The 12 steps to a thoracoscopic anterior segment segmentectomy: Oncologically safe and sound

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Excellent visualization of segmental anatomy with identification of aberrant anatomy.

CENTRAL MESSAGE

Segmentectomy via thoracoscopic techniques can be performed with exceptional exposure and visualization without compromising oncologic principles.

See Commentary on page 205.

▶ Video clip is available online.

Carcinoid tumors of the lung as well as central pulmonary metastases represent a group of tumors that can be challenging to manage in patients with marginal pulmonary function. In these cases, lobar anatomic pulmonary resection may leave patients with significantly decreased pulmonary function and quality of life.[1-3] In contrast, a wedge resection may not be achievable due to central location of the tumor and may be oncologically suboptimal without a complete lymph node dissection and/or in cases of atypical carcinoid histology.[1,2] Therefore, performing pulmonary segmentectomy to achieve complete resection and preserve parenchyma and function is often warranted or desired.[3]

In addition, minimally invasive resection via video-assisted thoracoscopic surgery techniques can further accelerate recovery in patients with borderline pulmonary function and performance status without compromising oncologic principles.[3,4] Common sublobar anatomic resections that have been described previously include superior segmentectomy, basilar segmentectomy, lingulectomy, and lingula-sparing upper lobectomy. Less frequently described operations include posterior or anterior segmentectomies of the upper lobes.[4] The resection of the anterior segment (S3) of the right upper lobe is described in the following 12 steps.

MATERIALS AND METHODS

The techniques for performing a S3 segmentectomy of the right upper lobe is outlined and depicted in the accompanying Videos 1 through 12. Informed consent was obtained from the patient for the video recording and its utilization in education and research. Necessary instrumentations include the use of a 30° 5-mm thoracoscopic camera, electrocautery, an energy device, thoracoscopic instruments, and linear endoscopic stapling device. A complete list of instrumentation can be found in Table 1. Regional pain control is obtained via placement of an erector spinae plane catheter. This method of pain management is preferred because it does not require the infiltration of an epidural space and therefore there is no need for an indwelling urinary catheter. The 12-step process conceptually demonstrates a systematic approach in hilar dissection, lymphadenectomy, and parenchymal resection.

RESULTS

The technique of thoracoscopic S3 segmentectomy of the right upper lobe is demonstrated in a patient with a biopsy-proven typical carcinoid tumor. Preoperative computed tomography imaging showed a nodule in the anterior segment of the right upper lobe (Figure 1). Preoperative pulmonary function tests included a forced expiratory volume in 1 second of 90% predicted, a diffusing capacity of the lungs for carbon monoxide of 89% predicted, and a residual volume that is 90% predicted. Lung isolation is achieved via a double-lumen endotracheal tube and patient is placed in a left lateral decubitus position. The 4-cm standard access incision is made at the anterior axillary line in the fifth intercostal space and accommodates all instruments during the

TABLE 1. List of instruments for thoracoscopic segmentectomies

| Instrument	Example
General	30°, 5-mm camera
	Wound retractor
Electrocautery/energy device	Maryland-tip bladed bipolar
	device (Ligasure, Medtronics)
	Monopolar electrocautery
Thoracoscopic instruments	Foerster lung grasping clamps × 2
	Dennis dissector
	Metzenbaum scissors
	Thoracoscopic suction
	Duval lung grasping clamps × 2
	Node grasping clamp
Stapler/staple load	EndoGIA universal handle
	45-mm Curved tip vascular
	load (tan) × 2
	45-mm Curved tip medium load
	(purple)45-mm Straight medium
	load (purple) × 4

case (typically 1-2 lung retractors, a dissecting tool and/or energy device, a thoracoscopic suction, and an endoscopic stapler). This incision allows the use of 3 to 4 instruments simultaneously and negates the need for any additional assist ports. At the end of the case, the specimen can be retrieved through the same access incision without any additional extension of the incision. A camera port incision is made in the posterior axillary line at the seventh intercostal space. This port incision becomes the chest tube port at the conclusion of the case.

Posterior Anatomy

Initial view of the posterior pleura involves retraction of both the upper lobe and lower lobe anteriorly using a thoracoscopic lung clamp. This allows for the identification of

FIGURE 1. Preoperative imaging of the pulmonary nodule. Computed tomography image of the right upper lobe pulmonary nodule that is centrally located and biopsy-proven typical carcinoid tumor.
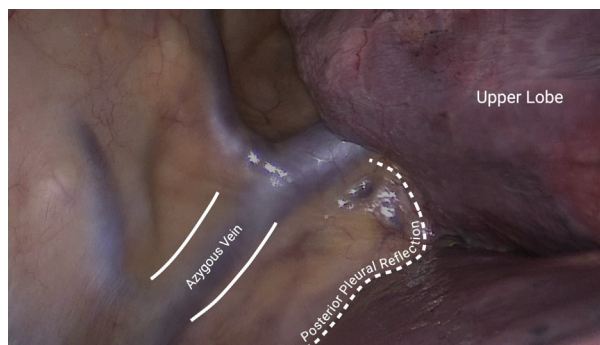
VIDEO 1. Posterior anatomy. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

azygous vein and posterior pleural reflection (labeled in Video 1).
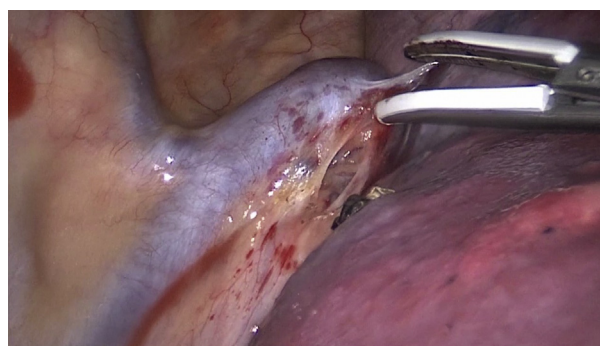
Posterior Pleural Dissection

The posterior hilar dissection begins by dividing the posterior pleural reflection at the level of the bronchus intermedius and moving cephalad toward the azygous vein. The vein is then retracted upward to develop a plane between the right mainstem bronchus and pleura (Video 2).
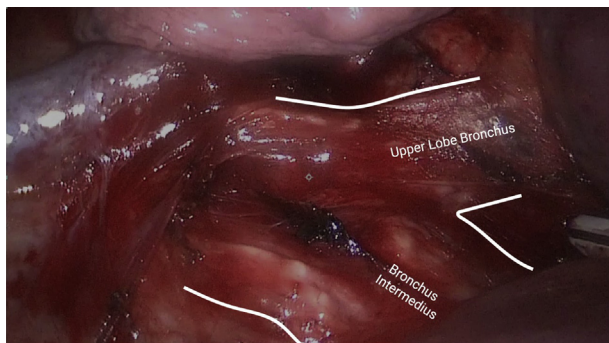
Lengthening of Posterior Hilum

Once the right mainstem bronchus has been identified, the combination of blunt and sharp dissection is used to lengthen the posterior hilum to identify the division between the right upper lobe bronchus and bronchus intermedius (labeled in Video 3). The continuation of the hilum-lengthening technique is performed along the posterior upper lobe bronchus until the bronchial division of the segments is visualized.

Hilar Lymph Node Dissection

To fully expose the segmental anatomy of the bronchial and vascular structures, a complete hilar dissection is performed. From an anterior view point, level 10R lymph

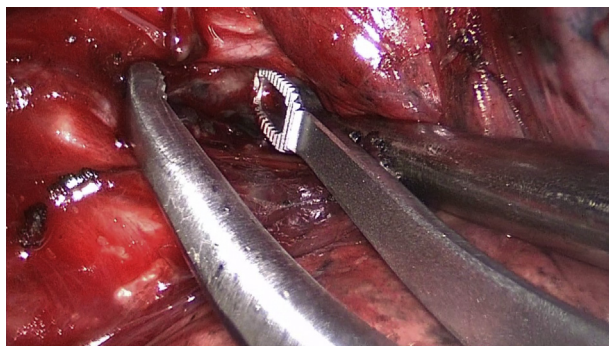**VIDEO 2.** Posterior pleural dissection. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

VIDEO 3. Lengthening of posterior hilum. Video available at: https:// www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

nodes located between the right mainstem bronchus and truncus arteriosus are dissected and removed completely. Retraction of the azygous vein superiorly aids in the exposure and dissection of the lymph node and results in adequate exposure and isolation of the right upper lobe bronchus. Moving posteriorly, level 11R is identified at the branch point between the right upper lobe bronchus and bronchus intermedius. This exposure confirms that the bronchus intermedius is excluded from bronchial division while maintaining an adequate hilar lymphadenectomy for oncologic staging (Video 4).

Anterior Dissection and Division of Horizontal Fissure

At this point, the lung is then retracted posteriorly to expose the anterior hilum. It is important to identify the phrenic nerve and ensure its preservation during the division of the pleura in the anterior hilum. This effectively lengthens the hilum and exposes the pulmonary vein and its branches. Next, the horizontal fissure is then identified and divided in its entirety. Most anteriorly, the fissure is divided with the linear stapler, taking care to engage the stapler tip between the upper lobe and middle lobe branches of the superior pulmonary vein, and superficial to the interlobar pulmonary artery. Most of the fissure may then be opened using an energy device, and this demonstrates the venous anomaly:

VIDEO 4. Hilar lymph node dissection. Video available at: https://www. jtcvs.org/article/S2666-2507(22)00078-5/fulltext.
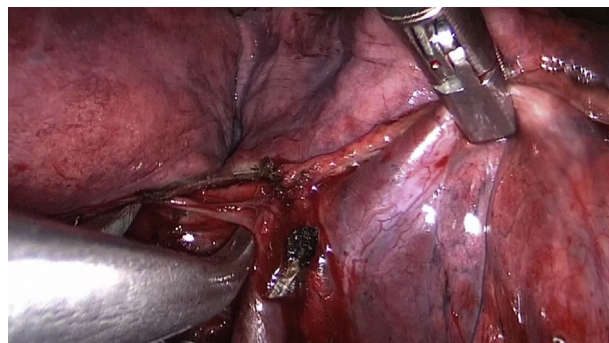
VIDEO 5. Anterior dissection and division of horizontal fissure. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

Accessory middle lobe draining into S3 pulmonary vein (V3) (Video 5).
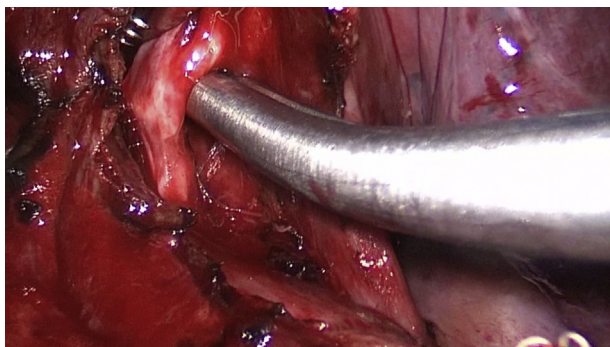
Dissection and Division of S3 Pulmonary Vein

Once the anterior portion of the horizontal fissure has been divided, attention is turned to confirm visualization of both the superior pulmonary vein and the middle lobe vein. Both blunt and sharp dissection are employed to lengthen the anterior hilum to further exposes the segmental branches (S1 pulmonary vein, V2, S2 pulmonary vein, V3). The posterior segment of the pulmonary vein should be visualized to confirm the anatomic location of the middle lobe vein. Aberrant anatomy can be identified in which an accessory middle lobe vein can arise from V3 (labeled in Video 6). If recognized, this should be carefully preserved to maximize venous drainage of the middle lobe. In cases where aberrant anatomy is identified and cannot be preserved, the presence of a middle lobe vein should be confirmed prior to dividing any venous anatomy. V3 is divided using the 45-mm curved tip tristaple vascular load on an endoscopic linear stapling device.

Dissection and Division of S3 Bronchus

The isolation of the segmental bronchus can now be achieved with relative ease after the vein has been divided. The majority of the dissection has already been performed
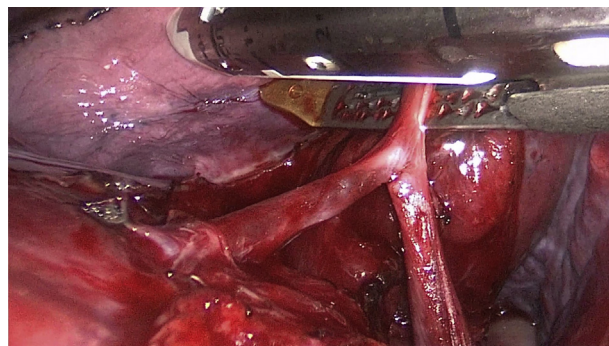
VIDEO 6. Dissection and division of S3 pulmonary vein (V3). Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

VIDEO 7. Dissection and division of S3 bronchus (B3). Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

posteriorly and the plane between the bronchus and artery has been established after the hilar lymphadenectomy. Encircling and division of S3 bronchus is performed using a 45-mm curved tip tristaple medium (purple) load on an endoscopic linear stapling device (Video 7).

Dissection and Division of S3 Pulmonary Artery

The remaining hilar structure is the arterial anatomy. The truncus arteriosus is carefully separated and lengthened until its trifurcation is identified. S3 pulmonary artery is then divided using a 45-mm curved tip tristaple vascular load on a linear endoscopic stapling device and subsequent sharp division. It is important not to force the stapling device through at the risk of injuring S1 pulmonary artery and S2 pulmonary artery. As can be seen, sharp division can be employed if the artery is completely stapled but not completely transected by the stapler (Video 8).

Test Inflation and Division of Parenchyma

Margin delineation for parenchymal resection is performed by test inflation (labeled in Video 9). Electrocautery can be used to mark the resection margin and the division of the lung parenchyma is performed using 45-mm straight medium (purple load) on a stapling device.
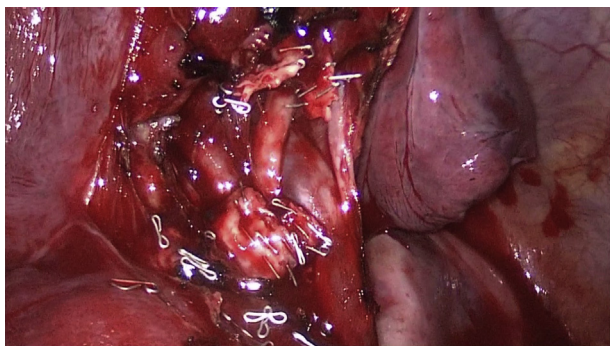
VIDEO 8. Dissection and division of S3 pulmonary artery (A3). Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.
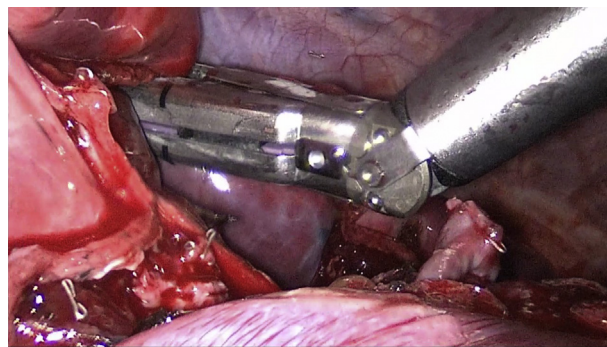
VIDEO 9. Test inflation and division of parenchyma. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.
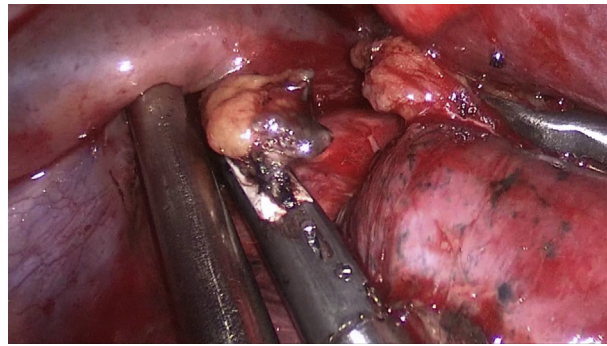
Mediastinal Lymph Node Dissection

Mediastinal lymph node dissection is recommended and performed after the specimen has been removed. Level 2 and level 4 lymph nodes are retrieved by developing a plane underneath the azygous vein. The borders for complete lymphadenectomy include the trachea, the superior vena cava, and the pericardium. Level 7 lymphadenectomy is achieved via dissection through the previous posterior pleural dissection just medial to the bronchus intermedius. The borders for complete lymphadenectomy of the subcarinal nodes include the left and right main stem bronchus, the esophagus posteriorly, and the posterior aspect of the left atrium anteriorly (Video 10).
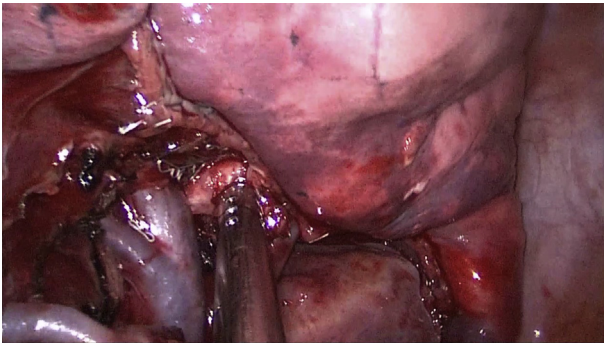
Final View of Anatomy and Reinflation

After completion of all dissection, a final view of the hilum is performed to ensure adequate hemostasis and correct orientation of the hilum. A 24 Fr chest tube is placed and the lung is reinflated under direct visualization (Video 11).

Identification of Specimen and Nodule

The specimen is removed and carefully inspected. Confirmation of the nodule within the specimen is required. An adequate 2-cm bronchial margin is demonstrated by identifying the relationship between the bronchial stump

**VIDEO 10.** Mediastinal lymph node dissection. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

VIDEO 11. Final view of anatomy and reinflation. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

and the nodule. There are currently no consensus guidelines for what constitutes an adequate parenchymal margin for carcinoid tumor in sublobar anatomical resections. For central tumors, the ability to obtain a negative parenchyma margin is achievable and we therefore recommend a resection margin to tumor ratio ≥1 when possible. For more peripheral carcinoid tumors, a negative margin including the staple line has been shown to be adequate but optimally, we would prefer a margin of at least 5 mm from the parenchymal staple line especially in cases with atypical carcinoid histology. Cases of stage I non–small cell lung cancer should adhere to the American College of Chest Physicians guidelines to achieve a margin to tumor ratio >1 (Video 12).

DISCUSSION

The overall success of single segmentectomy depends on the identification of cases that are appropriate for sublobar resection and an oncologically sound technique. Most cases with adenocarcinoma or squamous cell carcinoma of the lung in patients with adequate pulmonary function should be considered for an anatomic lobectomy to achieve a complete oncologic resection.[4-8] In contrast,
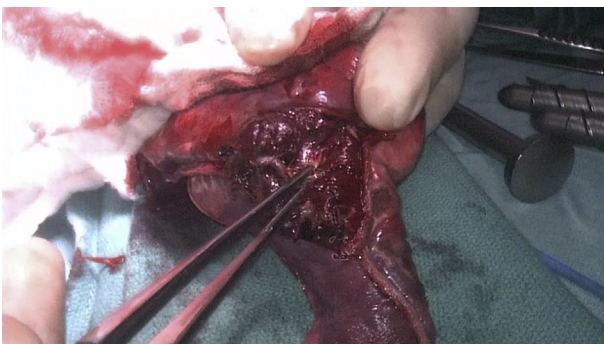
VIDEO 12. Identification of specimen and nodule. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00078-5/fulltext.

posterior or anterior segmentectomies in patients with upper lobe-predominant bullous emphysema may not preserve any meaningful pulmonary function while predisposing patients to prolonged airleak and hospitalization.[4,5] Therefore, patient and tumor selection are crucial.

Although anatomic lobectomies have been performed thoracoscopically at high-volume centers for more than a decade with a conversion rate of <2%, the widespread use of the minimally invasive technique has not been adopted nationwide for a variety of reasons, including surmounting the learning curve to having the appropriate instrumentation and ancillary staff.[9] Progressing to thoracoscopic segmentectomies, therefore, can seem even more formidable. However, given the decrease in postoperative complications, attempts should be made to ascertain the skills to perform sublobar anatomic resection thoracoscopically.[5-7]

Review of the literature noted minimal differences in terms of short-term outcomes between open and thoracoscopic sublobar segmentectomies with the exception of shorter hospital length of stay and essentially zero mortality at 30-day in the video-assisted thoracoscopic surgery group.[1-7] Although the long-term results of Cancer and Leukemia Group B 14053 is pending, the improved postoperative outcomes should negate any concerns regarding technical difficulties in thoracoscopic segmentectomies in the resection of typical carcinoids or central pulmonary metastases.

CONCLUSIONS

Single pulmonary segmentectomies can be performed thoracoscopically safely with excellent visualization and exposure without compromising oncologic principles.

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