Robotic left S^{9-10} lung segmentectomy: how I do it?

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Abstract: Left S^{9-10} segmentectomy is one of the most difficult lung segmentectomies because of the highly variable peripheral pulmonary anatomies and the difficulty of dividing the intersegmental plane. The robotic system is helpful to perform through a full thoracoscopic approach this challenging procedure. We describe the technique of robotic left S^{9-10} lung segmentectomy.

Keywords: Lung segmentectomy; thoracic surgery; robotic surgery; lung cancer

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Introduction

Lung segmentectomy is an intervention more and more practiced by thoracic surgeons in the area of lung parenchyma preservation. Indeed, there are several indications for this kind of procedure:

- For benign diseases or metastases with a localization not favorable for a wedge resection.
- For primary lung cancer, thoracic surgeons may offer to their patients a segmentectomy with radical lymph nodes dissection in two different situations:
  - Patients with good respiratory function and a small lesion (cT1a-bN0M0): a segmentectomy may be an option, instead of a lobectomy, if tumor's localization is anatomically favorable with safe margins and also if frozen section examination of N1 lymph nodes is negative. We call it an intentional segmentectomy.
  - Patients with limit respiratory function and a small lesion (cT1a-bN0M0): a segmentectomy may be an option for local treatment because these patients cannot benefit of a lobectomy. We call it a compromised segmentectomy.

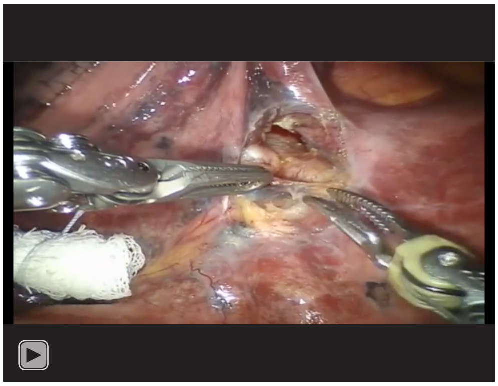
The left S^{9-10} segmentectomy is a very technical intervention that can be challenging mainly because of anatomical variations and the difficulty of the intersegmental plan (1).

Operative technic

Ports placement

Depending on the surgeon, there is a wide variety of port positioning. The authors have chosen for all kind of lung resection a technique similar to that described by Dr. Robert Cerfolio (2). It is a total port approach with 4 ports in the 8^{th} intercostal space and a last one (the most anterior) in the 6^{th} space. The advantage of this complete port access is to group 4 of the 5 ports in a single intercostal space in order to reduce the parietal trauma. Firstly, it needs to identify the 8th space, then to place the ports along this space with, from back to front:

- A first port of 5 mm (8 mm on the Xi) about 4 cm (5 cm on the Xi) from the spine for the arm which will serve as an exposure using a soft grip forceps (Thoracic Grasper on the Si, Fenestrated Grasper or Tip Up Grasper on the Xi).
- A second port about 9 cm from the previous one (8 cm on the Xi). The authors use by this port an instrument for dissection with bipolar energy (Maryland Bipolar).
- A third port about 9 cm from the previous one (8 cm on the Xi) to receive the camera arm (12 mm trocar on the Si, 8 mm trocar on the Xi).
- A fourth port about 9 cm from the previous one (8 cm on the Xi). It is the 12 mm assistant port



Video 1 Robotic left S9-10 lung segmentectomy step by step.

allowing help to carry out aspiration, exposure, stapling… After completing the segmental resection, the operative specimen will be placed in an Endobag before being extracted through this port that will be enlarged.

- ❖ The fifth and last port is located in the 6th intercostal space, in the most anterior position possible so as to make a triangulation between the latter, the assistant port and the camera. This triangulation is important in order to preserve sufficient working space for the assistant. This port will receive arm 4 with a gripping instrument (Caudiere). Finally, it is through this orifice that the chest tube will be introduced at the end of surgery.

Initial inspection

The first step is to assess the entire thoracic cavity, the quality of the parenchyma (emphysema), the fissures opening (Walker's classification), the anatomical disposition and the exact tumor's localization. Authors used to always have cigar sponges (rolls gauze) available in the chest for lung mobilization or compression in case of bleeding.

Radical lymph node dissection

Authors are used to remove the lymph nodes at the beginning of the intervention. It allows to clear the bronchovascular elements and makes easier the lung resection. The lymph node dissection is performed all around the hilum (station 10L), in mediastinal sites (station 8L&9L, station 7, station 5&6) and inside the fissure (station 11L and station 12L). All lymph nodes located at the arterial division of A^8 and A^{9-10} must be sent for frozen section examination in case of intentional segmentectomy.

Artery dissection

The pulmonary artery is approached in the middle portion of the major fissure as for a lower lobectomy. After Identification of the pulmonary artery in the fissure, its branches are dissected and A^6, A^8 and A^{9-10} are identified. Stapling the last exposes the segmental bronchus with runs posteriorly (*Video 1*).

Bronchus dissection

The most frequent anatomy of the basilar segment is B^8 and B^{9-10} and A^8 and A^{9-10} explaining this bi-segmentectomy. Dissecting the B^{9-10} branches, care has been taken to not hurt B^6 or the vein running behind it. It's helpful to use a vessel loop around A^8 for exposure by retracting it forward. Bronchus is then stapled after a reventilation test.

Venous dissection

The inferior pulmonary vein is cleared from the surrounding tissues, until the superior and inferior basal veins and also V^6 are identified. The lower root of the inferior pulmonary vein is the inferior basal vein and does not always represent the venous drainage of S^9 and S^{10}. One of its branches can drain S^8 or it could have no separate basal veins but a common basal vein and V^6.

Thus, there are 2 options to control veins:

- ❖ Proximally with identification of inferior basal vein if anatomical pattern is modal. In case of doubt, it can be safer to divide only the lowermost tributary.
- ❖ Distally with identification of the vein in the parenchyma under the bronchus.

Intersegmental plane

There are also 2 options for this moment: with or without S^6 split. At the beginning of the learning curve, we took the intersegmental plane at the end of the procedure without splitting S^6. We stapled from the diaphragmatic side of S^{9-10} and skewing the staple line to the rear when reaching the inferior border of S^6. We found this maneuver unsatisfactory to stay bronchovascular stumps remote on the specimen and now we apply a tunneling technique to separate S^6 and S^{9-10} (3). In this technic with S^6 split, bronchovascular stapling is performed after opening the intersegmental plane between S^6 and S^{9-10}, thus facilitating the exposure of the bronchovascular elements. This technic needs to start by clearing the inferior pulmonary vein from the surrounding tissues. A passage is created between V^6 and the superior basal vein, using a blunt dissection to avoid hurting V^6. The surgeons move then back to the fissure (where the bronchovascular elements have previously been dissected but not stapled) and find the tip of the blunt instrument coming from the back. After the easier stapling of the bronchovascular elements, the intersegmental plane between S^8 and S^{9-10} is taken from the diaphragmatic side and stapling should be done step by step progressing in a cephalad direction to the first staple line between S6 and S^{9-10}.

Discussion

Compared to VATS where the instrumentation remains limited, the robotic system offers large possibilities for dissection. First, eye-hand coordination is no longer reversed as in VATS. In addition, the system removes the physiological tremor known in VATS and even increases the surgeon's gestures with a scale of 3:1 or 5:1. This results in an excellent level of precision necessary for this kind of challenging cases. Indeed, the main difficulties of minimally invasive segmentectomies lie in locating the very small target lesion, in identifying precisely the intersegmental plane and in performing an intra-parenchymal radical lymph node dissection for stations 12&13. However robotic system has some advantages that can help surgeons for all these points.

Regarding the lesion's identification, surgeons can use bronchoscopic dye injection like indocyanine green (ICG) inside le target just before the intervention. When introducing the camera at the beginning of the surgery, the operator can identify the lesion with a near-infrared imaging system (Firefly technology). It also possible to use intrabronchial injection of methylene blue but identification is less accurate. Another option is to place a radiological coil close to the lesion just before the intervention. It needs an interventional radiologist available and a good logistic to synchronize both procedures. In all cases a precise localization of the lesion is mandatory to ensure correct safety margins.

Fluorescence is also essential for intersegmental plane (4). Clamping A^{9-10} and using a systemic injection of ICG at the dose of 0.2 mg/kg allows to identify S^{9-10}. Indeed, areas that did not take the green color corresponded to segments to resect. This is also helpful to ensure the respect of the vascularization of the remaining segments after removing the specimen. Without fluorescence the intersegmental plane can be identified during the reventilation test, but this is less precise mainly for patients with emphysema.

To ensure good oncological outcomes, lymph node dissection of remaining segments must be done (5,6). The dexterity offered by the robot allows fine dissection even for very small lymph nodes. Note that the procedure must be converted to a lobectomy in case of invaded lymph node sent for the frozen section examination (for an intentional segmentectomy) or if insufficient safety margins.

Finally, because of several anatomical variations, 3D reconstruction is strongly recommended to avoid misunderstandings of pulmonary structures. Without reconstruction, dissection has to be pursued as low as possible to identify all the branches before stapling. Regarding the arterial branches, a low A^6 can be mistaken for an A^{9-10}. More, instead of A^8 and A^{9-10} , the branching pattern with A^{8-9} and A^{10} or A^8, A9 and A^{10} can be encountered (7). The same variation is possible for bronchi. 3D reconstruction allows for a dynamic navigation in the arteries, veins and bronchi, and calculates the volume of the segments to be resected and a safety margin can be visualized.

Conclusions

Left S^{9-10} segmentectomy is a very challenging intervention. Knowing anatomical landmarks is mandatory to ensure a safe resection. Quality metrics are essential, and the robotic platform is an undeniable help to perform this procedure with good oncological outcomes.

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Footnote

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