Thoracoscopic Lobectomy

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15.1 Introduction

There are numerous indications requiring pulmonary lobe resections in infants and children. The majority are for the broad spectrum of bronchopulmonary malformations that present in early infancy and childhood. These include bronchogenic cysts, bronchopulmonary sequestrations (BPS), congenital pulmonary airway malformation (CPAM), and congenital lobar emphysema (CLE) [1]. These lesions may be detected by prenatal ultrasound, present as acute respiratory distress in the newborn period, or may remain undiagnosed and asymptomatic until later in life. The other major indications include chronic infection resulting in bronchiectasis and malignancy. Treatment may vary somewhat depending on the time of diagnosis and the presentation, but in most cases complete lobar resection is the desired therapy. Minimally invasive techniques now allow these procedures to be done with much less pain and morbidity and avoid the long-term consequence of a thoracotomy in an infant or small child.

However, thoracoscopic lobectomy can be one of the most technically demanding procedures performed by a pediatric surgeon. The ability to first correctly identify vital structures to both the affected lobe and those going to areas needing to be preserved, and then safely secure the large pulmonary vessels, and a general lack of adequate lung case volume for most pediatric surgical trainees make these procedures even more difficult to adopt. In order to address these issues, we have developed a standardized approach to perform thoracoscopic lobectomy and applied these techniques in training fellows and junior staff.

15.2 Positioning

The procedure should be performed with the patient in a lateral decubitus position with the affected side up. In most cases with single lung ventilation, obtained by mainstem intubation of the contralateral side. In larger patients a double lumen endotracheal tube or bronchial blocker can be used. In cases where single lung ventilation cannot be achieved, CO_2 insufflation alone can used. The surgeon and assistant stand at the patient's front. In smaller children the patient should be placed near the edge of the table, so the handle of the instruments are not obstructed by the table.

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15.3 Instrumentation

Three valved ports, ranging from 3 to 5 mm, are used. In the majority of cases, a bipolar vessel-sealing device is used to manage the pulmonary vessels. In most cases, a 3 mm vessel sealer (JustRight Surgical, Louisville, CO) is employed; in patients over 15 kg, a Maryland 5 mm LigaSure is used. These devises are also used to seal and divide the lung parenchyma in cases of an incomplete fissure. The vessels are managed by obtaining adequate length of the vessel to create two seals approximately 3–5 mm apart and then dividing the vessel between them (Fig. 15.1). In larger patients (generally those over 15–20 kg), a 5 or 12 mm endoscopic stapler can be used to secure some or all of the major pulmonary vessels. If these are not available, clips for smaller bronchi or division and suture ligature can be used.

15.4 Technique

The room is set up to facilitate an anterior approach. The surgeon and assistant are at the patient's front with the monitor at the patient's back (Fig. 15.1). First the chest is insufflated with CO_2 using a Veress needle to help collapse the lung and avoid injury of the parenchyma with a trocar. Three trocars are used in almost all cases. The first port is placed in the mid- to anterior axillary line in the fifth or sixth interspace to determine the position of the major fissure and evaluate the lung parenchyma. Position of the fissure should dictate the placement of the other ports. The working ports are placed in the anterior axillary line above and below the camera port (Fig. 15.2).

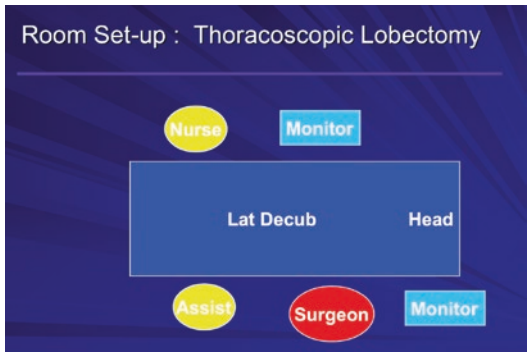

Fig. 15.1 Appropriate room setup for thoracoscopic lung resection

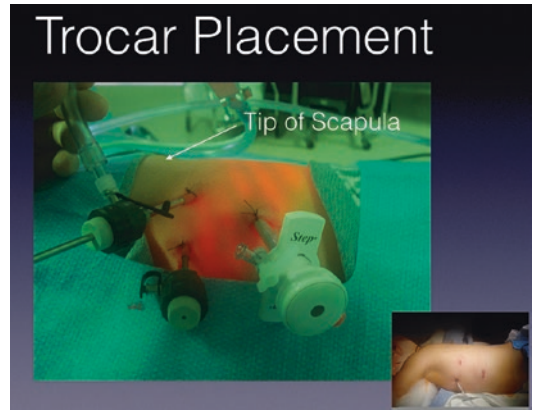

Fig. 15.2 Trocar placement for LLL. 4 mm camera port, left hand 3 mm port, and right hand 5 mm port for endoscopic stapler

For a lower lobe, the inferior pulmonary ligament is taken first until the inferior pulmonary vein (PV) is exposed. During this portion care is taken to look for a systemic vessel arising from the thoracic aorta or up through the diaphragm. The major fissure is then examined and if necessary completed using tissue sealing. This is done in an almost finger fracture technique until the pulmonary artery is seen transversing the fissure. The branches of pulmonary artery to the lower lobe are then sealed and divided, often at the segmental level. If necessary dissection can be carried out into the parenchyma of the lower lobe to obtain adequate length of the segmental branches for safe sealing and division. After this the bronchus to the lower lobe is visualized lying directly under the divide arterial trunk. It is mobilized and divided with the endoscopic stapler (Fig. 15.3). In many cases it is beneficial to take the superior segmental bronchus first and then the trunk to the basal segments. This exposes the inferior pulmonary vein trunk which can be easily divided with the 5 mm stapler (Fig. 15.4). If not available, the vessel should be followed proximally toward the parenchyma where it branches,

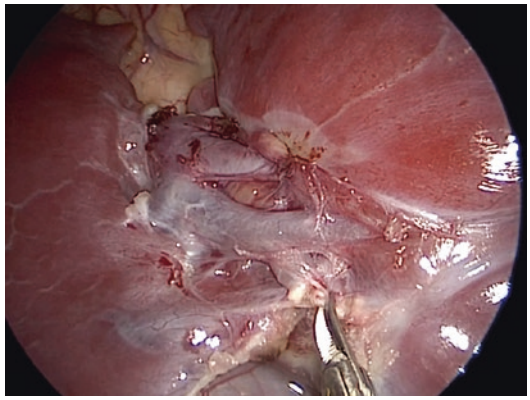

Fig. 15.3 Proximal and distal seals on anterior basal branch of pulmonary artery with scissors dividing vessel between the two seals

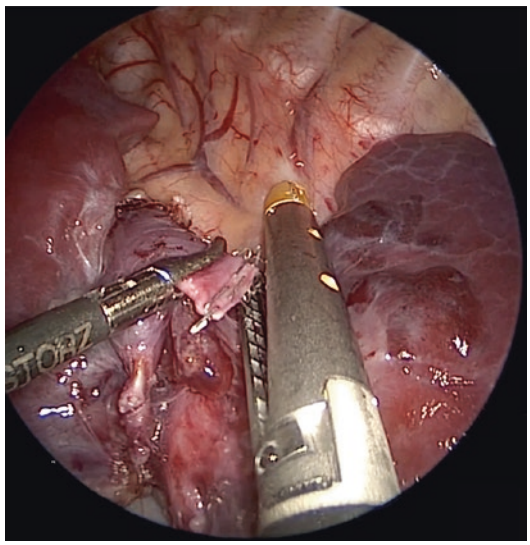

Fig. 15.4 Dividing main pulmonary artery to LLL with 5 mm stapler. The 3 mm Maryland keeps proximal vascular control until it is clear that the staple line is secure

and the smaller branches can be sealed and divided as already described. If there are large space-occupying cysts, these are "collapsed or popped" first using the vessel sealer. The cystic areas of the lung are grasped and energy applied (Fig. 15.5). This causes the cyst to decompress and collapse, creating more intrathoracic space and improving the surgeon's ability to manipulate the lung and identify important structures. The specimen is then removed in a piecemeal fashion through a slightly dilated 5 mm trocar

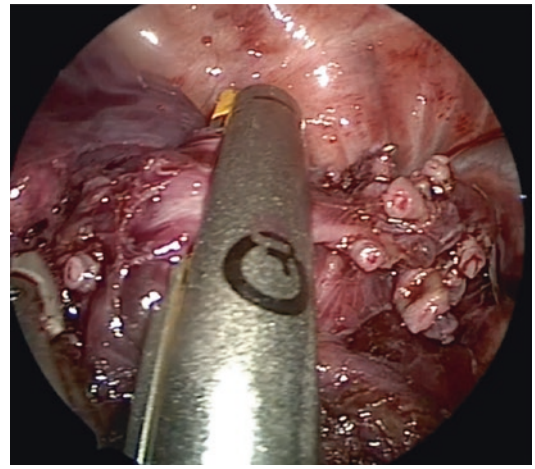

Fig. 15.5 Taking bronchus to RUL with 5 mm stapler

site. A chest tube is left in all cases of lobar resection.

15.5 Postoperative Care

The patient is managed on the ward with IV narcotics for the first night. The CT is kept to 10–15 mmH_2O suction. If there is no air leak, it is placed to H_2O seal, and an X-ray is obtained in 2 h. If there is no pneumothorax, the CT is removed. Most patients are discharged on the second postoperative day.

15.6 Results

Over the last 25 years, 499 of 502 procedures were completed thoracoscopically. Operative times ranged from 35 to 240 min (avg. 115 min). Average operative time when a trainee was the primary surgeon was 160 min (N = 83) and 95 min when the senior surgeon was performing the procedure. There were 109 upper, 33 middle, and 260 lower lobe resections. There were four intraoperative complications (1.1%) requiring conversion to an open thoracotomy. Three of these were secondary to bleeding, and one was to repair a compromised bronchus to an upper lobe following a lower lobectomy. Only one of these, a bleeding vessel to a pulmonary sequestration,

occurred in the last 15 years of the study period. The postoperative complication rate was 3.3%, and three patients (0.8%) required re-exploration for a prolonged air leak. In two cases a small accessory bronchus was found and sutured closed. In the third, no leak was identified, and the patient had no air leak postoperatively. Hospital stay (LOS) ranged from 1 to 16 days with a mean of 3.2 days. In patients <5 kg and < 3 months of age, the average operative time was 78 min, and LOS was 1.8 days. The postoperative complication rate was 2.6% and LOS 2.1 days.

15.7 Tips and Tricks

Use vessel sealing as the primary mode of vessel division.

Collapse all large cystic spaces.

Dissect into the lung parenchyma to gain greater vessel and bronchus length.

15.8 Discussion

Thoracoscopic lobectomy in children for congenital cystic lung disease is now an accepted and well-described technique [2–6]. Most authors agree on the relative merits of a thoracoscopic approach including less pain, shorter hospital stay, and decreased long-term morbidity, including chest wall deformity, shoulder girdle weakness, and scoliosis [7]. Despite this general consensus, the adoption of this technique and surgeon comfort with the approach remains relatively low primarily because of the procedure is technically demanding and because most surgeons see a low volume of cases which results in a decreased familiarity with pulmonary anatomy. Using a thoracoscopic approach further compounds this, as the surgeon can no longer put their hand in the chest cavity to palpate the structures and identify the anatomy. Therefore, standardization of technique and approach is critical.

One of the most difficult aspects of these cases is when the fissure is incomplete and the pulmonary vessels are not readily visible. We have found that using the tissue sealing technology to dissect and divide the parenchyma of an incomplete fissure is the safest way to approach this. The fissure is approached layer by layer until the pulmonary artery is visualized (Fig. 15.4). In our experience using the vessel sealer results in limited bleeding and air leak as compared to other methods.

The second issue has been standardizing an anterior approach. During an open thoracotomy, the surgeon is generally positioned at the patients back. For thoracoscopic lobectomies the surgeon and assistant are positioned at the patient's front. This is especially important in smaller patients, as there is more room from the chest wall to the mediastinum, where the pulmonary vessels arise.

The anatomic relationships for each lobe using this anterior approach are critical. The three-dimensional relationships of the vessels and bronchi to each lobe, which cannot always be seen in the two-dimensional view of the scope, are critical in understanding and comfort with the anatomy.

The third major issue is standardizing the management of the pulmonary vessels. Early in our experience we learned that thoracoscopic suture ligation of each individual vessel was difficult and time-consuming. The small working space, difficulty in achieving traction and counter-traction to obtain adequate vessel length while suturing, and the technical demands of tying a secure knot made this process laborious. We did not favor endoscopic clips for most vessels because of the risk of dislodging them during the extensive tissue manipulation necessary during a lobectomy. Therefore, we adopted vessel sealing as a way to safely manage the pulmonary vessels [8]. The initial 5 mm sealing device used could manage a vessel up to 7 mm in diameter and was an adequate tissue dissector. The 3 mm sealing device now available can seal vessels up to 5 mm and works well as a dissector especially in the smaller chest cavities of infants. It is more than adequate for most pulmonary vessels in children under 10 kg and for segmental branches in larger children. A key to using vessel-sealing technology effectively is to make proximal and distal seals on the vessel approximately 3–5 mm

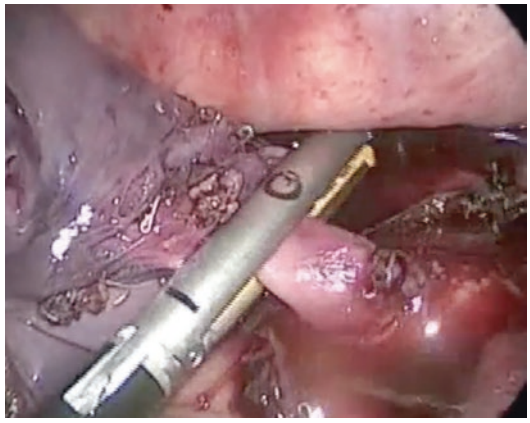

Fig. 15.6 Taking the inferior pulmonary vein to the RLL with the 5 mm stapler. Care is taken to insure there is an adequate stump length in case there are any issues

apart. Using scissors, a partial cut is made to determine that the seals are secure and that there is no bleeding once the lumen is entered. Once the vessel is partially divided and no bleeding is seen, the vessel can be completely divided (Fig. 15.6). If there appears to be some bleeding, there is an opportunity to reseal the vessel before the vessel retracts and control is lost. Because of the relatively large nature of the pulmonary vessels, and the limited space in the chest cavity, it takes very little blood to obscure the operative field and force conversion to an open thoracotomy. For this reason we have avoided any energy devises which seal and divide the vessel in one step, because if the seal fails the ability to salvage the situation is minimal.

For bronchus management we initially cut and then suture the bronchus using PDS suture in smaller patients. This can be time-consuming and technically demanding. We discovered that in most patients less than 10 kg, the lobar or segmental bronchus could be occluded using 5 mm endoscopic clips. If the lobar bronchus is too large, then distal dissection allows for a segmental bronchus to be taken. This decreases the size of the remaining main trunk. For example, the superior segment bronchus in a lower lobectomy can be occluded separately, and then the trunk to the basal segments can be taken with a second clip. In larger patients we used the 12 mm endoscopic linear staplers. However, because of the variations in anatomy and the close proximity of the bronchus to the other lobes, extreme care must be taken to avoid compromising the other bronchi. Therefore, if there is any question, the bronchus to the target lobe should be divided sharply and sutured close. There is now new 5 mm stapling technology which better fits in the chest cavity of infants and children and should eliminate the use of clips and larger staplers in these smaller patients.

The timing of surgery remains somewhat controversial, but there is little evidence to suggest that delayed resection improves outcome. We favor earlier resection of prenatally diagnosed lesions before they become infected or the patients become symptomatic. We have previously documented our experience with infants under 10 kg and showed that these procedures had shorter operative times, lower complication rates, and shorter hospital stays [9]. In older infants, there can be significant adenopathy and inflammation in the fissures and around the pulmonary artery making identification and safe division of these vessels much more difficult. These procedures are technically easier in infants at or near 5 kg despite the smaller working space as evidenced by the shorter operative times in this group as compared to older patients. The length of stay in this group is also shorter. Lastly for those who argue for conservative nonoperative management of these lesions in asymptomatic patients, despite the high incidence of infection, we had two cases of unsuspected pulmonary blastoma [10, 11]. We feel the risk of recurrent infection and possible malignancy outweigh the risks of intervention if a thoracoscopic approach is used in an institution with a large experience in these procedures.

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