Experience With Thoracoscopic Lobectomy in Infants and Children

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Purpose: This study evaluates the safety and efficacy of thoracoscopic lobectomy in infants and children.

Methods: From January 1995 to May 2002, 45 patients underwent video-assisted thoracoscopic lobe resection. Ages ranged from 2 days to 18 years and weights from 2.8 to 78 kg. Preoperative diagnosis included sequestration/congenital adenomatoid malformation (n = 28), severe bronchiectasis (n = 12), congenital lobar emphysema (n = 3), and malignancy (n = 2).

Results: Forty-three of 45 procedures were completed thoracoscopically. Operating times ranged from 35 minutes to 210 minutes (average, 125 minutes). There were 6 upper, one middle, and 38 lower lobe resections. There was one intraoperative complication (2.4%) requiring conversion to an open thoracotomy. Chest tubes were left in 38 of 45 patients for 1 to 3 days. Hospital stay ranged from 1 to 5 days (average 2.4).

Conclusions: Thoracoscopic lung resection is a safe and efficacious technique. It helps avoid the inherent morbidity of a major thoracotomy incision and is associated with the same decrease in postoperative pain, recovery, and hospital stay as seen in minimally invasive procedures.

INDEX WORDS: Thoracoscopy, long resection, lobectomy, sequestration, congenital adenomatoid malformation

THORACOSCOPY has been in use since the turn of the century when first described by Jacobeus in 1910.[1] The first significant use in children was not recorded until the late 1970s when Rodgers reported his experience with modified cystoscopy equipment to perform evaluation of intrathoracic lesions, small biopsies, and limited pleural debridements.[2] By the mid 1990s thoracoscopic lung biopsy had become an accepted, and, in many cases, superior technique for obtaining tissue in cases of interstitial lung disease or malignancy.[3] The use of thoracoscopy had also become common place in the treatment of empyema and mediastinal masses.[4,5] Perhaps because of the complex nature of the disease process and surgical dissection, no significant experience with thoracoscopic lobectomy in children has been described. This report details our experience with the evolution of thoracoscopic lobectomy for congenital and acquired lung disease over the last decade.

MATERIALS AND METHODS

From January 1995 to May 2002 all patients with lung pathology requiring resection were considered for a video-assisted thoracoscopic (VATS) approach. The only patients excluded were those with solid mass lesions occupying over 50% of the chest or those with extreme respiratory compromise suggesting they would not tolerate any length of single lung ventilation. Ages ranged from 2 days to 18 years (mean, 4.2 years) and weight 2.8 to 78 kg (mean, 18.7 kg). Preoperative evaluation suggested upper lobe pathology in 6, middle lobe in one, and lower lobe in 38. Presumed diagnoses included sequestration or congenital adenomatoid malformation (CAM) in 28, severe bronchiectasis in 12, congenital lobar emphysema (CLE) in 3, and malignancy in 2. Fourteen of the CAMs and sequestrations and one of the CLE were prenatal diagnoses. Six of the patients with bronchiectasis had cystic fibrosis; the others had chronic aspiration and pneumonia. The 2 malignancies were in patients with metastatic osteogenic sarcoma.

Technique

The procedures were performed with the patient in a lateral decubitus position and single lung ventilation. In larger patients, a double-lumen endotracheal tube was used. In infants and smaller children single lung ventilation was obtained by mainstem intubation of the contralateral side.

The initial procedures were performed using a combination of a mini-thoracotomy and 2 to 3 thoracoscopic ports. The thoracotomy generally was in the fifth intercostal space, 5 to 8 cm long, and used a total muscle-sparing technique. A combination of thoracic and thoracoscopic instruments were used. Standard linear staplers (GIA and TA) were inserted through the thoracotomy incision to complete the fissure and take the main pulmonary vessels and bronchus.

As instrumentation and technique improved, the mini-thoracotomy was eliminated. The procedures still were done in a lateral decubitus position to give access to both the anterior and posterior hilum. Three-to 5-valved endoscopic ports ranging from 3 mm to 12 mm were used. The EndoGIA was used in larger patients to complete the fissure and take the main pulmonary vessels and bronchus. In smaller patients (<15 kg) endoclips and ligatures were used because the EndoGIA is too large to for the thoracic cavity of a small child. Over the last 3 years, the Ligasure (Valleylab; Boulder, CO) a bipolar sealing device that comes in a 5-mm curved dissector design, was the primary mode of vessel ligation. It also proved useful in sealing the lung and

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completing the fissure. The room set-up has been described previously in detail. The surgeon and assistant are at the patient's front with the monitor at the patient's back. The chest initially is insufflated with a low flow low pressure of CO_2 to help complete collapse of the lung. A flow of one liter per minute and pressure of 4 to 6 mm Hg is maintained throughout the case. 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 because the most difficult dissection occurs in this plane. If the EndoGIA is to be used, a 12-mm port is placed near the anterior axillary line at the interspace aligned with the front edge of the fissure. This usually is the seventh interspace.

The exact procedure varied in each case depending on the lobe resected and the pathology encountered. A detailed description of a lower lobectomy is described for illustration purposes because this was the most common procedure performed. The first step is with mobilization of the inferior pulmonary ligament. During this maneuver, care is taken to look for the systemic vessel coming off the aorta in cases of sequestration. When found, the vessel is ligated and divided. The inferior pulmonary vein is dissected out but not ligated at this point. Ligation before division of the pulmonary artery can lead to congestion in the lower lobe, which can create space issues especially in the smaller child and infant. The fissure then is approached going anterior to posterior. The pulmonary artery to the lower lobe is isolated and ligated at its main trunk or at the segmental level, depending on the anatomy. The inferior pulmonary then is divided and the bronchus to the lower lobe isolated. The bronchus is divided with the EndoGIA in larger children or cut sharply and closed with 3-0 PDS suture in smaller patients. The specimen then is brought out through a slightly enlarged trocar site either whole or piecemeal. A chest tube was left in all cases except extralobar sequestration.

RESULTS

Forty-three of 45 lobectomies were completed endoscopically. Operating times ranged from 35 to 210 minutes (average, 125 minutes). There were 6 upper, one middle, and 38 lower lobectomies. Six of the lobectomies, 5 lower and one upper, were extralobar sequestrations. Pathology of the other specimens included sequestration/CAM in 22, severe bronchiectasis in 12, CLE in 3, and malignancy in 2. There were no bleeding complications and only one intraoperative complication (2.2%). This was in a case of severe bronchiectasis in the left lower lobe. The bronchus was divided with an EndoGIA, and the firing resulted in compromise of the left upper lobe bronchus. The procedure was converted to open to perform a bronchoplasty on the left upper lobe bronchus. The other conversion was in a patient with metastatic osteosarcoma with a large centrally located tumor. She required a left lower lobectomy to remove the mass. The procedure was converted because of the size and location of the mass so as not to violate the tumor. Chest tubes were left in 39 of 45 cases and remained in one to 5 days postoperatively (average, 1.6). There were 2 postoperative complications. The first was a pneumothorax on postoperative day 7 in a patient with cystic fibrosis. A chest tube was placed with immediate expansion of the lung and no evidence of air leak. The tube was removed after 72 hours without incident. The second was a postoperative pneumonia which resolved with antibiotics and aggressive respiratory care.

Hospital stay ranged from 1 to 5 days (average, 2.4) in the 43 patients whose surgery was completed successfully thoracoscopically. There was one prolonged hospitalization, 12 days in the patient who required a bronchoplasty; this was primarily to treat a postoperative pneumonia.

DISCUSSION

Over the last decade thoracoscopy has become an increasingly important tool in the armamentarium of the pediatric surgeon. The limited explorations, biopsies, and debridements described by Rodgers in the mid to late 1970s have become replaced by extensive, technically demanding resections and reconstructive procedures.

Thoracoscopic lung biopsy, decortication, and bleb resection for pneumothorax has been shown to be so safe and effective that in many centers it has completely replaced open thoracotomy as the treatment of choice. Reports of more technically demanding procedures such as resection of mediastinal masses, patent ductus arteriosus ligation,[6] thymectomy,[7] and other intrathoracic procedures[8] also have shown extremely promising results. Even one of the most technically demanding thoracic procedures, repair of a TEF, now has been accomplished in a number of centers.[9] The obvious driving force behind this is to avoid the short- and long-term morbidity of a thoracotomy in an infant or child.[10]

The application of thoracoscopic techniques in performing a formal lobectomy presents a number of unique and difficult problems and can be broken down into 3 different areas. The first is anesthetic considerations. For the majority of cases it is necessary to obtain single lung ventilation to create space for adequate visualization and dissection. We have found that the majority of infants and children, even with significant parenchymal disease, can tolerate this for the length of the procedure without significant compromise. The greatest aid to the surgeon in maintaining full lung collapse is the use of valved ports and a creation of a mild tension pneumothorax using CO_2 insufflation. This ties into the second hurdle, creating adequate space to work. For solid tumors there is little that can be done other then to have the normal lung collapsed as much as possible. However, in cases of CAM or CLE, in which a cyst or cysts are occupying a large portion of the intrathoracic cavity, space can be created by rupturing the cyst. This has been helpful in a number of the cases.

The third major hurdle is control of the vascular structures. During the early part of the series this was accomplished through the mini-thoracotomy with a combination of suture ligatures and use of standard linear

staplers. This process was cumbersome and time consuming but effective. With improvements in the EndoGIA these vessels now could be controlled completely through endoscopic ports eliminating the need for the thoracotomy. The stapler requires a 12-mm port for access and at least 4 cm of intrathoracic space to fully open, making it difficult or impossible to use in infants and smaller children. In these cases, it was still necessary to use a combination of suture ligatures and 5-mm endoscopic clips. Over the last 3 years, the availability of a 5-mm device, the Ligasure, which provides a safe and effective way of sealing vessels up to 7-mm in size, has enhanced greatly the ability to perform complete lobectomies, even in newborn infants. The device also has proven to be effective in sealing lung tissue and now is the technique of choice for sealing and dividing incomplete fissures. There have been no air leaks in any of the cases using the Ligasure for this purpose, and all chest tubes have been removed on the first postoperative day.

Control of the bronchus has not been a major problem and can be accomplished with either an EndoGIA or sharp division and suture closure. There have been no cases of stump leak or broncho-pleural fistula. The one case requiring bronchoplasty may have been the result of a stenotic left upper lobe bronchus not recognized preoperatively. This complication probably could have been avoided if the lower lobe bronchus had been divided sharply and sutured closed.

This series shows that thoracoscopic lobectomy is feasible, safe, and effective. Recent technologic advances have made the procedures technically easier with operating times similar to, or in some cases faster than, that associated with and open thoracotomy. The surgeon must have a clear understanding of the regional anatomy and 3-dimensional relationships to safely perform these procedure because the thoracoscopic approach provides only a 2-dimensional picture. A thoracoscopic approach results in decreased postoperative pain, a shorter hospital stay, and a superior cosmetic result; the greatest advantage is the avoidance of a formal thoracotomy with its inherent long-term morbidity of scoliosis, shoulder muscle girdle weakness, and chest wall deformity.

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