Techniques of VATS lobectomy

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Introduction

Despite the objections of some zealots, there is clearly more than one way to successfully complete a video-assisted thoracoscopic or "VATS" lobectomy, and further refinements to the technique are added yearly. Most thoracic surgeons would define VATS lobectomy as one in which the dissection is completed with reliance on a video image, without the use of a retractor to spread the ribs and increase the width of the intercostal spaces. The actual number, location and aggregate length of the involved incisions are largely a matter of surgeon preference. Further, the actual methods used-fissure dissection compared with a "fissure-less" approach; Use of sharp, blunt or cautery techniques-is also at the discretion of the surgeon, as long as the basic tenet of individual dissection and ligation of the lobar structures is observed.

Operative technique

Preoperative assessment

Early stage (stages I and II) lung cancer is the most common indication for thoracoscopic lobectomy, although increasingly these techniques are applied in the setting of locally advanced disease following induction therapy. Benign tumors and focal areas of bronchiectasis are also usually amenable to a minimally invasive approach. The indications and contraindications to VATS lobectomy are covered in detail in another chapter in this monograph.

The preoperative assessment of patients considered for VATS lobectomy is routine, and is tailored to the indications for surgery. Preoperative imaging studies, including the use of computed tomography (CT) and positron emission tomography (PET), are helpful to confirm the planned extent of resection and the suitability of a VATS approach. Adequate pulmonary reserve is assessed through the use of pulmonary function testing, with occasional use of perfusion scanning and exercise testing when appropriate. Testing for occult cardiac disease is performed when indicated. In general, the preoperative assessment of a prospective patient is similar to any individual considered for pulmonary resection.

Anesthesia and preoperative bronchoscopy

The anesthetic technique for VATS lobectomy is similar to other cases of pulmonary resection. A means for lung isolation, either with the use of a double lumen endotracheal tube or bronchial blocker, is routine. Placement of a thoracic epidural catheter for postoperative pain control, while common in open thoracotomy cases, is usually not needed following thoracoscopic resection and is routinely omitted. It is often helpful to place intercostal blocks using 0.25% bupivacaine at the end of the procedure to aid immediate postoperative analgesia.

Surgeons are well advised to perform bronchoscopy prior to the procedure, to assess the targeted lobar orifice for abnormalities or any variations in anatomy which could have a significant impact on successful completion of the case. For example, encroachment of tumor on the planned line of bronchial resection could lead to abandonment of the minimally invasive approach.

Incisions and general dissection techniques

The vast majority of thoracoscopic lobectomy techniques employ either two, three, or four incisions, with three perhaps the most common. In all approaches, the camera port (5 to 10 mm) is typically placed low in the chest—7th or 8th intercostal space—and either in the mid or anterior axillary line. A "utility" or "access" incision (3 to 6 cm) is usually placed in the anterior axillary line, over the anterior hilum (about 5th intercostal space) in the cases of upper lobectomy, and an interspace or two lower (adjacent to the major fissure) for middle and lower lobectomies. Third and fourth incisions, commonly 10 mm in size, are placed

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either through the auscultory triangle, high in the mid-axillary line, or low in the chest in the posterior axillary line. In all cases, no rib spreading is used at any of the incision sites. A soft tissue retractor, either a weitlaner or a commercially available device, is often used at the utility incision. Care must be used at all the incisions to avoid excessive "torqueing" of the rigid instruments on the adjacent ribs and intercostal bundles to avoid postoperative neuralgia.

The surgical procedure is facilitated by roughly aligning the view of the camera with the general direction of the dissection. This is most easily achieved with cameras designed to provide an angled view, either at 30 or 45 degrees from the long axis of the scope. This also allows the surgeon to "see around" the hilum with the camera in a trocar site low in the chest. It is important for the surgeon to remember that occasionally a better view may be available by placing the camera in the access or posterior incision; Flexibility with the operative technique in this fashion can often dramatically lessen the difficulty of the procedure.

Dissection of the hilar structures may be accomplished either using a largely blunt, sharp or cautery-based technique. A thorough knowledge of the hilar anatomy greatly enhances the safety of all of these techniques. Vital structures such as the phrenic nerve or recurrent laryngeal nerve should be identified early and preserved. While all of these techniques are useful, each has obvious drawbacks. It is likely that a combination of approaches probably produces the best results.

Pulmonary vessels and bronchi within the hilum are ligated with endoscopic staplers, although a "TA" type stapler may be used for the bronchus at the surgeon's discretion. It is important to introduce the stapler into the chest such that, once around the vessel or bronchus, it exits into "free space" and is not encumbered by other structures. This will avoid injury to other tissues, and assure a secure closure of the target. Bronchial arteries may be cauterized or clipped, or stapled in rare cases involving long standing pulmonary infection. Fissures are typically stapled unless complete, in which case cautery may be used. It is recommended that specimen removal is achieved with the use of a specimen bag, to minimize contact with the soft tissues at the access incision site. Use of this technique has reduced the incidence of "port-site" recurrence which plagued early attempts at thoracoscopic resection.

In cases of malignancy, nodal dissection may be performed either before or after completion of the pulmonary resection. Initial dissection often facilitates the subsequent lobectomy by increasing the mobility of the specimen at the hilar level. Further, identification of significant N2 disease, previously unrecognized, would allow for termination of the procedure prior to resection to allow for induction therapy. Alternatively, access to the various nodal stations is often improved after the pulmonary resection, thus enhancing the completeness of the dissection. Removal of the hilar and lobar nodes is performed during the ligation of the various hilar structures.

Recently, reports of minimally invasive lobectomies utilizing a single port, or "uniport" approach, have been published. This fascinating technique, still in evolution, is described in a separate submission to this monograph.

Right upper lobectomy (RUL)

The most common technique for "fissure-less" right upper lobectomy utilizes an "anterior to posterior" approach, wherein the dissection progresses from the anterior structures in the hilum to the more posterior structures, dividing the involved fissures last. This technique is felt to minimize complications of air leak which may be associated with significant dissection within an incomplete fissure.

The branches of the superior pulmonary vein pertaining to the RUL are dissected free, and divided with a vascular stapler. In most cases, the stapler is best introduced through the posterior trocar site, or through the camera port. The pleura is incised around the top of the hilum, extending posteriorly to the bronchus intermedius. This allows dissection of the truncus anterior branch of the pulmonary artery, which is divided in a similar fashion. Great care must be taken to avoid excessive retraction of the lobe posteriorly during this maneuver, which may result in arterial injury. It is a good practice to minimize traction on pulmonary vessels during staple ligation, leading to a more secure vascular closure.

Division of the truncus anterior branch will allow improved retraction of the lobe posteriorly, exposing the right upper lobe bronchus and the posterior ascending branch of the pulmonary artery. Either may ligated first, allowing improved exposure for the second structure. Dissection along the ongoing pulmonary artery will allow identification of the middle lobe branches, as well as the branch to the superior segment of the lower lobe. Occasionally, a separate arterial branch may be identified to the anterior RUL segment. Access to the structures to be divided may be enhanced be initiating division of the minor fissure anteriorly; Alternatively, one may divide the RUL bronchus from a posterior approach.

Finally, one completes the major and minor fissures pertaining to the upper lobe with a stapler. As the RUL becomes more mobile, the surgeon must be careful not to prevent twisting or torsion of the lobe at this step, which may lead to inaccurate completion of the fissures.

If the major fissure is complete or nearly so, it is certainly permissible to dissect and expose the artery within the fissure. Doing so will likely aid in completion of the minor fissure, facilitate identification of the superior segmental pulmonary artery, and may improve exposure to the posterior ascending branch of the pulmonary artery for ligation. However, the surgeon should avoid routine dissection within the fissure for a RUL, as is commonly taught in open surgical techniques. Avoidance of air leak is important to maximize the benefits of a thoracoscopic approach, producing shorter chest tube duration and hospital stay.

Left upper lobectomy (LUL)

The location and number of incisions is analogous to those used in right upper lobectomy. An anterior to posterior, or fissure-less approach, is used. Retracting the lung posteriorly and caudally, the pleura overlying the anterior, superior, and posterior hilum is excised. The superior pulmonary vein is dissected free and ligated with a vascular endoscopic stapler. The surgeon must be assured that a separate inferior vein is present and not included in the stapler, as it is not uncommon on the left side for the two pulmonary veins to join prior to entry into the pericardium. The first branches of the pulmonary artery are then dissected free, a maneuver facilitated by removal of adjacent lymph nodes. Again, the surgeon must take care to avoid excessive traction on the LUL, which may lead to arterial injury as the surgeon attempts to expose these initial branches. Introduction of the vascular stapler for these branches is usually through the access incision or the camera port; the anterior location of these incisions allows the stapler anvil to slip around the branch into free space, with minimal torque on the vessel itself.

At this point, only the pulmonary artery branches to the posterior segment and the lingula remain. Exposing these branches is often helped by division of the LUL bronchus. After division of the superior vein, the surgeon has ready access to the crotch between the upper and lower lobe bronchi. Dissection in this area, along with separation of the pulmonary artery from the LUL bronchus as the former wraps around the bronchus superiorly, allows safe isolation of the LUL bronchus. Introduction of an appropriate endoscopic stapler from the anterior camera port will allow safe passage of the stapler between the bronchus and the pulmonary artery into the free space superior to the hilum. After bronchial division, it is fairly straightforward to identify and ligate the remaining pulmonary artery branches to the LUL. The fissure is then completed with a stapler. Occasionally, analogous to the RUL technique, it is advantageous to initiate fissure division prior to this point, to allow better exposure to the deeper hilar vessels.

Right middle lobectomy (RML)

A completely "fissure-less" technique for RML resection is not possible, due to the location of the lobe between the upper and middle lobes. However, as the dissection proceeds in a caudal to cranial direction, the minor fissure is divided last. Despite this, the RML is perhaps the easiest lobe to using thoracoscopic techniques. For this resection, it is helpful to employ an auscultory triangle port to allow passage of the endoscopic stapler, as noted below.

The RML vein is isolated and divided, with the vascular stapler introduced via the posterior (if present) or camera port. Minimal dissection within the major fissure usually yields the pulmonary artery, and the portion of the major fissure between the middle and lower lobes may be completed either with a stapler or the cautery if nearly complete. The surgeon must be careful to identify and preserve a small pulmonary artery branch, invariably present, arising in the medial major fissure to the medial basilar segments of the right lower lobe.

Completion of the fissure allows access to the RML bronchus. The bronchus is freed by developing the plane between the pulmonary artery in the fissure and the bronchus, following the artery more proximally as it wraps around the bronchus superiorly. More anteriorly, the bronchus is separated from the pulmonary venous branches to the RUL, and the bronchus is encircled and then ligated with an endoscopic stapler introduced via the posterior port.

With the bronchus divided, the lobe is retracted cephalad, and one or two pulmonary artery branches are exposed to the RML. Just superior to this, the vein to the posterior segment of the RUL is seen. The arterial branches are isolated and divided either individually or occasionally with the same vascular stapler. If a posterior port is used at this point, it is important that it not be located too caudal, which will make the safe passage of the stapler more difficult. After arterial division, the minor fissure is completed, separating the middle from the upper lobe.

Lower lobectomy (RLL, LLL)

In the case of either right or left lower lobectomy, the operation starts with division of the inferior pulmonary ligament, followed by isolation and ligation of the inferior pulmonary vein. The surgeon should attempt to visualize and include the branch to the superior segment, which in some cases may arise low or even separate from the basilar vein branch. In addition, the left side identification of a separate superior vein is prudent, as mentioned previously. Pleural division posteriorly to the area of the upper lobe and anteriorly to the major fissure facilitates this portion of the case.

At this point, as the dissection proceeds cephalad into the subcarinal space, the surgeon makes a choice about the fissure. If complete or nearly so, the fissure may be completed first, allowing access to isolate and divide the pulmonary artery branches to the lower lobe. On the right, the posterior ascending branch to the RUL must be visualized and preserved, while on the left the lingular artery must be identified. After arterial division, only the bronchus remains, which is dissected free of adjacent nodal material for isolation and ligation using either an endoscopic or TA stapler. The bronchial stump should be short, but on the left care must be taken not to incorporate the bronchial side of a migrated double lumen endotracheal tube in the staple line.

If the fissure is incomplete, one may dissect down through the fissure, identify the pulmonary artery, and proceed as above. However, a better approach is to complete a "fissure-less" dissection in a caudal to cranial fashion, developing the fissure last. To do so, after vein ligation, the surgeon proceeds with the dissection into the lower subcarinal space. Anteriorly, the wall of the lower lobe bronchus is followed into the fissure. On the right, the RML bronchus is identified and kept cephalad to the line of dissection. On the left, a similar approach is used to the identified upper lobe bronchus. If the pulmonary artery is seen at this point, this greatly facilitates dissection between the two structures. A similar dissection technique is utilized posteriorly. On the left, the pulmonary artery is simple to identify posteriorly, enabling dissection between bronchus and artery. On the right, dissection posteriorly proceeds just cephalad to the identified superior segmental bronchus. Working from both anterior and posterior directions, some blunt dissection may be needed to complete bronchial isolation. Partial division of the fissure at this point of the case may greatly enhance visualization. When the lower lobe bronchus is encircled, it is divided with an endoscopic stapler. This then allows isolation and ligation of the pulmonary artery to the lower lobe. Again, care must be taken with respect to the lingular artery and the posterior ascending branch on the right. Finally, the remaining major fissure is completed.

Closure and perioperative management

Following placement of a single chest tube and assurance of hemostasis, chest closure is routine. Absorbable suture is used for the muscle layers and soft tissues external to the chest wall, with no intercostal sutures placed. The skin is closed with absorbable subcuticular suture.

Postoperative management is also routine, but should incorporate a paradigm shift from management strategies used for open lobectomy. As mentioned earlier, some of the advantages in minimally invasive surgery are lost if care plans based on a several day hospital stay after thoracotomy are used. Early mobilization and ambulation, combined with aggressive chest tube management, will result in earlier discharge from hospital, faster recovery and better patient satisfaction.

Outcomes and conclusions

The safety and efficacy of thoracoscopic lobectomy have been demonstrated in several large studies, comparable to open lobectomy (1-3). VATS lobectomy has been shown to be associated with less morbidity (4-7), at least equivalent mortality (4,8,9), shorter hospital stays (4-8), improved functional outcomes (10-12), and less costs (13-15) compared with an open approach. Perhaps most important, minimally invasive lobectomy is oncologically equivalent (1,4,8,9,16,17), at a minimum, to lobectomy through open thoracotomy. A direct comparison with open lobectomy remains lacking, though, and the concept of a prospective randomized trial comparing the open and VATS approaches has been considered repeatedly. However, the recognized advantages of a thoracoscopic approach among dedicated thoracic surgeons have likely eroded any clinical equipoise needed for such a trial. Indeed, these advantages are not lost on practicing thoracic surgeons. Approximately 50% of lobectomies registered in the Society of Thoracic Surgeons General Thoracic Database are completed via a thoracoscopic approach (18), and the percentage continues to increase.

Current frontiers in thoracoscopic surgery now include chest wall resection and reconstruction, muscle flap transposition, sleeve resection, and the use of uniportal techniques. In the years ahead, we may expect advances in these areas, along with further refinement of established techniques in thoracoscopic surgery.

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