equivalent morbidity and mortality profiles. Techniques for thoracoscopic lobectomy have been previously well described.[14,17] This article describes the technique of thoracoscopic segmentectomy.

Definition

The term "thoracoscopic segmentectomy" refers to the resection of one or more anatomic pulmonary segments using a completely minimally invasive approach, where visualization is dependent on video monitors and rib spreading is avoided. Thoracoscopic segmentectomy employs anatomic resection, with individual vessel ligation, and includes hilar and mediastinal lymph node dissection.

Indications

Thoracoscopic segmentectomy may be used for resection of primary NSCLC, pulmonary metastases, and benign conditions that are best treated with anatomic resection (such as fungal disease).[16] For selected patients with early-stage NSCLC, segmentectomy may be safely performed for small ($<$2 cm) peripheral lesions, providing acceptable resection margins and without a decrease in survival as compared with lobectomy.[7,8] Preoperative staging should be completed to confirm the absence of nodal (mediastinal or hilar) disease. For patients with NSCLC, thoracoscopic segmentectomy is usually reserved for patients with small peripheral tumors and limited cardiopulmonary functional reserve. For patients with resectable central pulmonary metastases, thoracoscopic segmentectomy may represent the ideal approach for complete oncologic resection and preservation of pulmonary function.

Although the thoracoscopic approach may be employed for any anatomic segmental resection, it is rare that individual segmental resection in the upper lobes would offer a specific advantage to patients with NSCLC and upper lobe dominant emphysema. Thus, the segmental resections that are most commonly performed and described herein include lingual-sparing left upper lobectomy, lingulectomy, superior segementectomy, and basilar segementectomy.

Contraindications

Contraindications of the thoracoscopic segmentectomy include the inability to achieve complete resection with segmentectomy, the presence of N2 or N3 disease, and inability to achieve single-lung ventilation. Relative contraindications include T2 tumors, N1 disease, prior thoracic irradiation, and the use of induction therapy. Prior thoracic surgery, incomplete or absent fissures, and benign mediastinal adenopathy should not be considered contraindications.

Strategy for Thoracoscopic Segmentectomy

Preoperative computed tomography is used to determine lesion size, segment location, the presence of adenopathy, and

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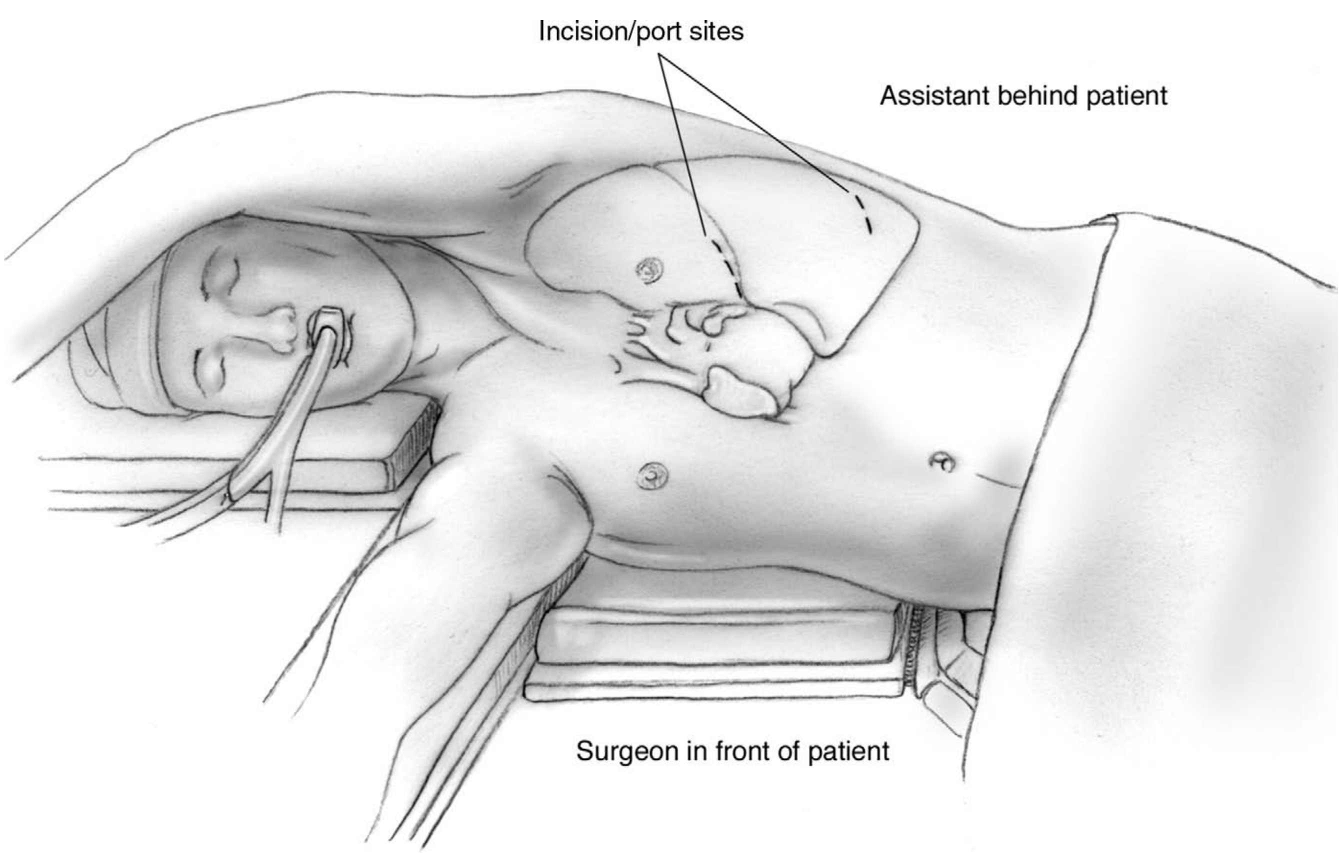

Figure 1 Positioning and port placement. Patients are placed in the lateral decubitus position. Our technique uses two incisions—one at the 7th or 8th intercostal space along the posterior axillary line, the other at the 5th or 6th intercostal space anteriorly.

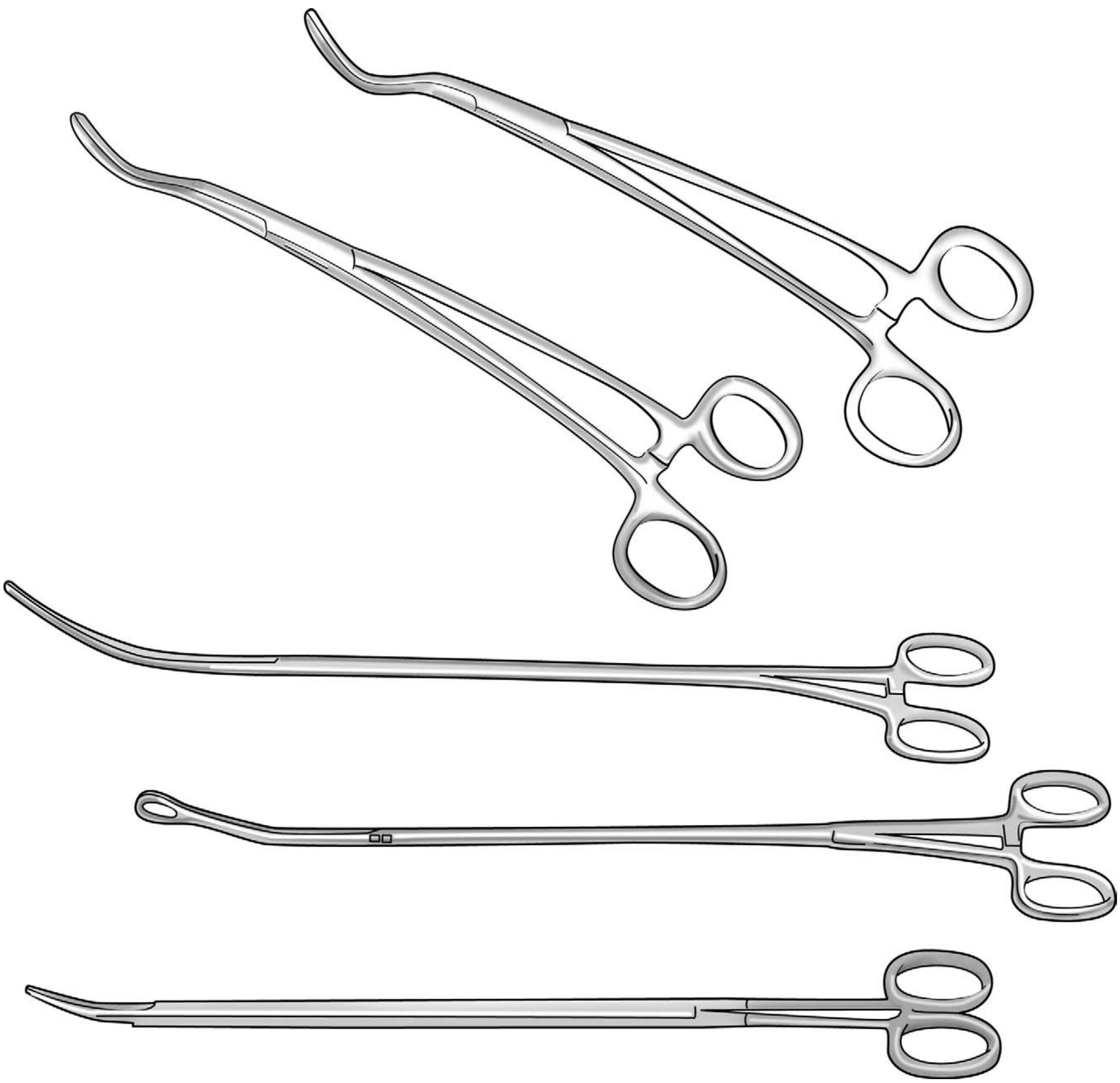

Figure 2 Instrumentation. The optimal profile for instruments used in minimally invasive thoracic surgery is long and curved. Sample instruments here include Harken clamps, a Scanlon clamp, long curved empty sponge-stick, and Scanlon scissors.

the presence of metabolically active nodal disease (with positron emission tomography). Anesthesia is administered in the usual fashion with single-lung ventilation achieved by double-lumen endotracheal tube or bronchial blocker placement. After bronchoscopy and mediastinosopy (when indicated), single-lung anesthesia is established. The patient is positioned in the lateral decubitus position with slight flexion of the table at the level of the hip. This slight flexion provides splaying of the ribs, improving thoracoscopic access and exposure. The chest is then marked for the placement of thoracoscopic incisions, prepped, and draped.

The placement of incisions may vary with surgeon preference. The technique described herein utilizes only two incisions. The first incision is placed in the 7th or 8th intercostal space, at the posterior axillary line. The second incision is for the anterior access and is placed in the 5th or 6th intercostal space (2.0-4.5 cm in length). Using this approach, additional incisions are rarely necessary but may be employed to improve visualization or to provide retraction (Fig. 1). To aid visualization and improve angles of approach with a limited number of incisions, the videoscope may be alternatively used in either incision, allowing the stapler to be introduced through the more posterior port.

Using a 30° thoracoscope improves visualization and versatility of this approach. A variety of surgical instruments may be employed. In general, the use of long, curved instruments and specialized minimally invasive instruments improves the conduct of the procedure (Fig. 2). Thoracoscopic linear mechanical staplers, such as the Endo GIA (US Surgical, Norwalk, CT), are employed for control of the vessels (2.0-mm or 2.5-mm staples), bronchus (3.5- or 4.8-mm staples), parenchyma, and fissures.

The surgeon proceeds with thoracoscopic exploration for exclusion of additional nodules and pleural metastases. Confirmation of tumor location is also performed at this time. Dissection is performed through the access incision. Retraction and mobilization of the segmental vessels are specific to each resection. In brief, segmentectomy is performed with division of segmental bronchi and vessels in a manner similar to the open approach.[18] The approach to thoracoscopic segmentectomy begins with ligation of the segmental pulmonary vein, followed by either the bronchus or the artery, depending on the segment. The parenchymal excision is taken in intersegmental fissures. Bi- or tri-segmentectomy is performed when tumors are close to intersegmental fissures. Systematic mediastinal lymph node dissection is performed on completion of pulmonary resection.

There are several steps that improve the efficiency of the conduct of thoracoscopic lobectomy. When beginning the hilar dissection, the segmental vein is usually easily identified and stapled. Subsequently, it is often advisable to remove all visible hilar lymph nodes associated with the adjacent segmental bronchus and artery. This strategy allows for more precise identification of these structures, improves oncologic efficacy, and "lengthens" these hilar structures to facilitate stapling.

After stapling of the segmental bronchus (and artery), the ipsilateral lung is temporarily reinflated to improve identification of the segmental fissures. Parenchymal division is then completed, using either the stapling device, electrocautery, or a combination of the two. Finally, the use of clips during the dissection is discouraged, as they may interfere with the function of the stapler.

Specimens are removed from the thoracic cavity with a protective specimen bag to prevent tumor implantation in the incision and to minimize additional injury to the specimen. The specimen is inspected to confirm that anatomic resection has been achieved. Following specimen retrieval, the hemithorax is irrigated with warm saline and the bronchial stump is inspected for air leaks. If an air leak is suspected, repeat stapling or endoscopic suturing may be necessary. On completion of the resection, a single chest tube (24-28 Fr) is inserted via the smaller incision in the 7th or 8th intercostal space and connected to an underwater seal system. The anterior incision is closed with absorbable sutures without rib reapproximation.

Thoracoscopic Segmentectomy: Technique

Lingula-Sparing Left Upper Lobectomy

The upper lobe branches of the left superior pulmonary vein are approached anteriorly, and it is stapled and divided (Fig. 3).

The segmental bronchus is easily visualized after ligation of the segment vein (Fig. 4).

After the bronchus is stapled and divided, the anterior, apical, and posterior segmental arterial branches are subsequently ligated (Fig. 5). The parenchymal resection is then completed in the segmental fissure.

Lingulectiomy

The lingular branch of the left superior pulmonary vein is approached anteriorly, and it is stapled and divided (Fig. 6).

The segmental bronchus is easily visualized after ligation of the segment vein (Fig. 7).

After the bronchus is stapled and divided, lingular segmental arterial branch is subsequently stapled (Fig. 8). The parenchymal resection is then completed in the segmental fissure.

Superior Segmentectomy

The superior segmental branch of the inferior pulmonary vein is approached posteriorly after division of the inferior pulmonary ligament, and it is stapled and divided (Fig. 9).

The segmental bronchus is visualized after the segmental vein is stapled, again from the posterior direction (Fig. 10).

After the bronchus is stapled, the artery may be approached, stapled, and divided. The parenchymal resection is then completed in the segmental fissure.

Basilar Segmentectomy

The basilar segmental branch of the inferior pulmonary vein is approached anteriorly after division of the inferior pulmonary ligament, and it is stapled and divided (Fig. 11).

The segmental bronchus is visualized after the segmental vein is stapled, again from the anterior direction (Fig. 12).

After the bronchus is stapled, the artery may be approached, stapled, and divided. The parenchymal resection is then completed in the segmental fissure.

Alternatively, after division of the basilar segmental vein, the basilar arterial trunk may be approached through the oblique fissure (Fig. 13).

Using this approach, the basilar segmental bronchus is stapled last.

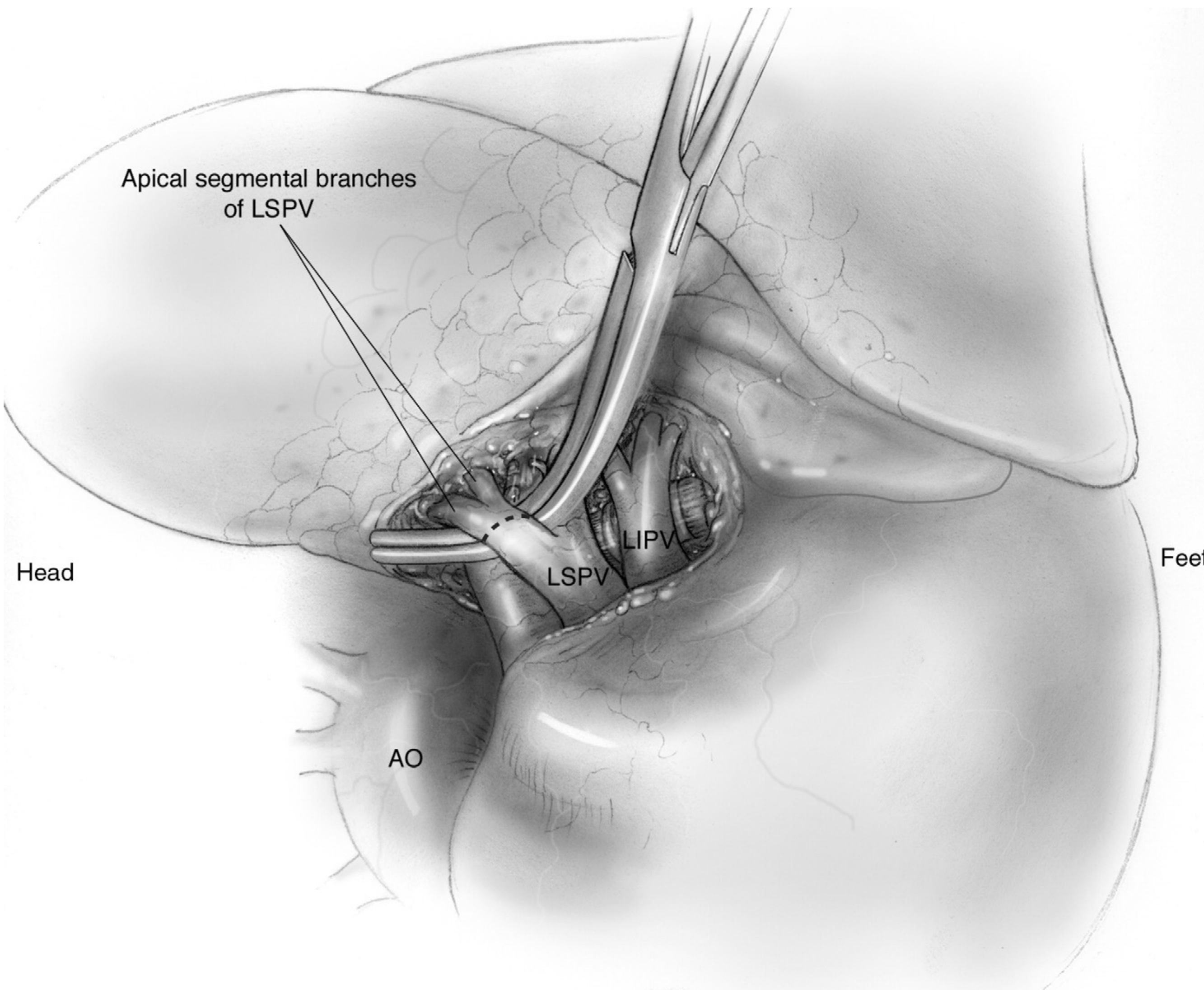

Figure 3 Branches of left superior pulmonary vein. From an anterior view, the upper lobe branches (dissected out with the Harken clamp) of the LSPV are dissected out and ligated. AO = aorta; LIPV = left inferior pulmonary vein; LSPV = left superior pulmonary vein.

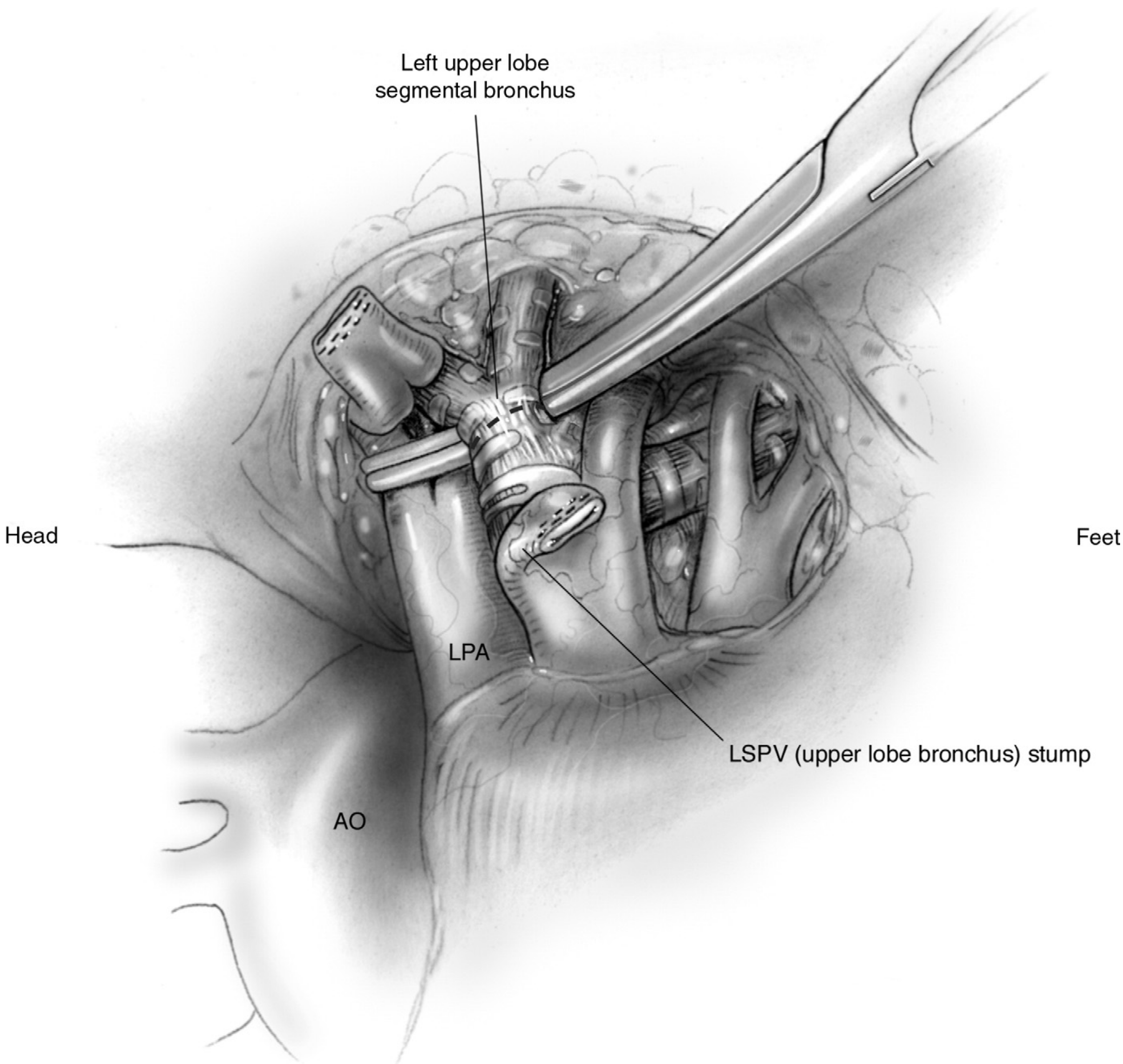

Figure 4 Left upper lobe bronchial anatomy. The segmental bronchus of the left upper lobe is exposed (above Scanlon clamp) and the superior division bronchus is stapled. AO = aorta; LPA = left pulmonary artery; LSPV = left superior pulmonary vein.

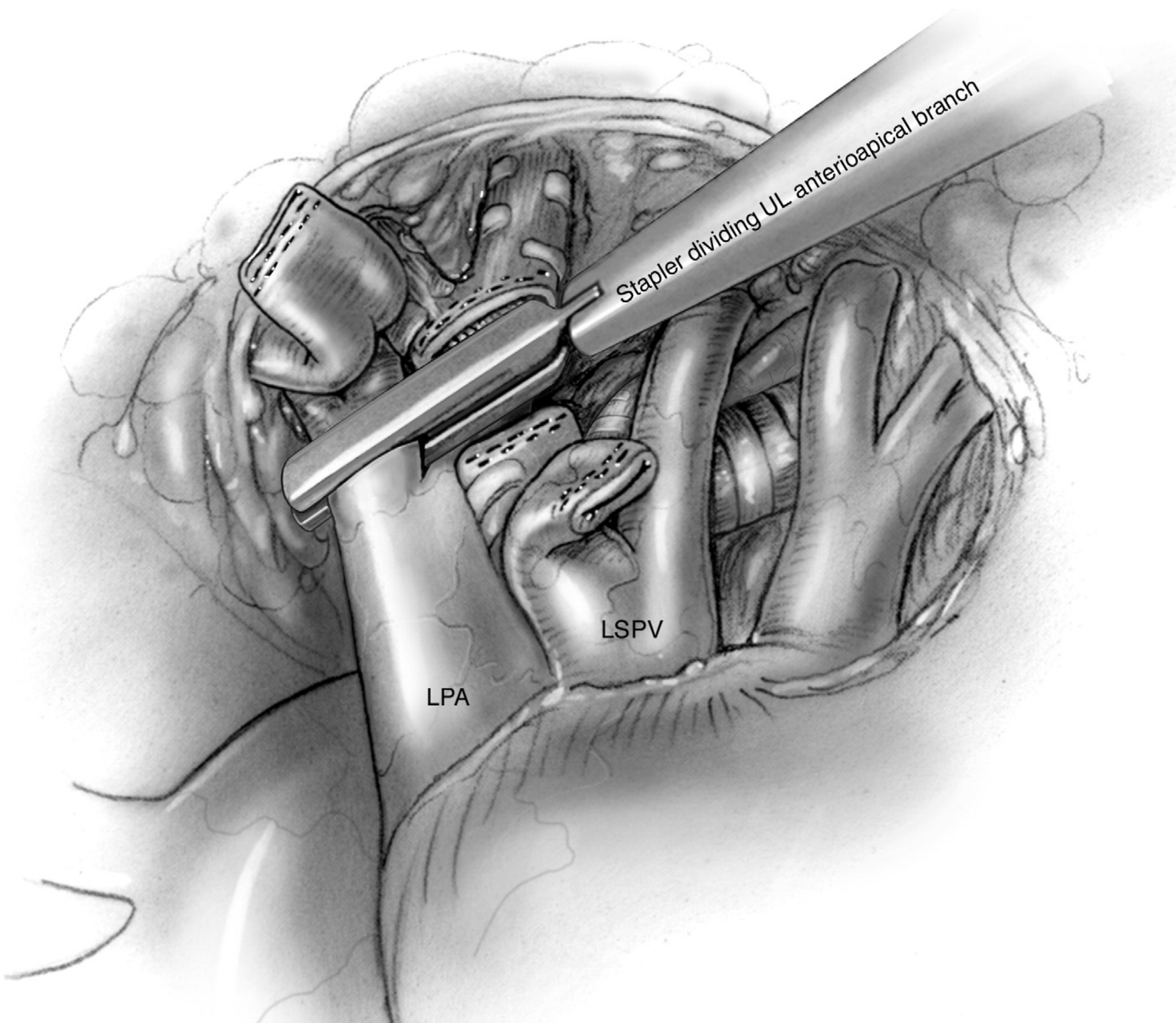

Figure 5 Anterior and apicoposterior arteries of left upper lobe. The anterior and apicoposterior branches of the LPA are dissected out and stapled, sparing the lingular branch of the pulmonary artery. LPA = left pulmonary artery; LSPV = left superior pulmonary vein; UL = upper lobe.

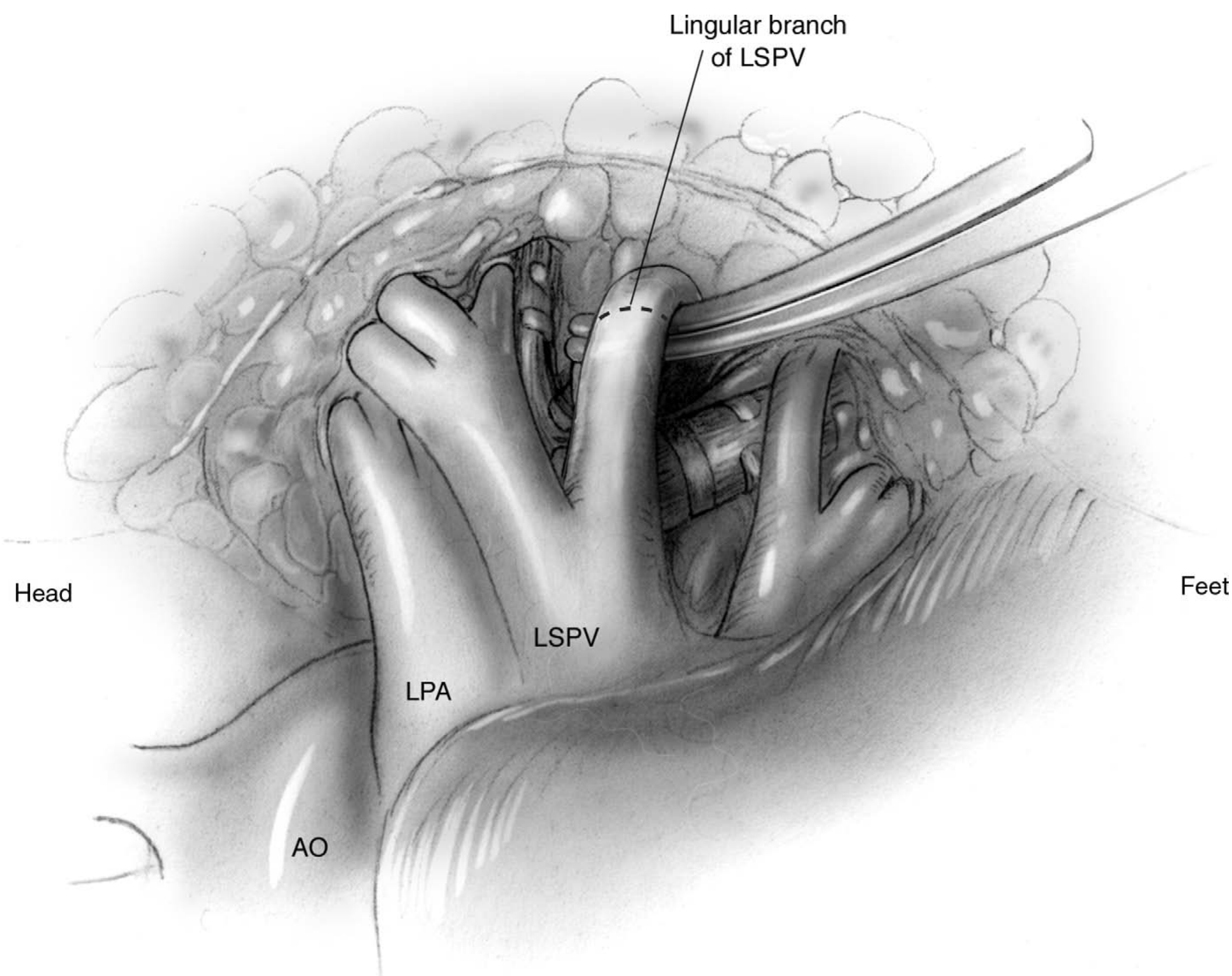

Figure 6 Lingular branch of left pulmonary vein. The lingular branch of the LSPV is approached anteriorly, exposed (above Scanlon clamp), and ligated. AO = aorta; LPA = left pulmonary artery; LSPV = left superior pulmonary vein.

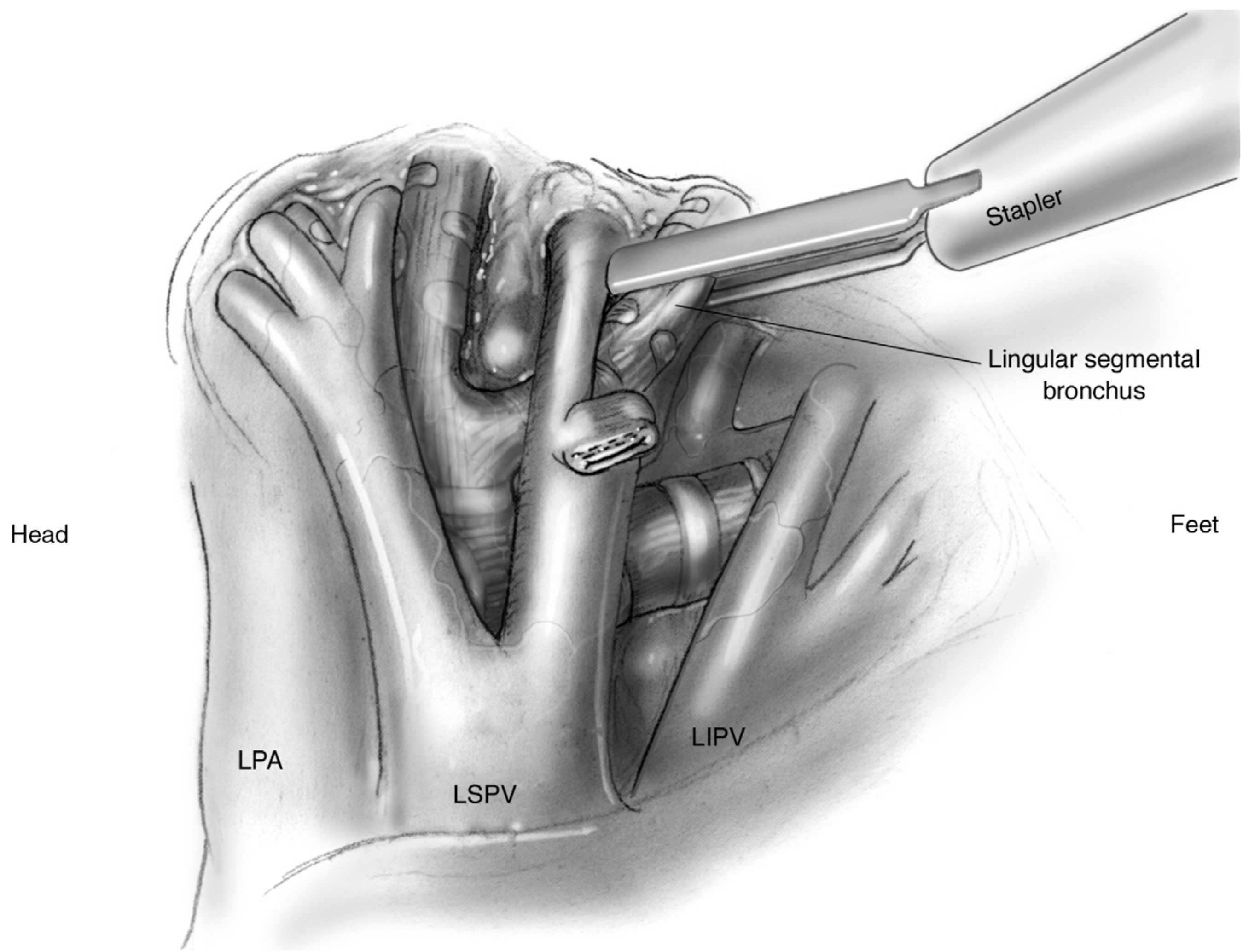

Figure 7 Left upper lobe lingular bronchial anatomy. Upon stapling of the vein, the bronchial anatomy is exposed, revealing the superior division and lingular division segmental bronchi. The lingular bronchus is then stapled. LIPV = left inferior pulmonary vein; LPA = left pulmonary artery; LSPV = left superior pulmonary vein.

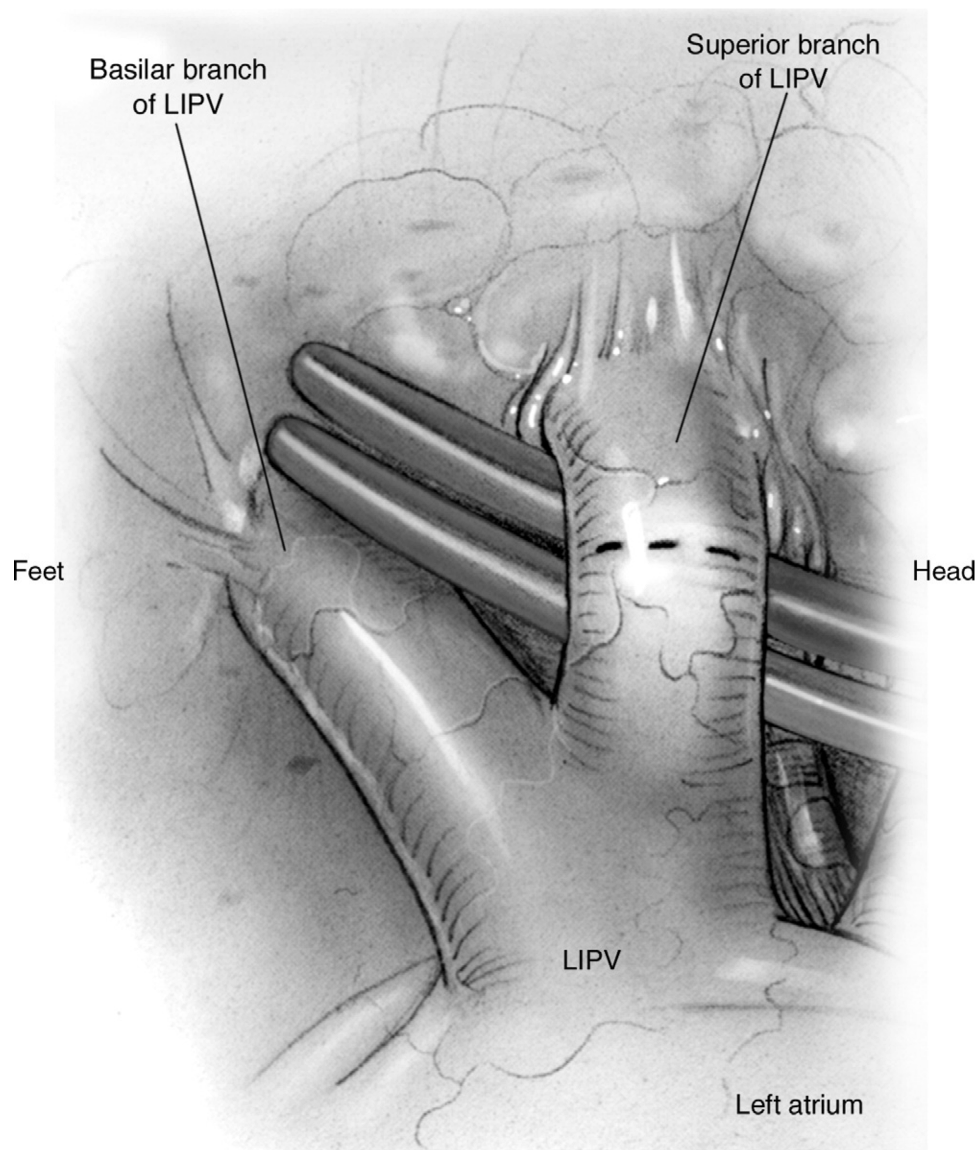

Figure 8 Posterior view of inferior pulmonary vein. In a superior segmentectomy, the pulmonary vein is approached posteriorly. The superior segmental branch (under Scanlon clamp) of the LIPV is dissected and stapled. LIPV = left inferior pulmonary vein.

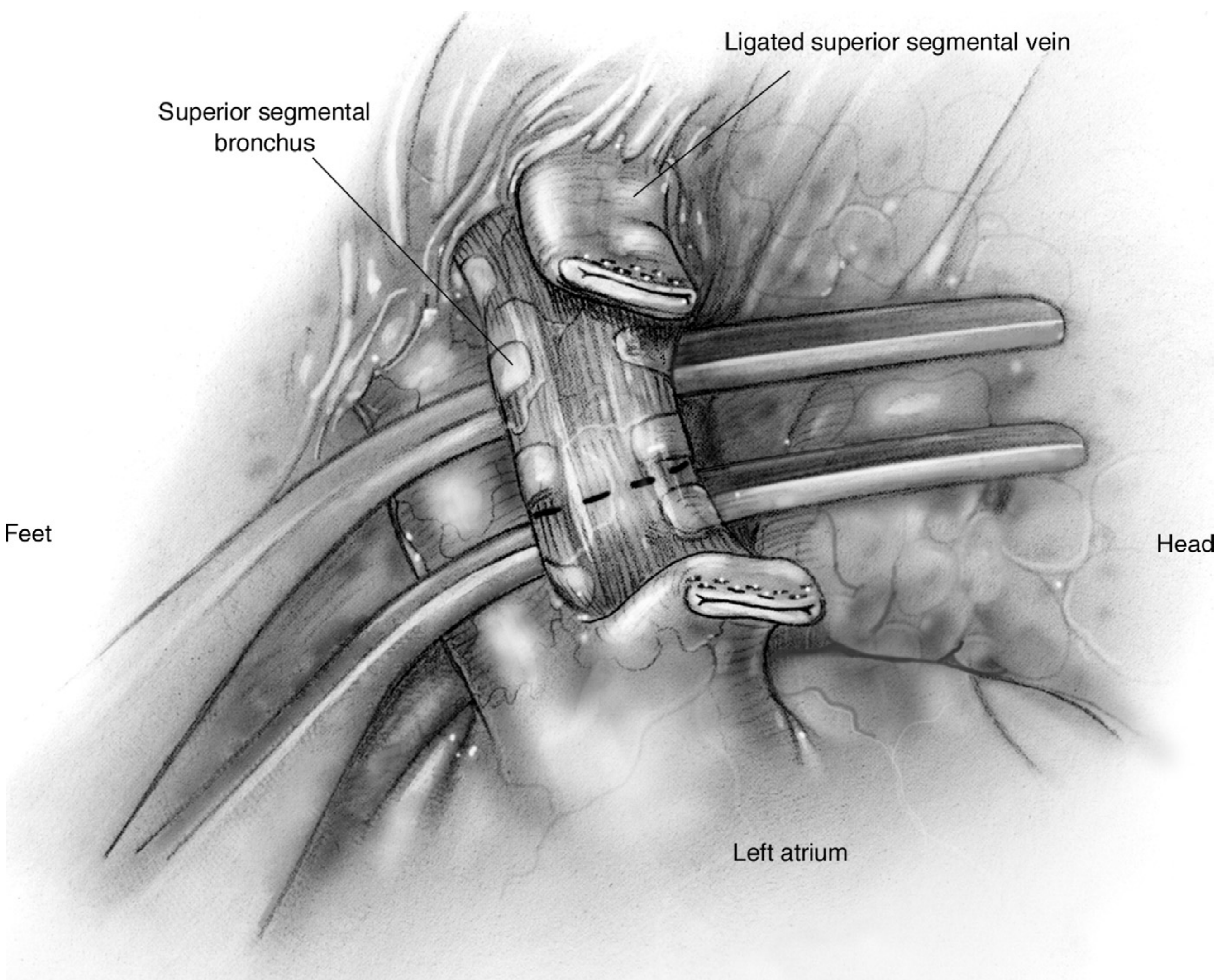

Figure 9 Posterior view of superior segment bronchus of left lower lobe. The superior segmental bronchus is exposed and stapled, sparing the basilar bronchi.

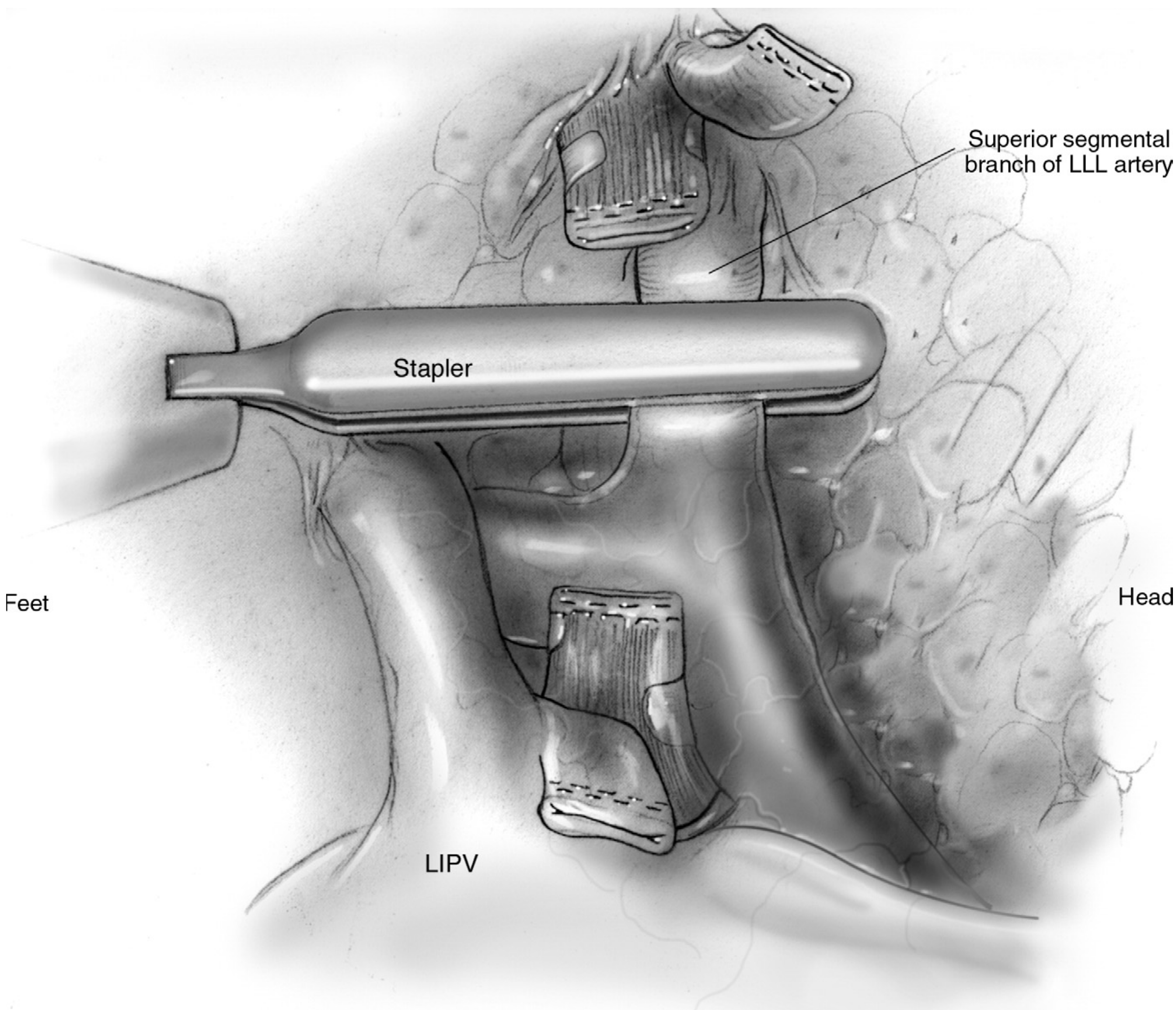

Figure 10 Posterior view of superior segmental artery. The superior segmental branch of the pulmonary artery is also approached and stapled posteriorly. LIPV = left inferior pulmonary vein; LLL = left lower lobe.

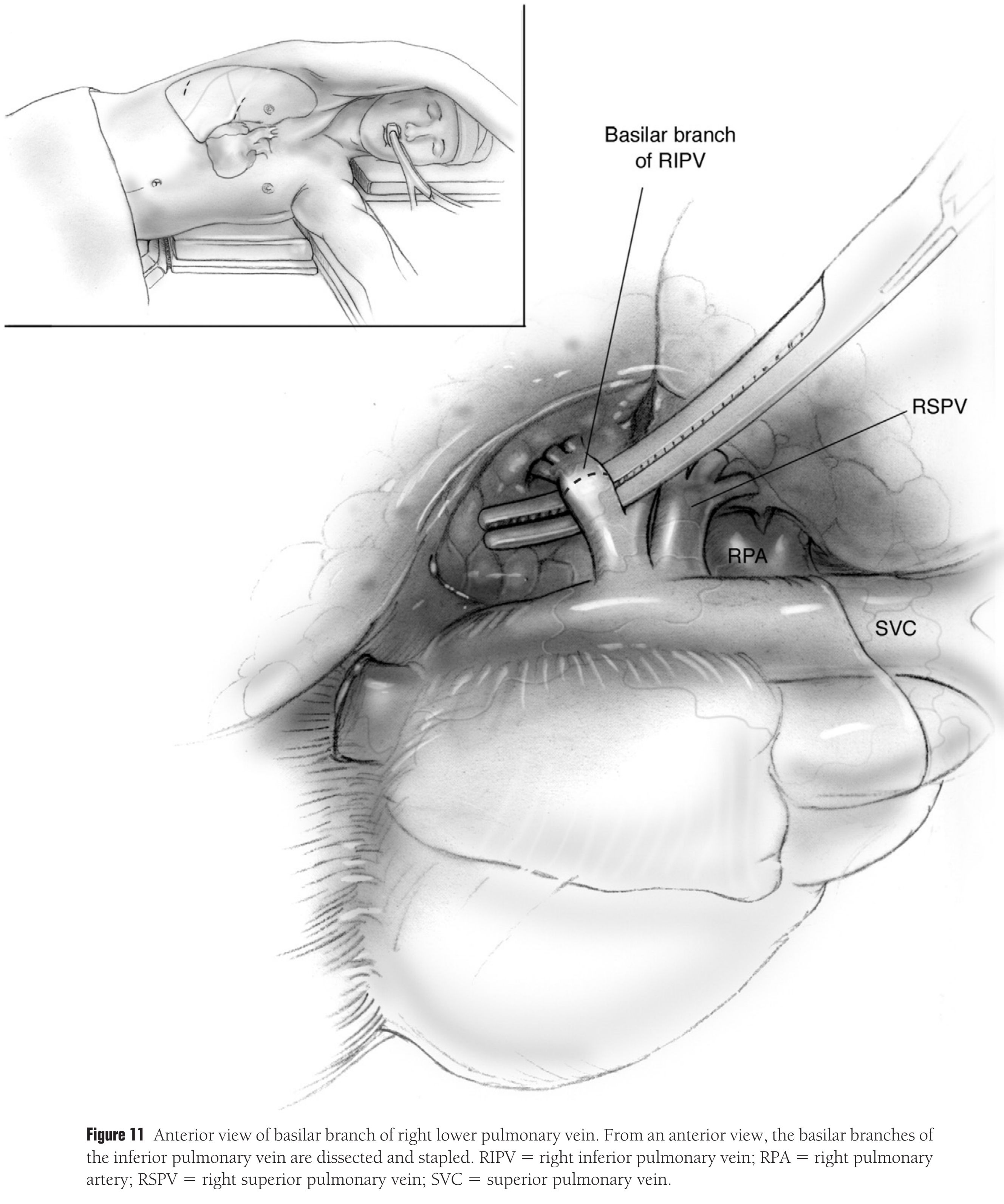

Figure 11 Anterior view of basilar branch of right lower pulmonary vein. From an anterior view, the basilar branches of the inferior pulmonary vein are dissected and stapled. RIPV = right inferior pulmonary vein; RPA = right pulmonary artery; RSPV = right superior pulmonary vein; SVC = superior pulmonary vein.

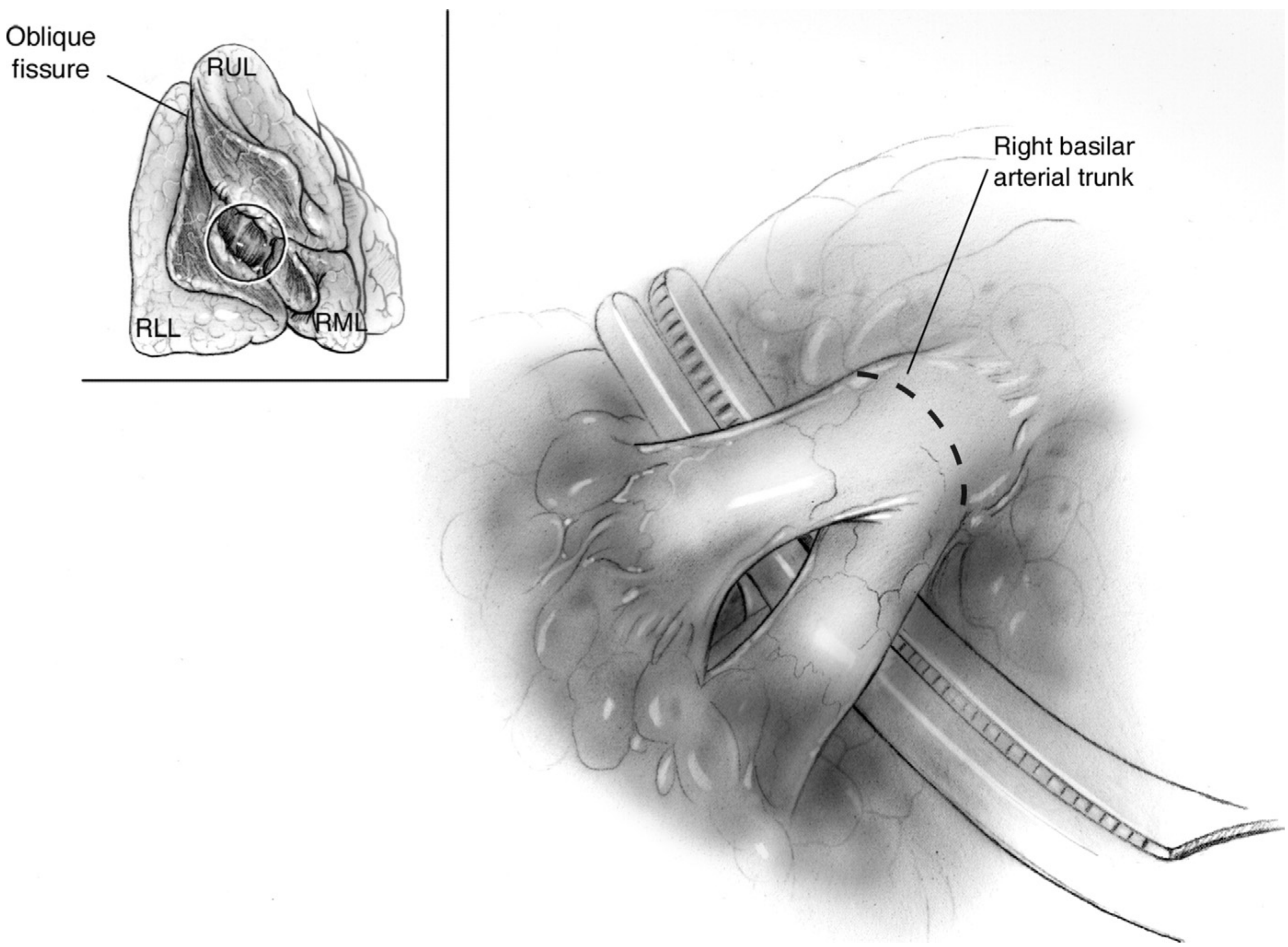

Figure 12 Right basilar arterial trunk. The basilar branch of pulmonary artery is approached through the oblique fissure and stapled. RLL = right lower lobe; RML = right middle lobe; RUL = right upper lobe.

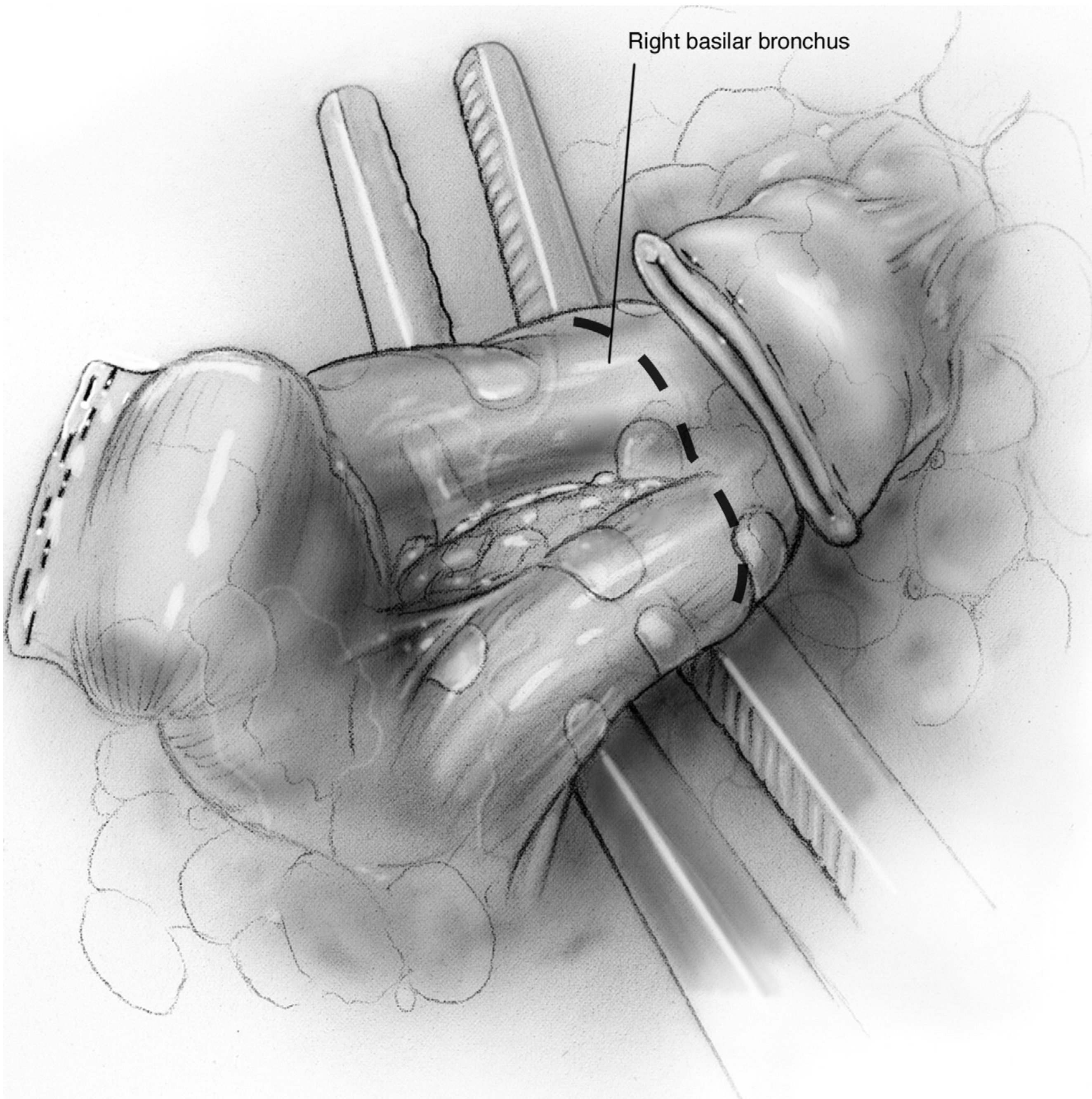

Figure 13 Right basilar bronchus. The basilar segmental bronchus is dissected from an anterior approach and stapled.

Conclusions

Thoracoscopic pulmonary segmentectomy is a sound option for lung-sparing, anatomic pulmonary resection for experienced thoracoscopic surgeons and can be safely applied to the treatment of a variety of pulmonary disorders, including small primary lung cancers, metastatic pulmonary disease, and benign disorders. This approach appears to have distinct advantages compared with thoracotomy, including reduced hospital length of stay.

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