Robotic-assisted left pneumonectomy

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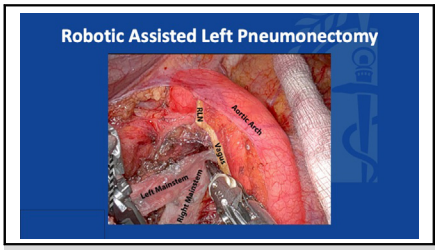
Video clip is available online.



Mediastinal anatomy.

CENTRAL MESSAGE

The described steps demonstrate a safe and reproducible approach to a robotic-assisted left pneumonectomy.

Pneumonectomy carries high morbidity and mortality rates ranging from 5% to 8%. Utilization of the robotic approach in major thoracic procedures continues to increase nationally.[1] Robotic pneumonectomy has been shown to be safe and effective with similar long- and short-term oncologic outcomes compared with open and video-assisted approaches.[2,3] Pneumonectomy is indicated in primary lung malignancies when R0 resection cannot be obtained with lobectomy, bilobectomy, or sleeve resection. Pneumonectomy in patients with N2 disease is controversial.[4,5]

Robotic pneumonectomy was performed on a 32-year-old female never smoker, who presented with a long-standing history of cough with hemoptysis. Ultimately a computed tomography image of the chest demonstrated complete left lower lobe collapse, with air trapping of the left upper lobe and nodular extension from the left lower lobe airway into the left mainstem bronchus. She then underwent bronchoscopy and endobronchial ultrasound. During this procedure, the mass biopsied and debrided. The pathology demonstrated an atypical carcinoid tumor, with negative mediastinal lymph nodes. Dotatate scan showed no evidence metastatic disease. Given the location and size of the lesion, R0 resection could not be obtained without pneumonectomy. A discussion was had with the patient and she elected to proceed with pneumonectomy. Institutional review board approval was not required; the patient consented to publication of de-identified pictures and videos collected during this procedure.

MATERIALS AND METHODS

Robotic approach to pneumonectomy is described in 8 steps (with accompanying videos from a single operation). The specific steps are described based on the authors' experience and how the operation is performed at our institution. Three robotic instruments are used in this procedure: long bipolar, used for all the dissections with an energy setting of 8 MW and 120 W; force bipolar, used for manipulating and positioning for exposure to assist dissection and stapling; and a tip-up grasper, used for retraction of the lung. The 30° robotic camera was utilized.

OPERATIVE TECHNIQUE

Step 1: Port Placement/Chest Exploration

See Video 1. The patient is placed in right lateral decubitus position, prepped, and draped. A Veres needle is used to insufflate to 8 to 10 mm Hg and optical entry is used with the 8-mm robotic port to access the chest.

Three ports are placed in the ninth interspace approximately 8 cm apart. The most posterior port (#1) is placed 3 to 4 cm lateral to the spine. Port #2 is placed 8 cm lateral to port #1, followed by port #3 8 cm lateral to port #2, which is at or just posterior to the posterior axillary line.

One anterior 12-mm robotic port (#4) is placed in the subpectoral line as medial and inferior as possible, usually in the seventh interspace. Care is taken to ensure a distance of 8 cm from the camera port #3. Next the 12-mm robotic assistant port is triangulated inferior to the camera port #3 and next closest posterior port #2 entering just above the diaphragmatic insertion. Video 1 demonstrates the use of a 15-mm disposable assistant port, not a 12-mm robotic port. This change transition was implemented at the time of writing this article. After this, the robot is docked and the camera is centered in the working space. Airseal is activated and the chest cavity and lung are then thoroughly inspected for possible metastatic disease.

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Received for publication Jan 16, 2024; revisions received Feb 5, 2024; accepted for publication Feb 7, 2024; available ahead of print Feb 29, 2024.

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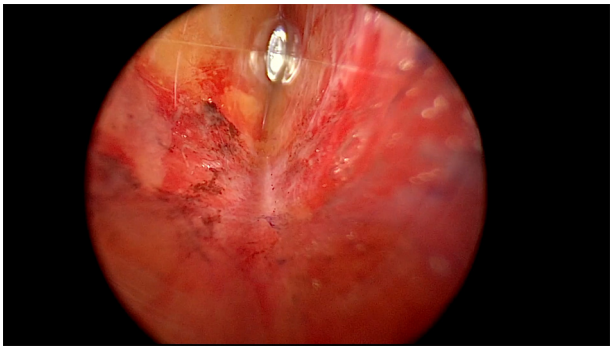
JTCVS Techniques 2024;25:186-9
2666-2507

https://doi.org/10.1016/j.xjtc.2024.02.018



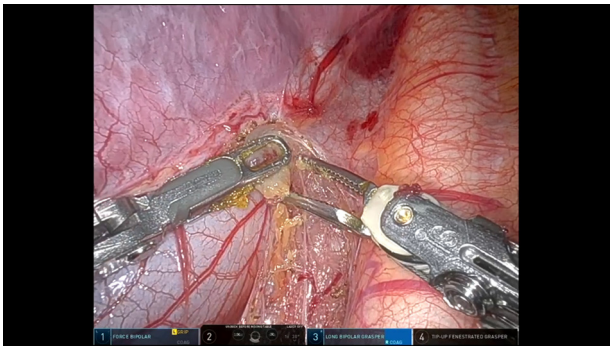
VIDEO 1. Step 1: Port placement/chest exploration. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00070-1/fulltext.

Step 2: Posterior Hilar Dissection/Takedown of Inferior Pulmonary Ligament

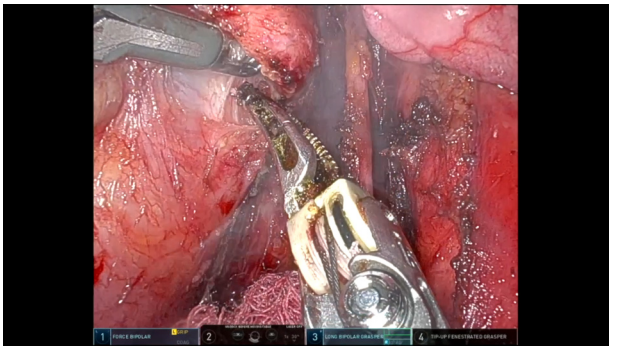
See Video 2. The lung is retracted anteriorly and apically with a cigar and the tip up forceps from port #4 to expose the inferior pulmonary ligament as well as the subcarinal space. The inferior pulmonary ligament is dissected using the long bipolar instrument to expose the inferior pulmonary vein using a combination of bipolar cautery and blunt dissection. Level 8 and 9 lymph nodes are harvested as they are encountered. Anterior retraction of the lung is maintained to facilitate the posterior hilar and mediastinal dissection as it is carried above the inferior pulmonary vein. The hilar pleura is opened the entire length of the posterior mediastinum along the edge of the lung. This parachutes the structures up into the operative field. Level 10 lymph nodes are harvested just above the inferior pulmonary vein.

Step 3: Posterior Subcarinal/Mediastinal Dissection

See Video 3. The dissection is carried along the pericardium making sure to identify the inferior aspect of the bronchus, which is superior to the vein. The vagus nerve is identified and mobilized off of the hilar structures. The esophagus is mobilized off the posterior pericardium and the subcarinal



VIDEO 2. Step 2: Posterior hilar dissection / takedown of inferior pulmonary ligament. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00070-1/fulltext.



VIDEO 3. Step 3: Posterior subcarinal/mediastinal dissection. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00070-1/fulltext.

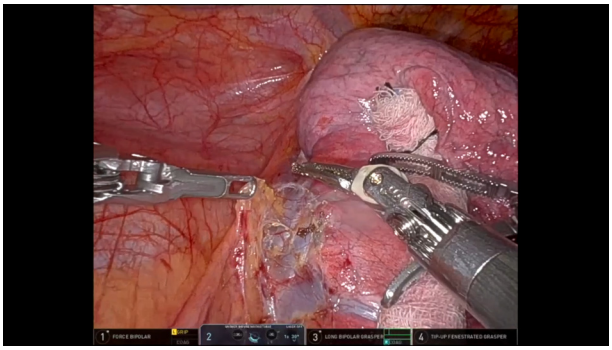
space is opened. The level 7 lymph node packet is fully excised to expose the entire carina, left mainstem bronchus, and right mainstem bronchus. Retraction is moved superiorly to focus exposure between the left mainstem bronchus and main pulmonary artery (PA). A thorough mobilization of the left mainstem bronchus and carina off the left main PA is performed. The level 10 lymph nodes between the left mainstem and left main PA are excised and this facilitates visualization of the anterior cartilaginous portion of the left bronchus and allows for more mobility of the airway. Once this step is complete, the surgeon should have a clear view of the carina from both a posterior view and an anterior view. This will facilitate the safe retraction of the bronchus away from the main PA when passing the stapler across the main PA.

Technical pearl: Using a right-sided double lumen tube allows for more facile dissection around the left mainstem. This also avoids the need to retract the endotracheal tube before bronchial transection. A left-sided bronchial balloon can also be misconstrued for a subcarinal lymph node resulting in airway injury.

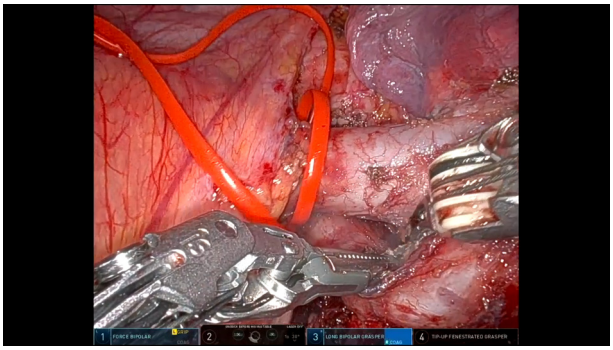
Step 4: Anterior Hilar Dissection/Dissection of Pulmonary Veins

See Video 4. The lung is reflected posteriorly and laterally to expose the anterior hilum and the superior and inferior pulmonary veins. Dissection is carried from inferior to superior with care taken to identify and preserve the phrenic nerve. Emphasis is placed on excising anterior hilar lymph nodes and dissection on the periareolar plane of the vein. Once the tissue is dissected between the inferior and superior pulmonary veins, the subcarinal space will be clearly visible from an anterior perspective as well due to the prior complete dissection of the subcarinal space posteriorly. This will facilitate safe division of the inferior pulmonary vein.

The same technique is then used to develop the plane between the superior pulmonary vein and the main PA. Retraction and manipulation of the superior pulmonary vein is used to expose and develop the plane between the vein and the main PA.



VIDEO 4. Step 4: Anterior hilar dissection/dissection of pulmonary veins. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00070-1/fulltext.



VIDEO 6. Step 6: Division of pulmonary artery. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00070-1/fulltext.

Step 5: Division of Pulmonary Veins

See Video 5. The inferior pulmonary vein is divided first. A blue vessel loop is used to encircle the vein and retracted it to create a generous window to pass a stapler and transect the artery. The lung is then retracted toward the apex of the chest, exposing the inferior aspect of the left mainstem bronchus and the main PA. This plane is developed further with dissection of the adventitial tissue and excision of lymph nodes on the inferior aspect of both structures. This dissection was started when the posterior dissection was performed and the lymph node removed, hence facilitating the current dissection of completing he safe and well-visualized separation of the bronchus from the PA. The superior pulmonary vein is then encircled and divided.

Step 6: Division of the PA

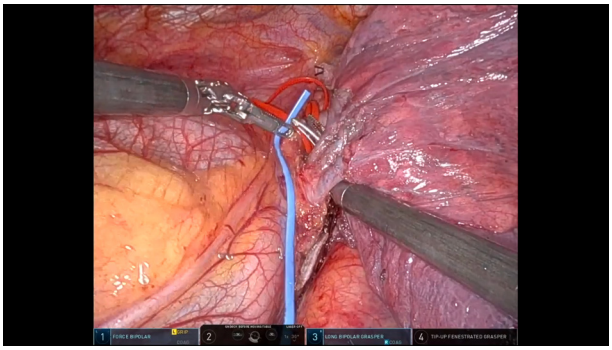
See Video 6. A red vessel loop is placed around the PA twice. This serves to assist in retraction but also can be used as a Rummel-like tourniquet. If additional control is need, an additional vessel loop can be placed more distally on the artery. The yellow vessel loop is passed around the left mainstem bronchus. The red vessel loop is removed and the artery is divided with a vascular (white) load.

Step 7: Division of the Bronchus

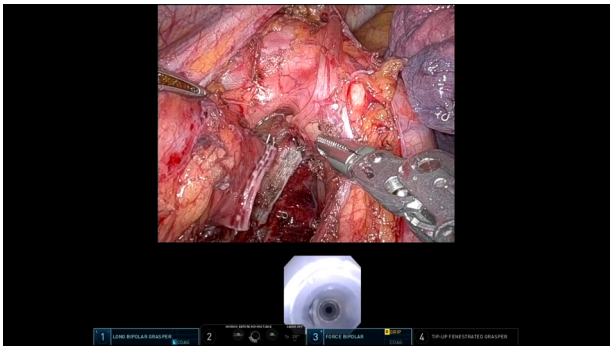
See Video 7. The bronchus is retracted posterior and inferior. Appropriate tension on the vessel loop is placed to deliver the carina out of the mediastinum so the stapler can be passed flush to the base of the left mainstem bronchus without encroaching on the left main PA stump. Bronchoscopy is performed concurrently to ensure that no blind bronchial stump remains before transection. Generally, a black stapler load is used.

Step 8: Leak Test/Hemostasis/Removal of Specimen

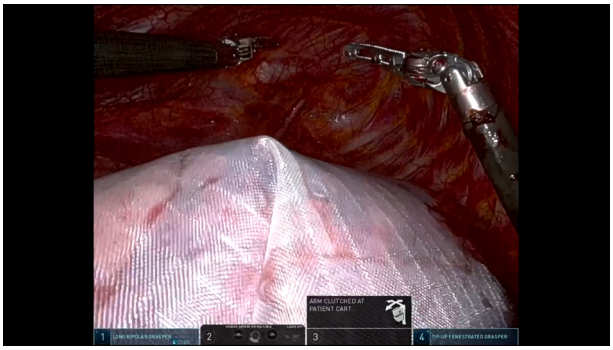
See Video 8. The bronchial stump is immersed with warm water. A leak test is performed up to a pressure of 30 mm Hg. Hemostasis is confirmed. Intercostal nerve blocks are performed. The specimen is extracted with a 15-mm bag. A single 20Fr chest tube is placed.



VIDEO 5. Step 5: Division of pulmonary veins. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00070-1/fulltext.



VIDEO 7. Step 7: Division of bronchus. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00070-1/fulltext.



VIDEO 8. Step 8: Leak test/hemostasis/removal of specimen. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00070-1/fulltext.

Conflict of Interest Statement

Drs Soukiasian and Brownlee are proctors for Intuitive.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

References

1. Alwatari Y, Khoraki J, Wolfe LG, et al. Trends of utilization and perioperative outcomes of robotic and video-assisted thoracoscopic surgery in patients with lung cancer undergoing minimally invasive resection in the United States. *J Thorac Cardiovasc Surg Open*. 2022;12:385-398.
2. Patton BD, Zarif D, Bahroloomi DM, Sarmiento IC, Lee PC, Lazzaro RS. Robotic pneumonectomy for lung cancer: perioperative outcomes and factors leading to conversion to thoracotomy. *Innovations (Phila)*. 2021;16(2):136-141.
3. Mack SJ, Collins ML, Till BM, et al. The safety of robotic pneumonectomy. *Ann Thorac Surg Short Rep*. 2024;2(1):P82-P87.
4. Paul S, Mirza F, Port JL, et al. Survival of patients with clinical stage IIIA non–small cell lung cancer after induction therapy: age, mediastinal downstaging, and extent of pulmonary resection as independent predictors. *J Thorac Cardiovasc Surg*. 2011;141(1):48-58.
5. Santana-Davila R, Martins R. Treatment of stage IIIA non-small-cell lung cancer: a concise review for the practicing oncologist. *J Oncol Pract*. 2016;12(7):601-606. https://doi.org/10.1200/JOP.2016.013052

Key Words: minimally invasive pneumonectomy, robotic pneumonectomy, robotic thoracic surgery