Video-assisted thoracoscopic surgery lobectomy with chest wall resection

Guilherme Dal Agnol[1], Ricardo Oliveira[2], Paula A. Ugalde[3]

[1]Divison of Thoracic Surgery, Americas-Centro de Oncologia Integrado, Rio de Janeiro, Brazil; [2]Division of Thoracic Surgery, Santa Casa de Misericórdia da Bahia, University-affiliated hospital, Quebec, Canada; [3]Department of Respiratory Medicine and Thoracic Surgery, Institut Universitaire de Cardiologie et de Pneumologie de Québec, Laval University, Quebec, Canada

Correspondence to: Paula A. Ugalde, MD. Division of Thoracic Surgery, Institut Universitaire de Cardiologie et de Pneumologie de Québec, 2725 Chemin Sainte-Foy, Ville de Québec, Québec G1V 4G5, Canada. Email: paula.ugalde@criucpq.ulval.ca.

Abstract: Lung cancer presents with chest wall invasion in 5–8% of patients, which imparts some treatment challenges. Surgical resection is currently the standard of care, and there are some controversies regarding the best approach. Published series and case reports confirm the safety and feasibility of video-assisted thoracoscopic surgery (VATS) in highly complex surgical cases including lobectomy with chest wall resection of locally advanced lung cancer. In this article, we present the clinical indications of locally advanced lung cancer that infiltrates the chest wall, the modalities for and importance of accurately staging lung cancers with chest wall invasion, and the technical aspects of accomplishing a safe and oncologically sound extended resection through VATS.

Keywords: Lung neoplasms; chest wall; metastasis; thoracic surgery; video-assisted

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Introduction

As recently as 1947, Coleman and colleagues reported the first surgical treatment of lung cancer invading the chest wall (1). Although for some time, chest wall invasion was considered a contraindication for upfront resection (2), nowadays, despite some controversies, non-small cell lung cancer (NSCLC) invading the parietal pleura and the chest wall is primarily a surgical disease (3). Lung cancers that infiltrate the parietal pleura, subpleural soft tissue or bony structures of the chest wall by direct contact are T3 tumors according to the tumor, node and metastasis (TNM) lung cancer staging system (4), and occur in only 5–8% of reported cases (5). In the absence of lymph node metastasis, 5-year survival is 40–50% (2,3,6-16). Superior sulcus tumors or Pancoast tumors occur in 1% of patients and will not be discussed in this article.

Minimally invasive approaches to lobectomy in early-stage lung cancer have been demonstrated safe and effective, with equivalent oncologic outcomes to open thoracotomy and lower overall complication and mortality rates (17). Despite controversies regarding feasibility and completeness of resection, thoracic surgeons who work in high-volume centers keep pushing the limits to perform complex procedures, also known as “extended resections”, through minimally invasive surgery. Published series and case reports have confirmed the safety and efficacy of video-assisted thoracoscopic surgery (VATS) in highly complex surgical cases, such as lobectomy with chest wall resection of locally advanced lung cancer (18-21). In this article, we will present the clinical indications of locally advanced, T3 NSCLC that infiltrates the chest wall and the technical aspects of accomplishing a safe and oncologically sound extended resection through VATS.

Clinical presentation

As a rule, patients with lung cancer with chest wall invasion will present with thoracic pain, although the absence of pain does not exclude the possibility of chest wall infiltration (22), and only 50% of the patients with thoracic pain will, in fact, present chest wall invasion (10). Localized pain in association with a lung cancer that has intimate contact with the chest wall is a highly specific sign of chest wall infiltration. The pain is described as severe, continuous, and burning-like and does not respond to conventional analgesics (10). Paulson described it as 'excruciating' pain (10). As with other lung cancers, patients with chest wall invasion may also present with cough, hemoptysis, dyspnea, or no symptoms at all (23,24).

Lung cancer staging

According to international guidelines, patients with suspected or proven lung cancer should undergo chest computed tomography (CT), positron emission tomography (PET), and brain imaging as part of the clinical oncological staging (25,26). Because lung cancer with chest wall invasion is classified as a locally advanced tumor, all patients should undergo invasive mediastinal staging, either by endobronchial ultrasonography (EBUS) or mediastinoscopy, to exclude mediastinal lymph node metastasis (17). Resectability is defined by the presence or absence of involved mediastinal lymph nodes or distant metastases (25,26).

It is critical to properly grade chest wall invasion preoperatively, because there is direct correlation between the level of infiltration and prognosis, as demonstrated by the work of Magdeleinat, Facciolo, and their colleagues (6,13). The depth of invasion is also an unfavorable prognostic factor (6,13). One theory is that intercostal muscle or rib invasion promotes distant metastasis because these structures are richly supplied with blood (23). Ultrasound, CT, and magnetic resonance imaging (MRI) are the standard imaging tests available to evaluate chest wall infiltration. Ultrasound is probably used the least due to the rare indications and operator-dependent limitations (27). CT scan has a good sensitivity, up to 50–81%, to correctly define the level of chest wall invasion (28,29). It is important to understand that a simple contact between the tumor and the chest wall or neighboring structures does not necessarily imply cancer invasion (30,31). MRI may better define the level of infiltration, because it increases the chances of precise chest wall evaluation; respiratory dynamic MRI demonstrated a sensitivity of 100% and specificity of 82.9% (32).

Invasive mediastinal staging with systematic sampling is a critical part of the preoperative evaluation, because the presence of N2 disease in combination with a T3 lung cancer due to chest wall invasion significantly affects overall survival (2,33). Facciolo and colleagues reported a 5-year overall survival of 18% for patients with T3N2 disease as compared with 61% 5-year survival in the absence of lymph node metastasis (T3N0) (13). In high-volume lung cancer centers, EBUS is the preferred modality to preoperatively investigate the mediastinum due to its efficacy, minimal invasiveness, and cost-effectiveness (33,34). If the CT scan or PET-CT is suspicious for N2 disease and the EBUS is negative, the added value of mediastinoscopy is well established (28). In fact, because N2 disease imposes a low survival rate, it is advisable to start the surgical resection with lymphadenectomy to validate the node-negative clinical staging. Even in clinical N0 patients, frozen sections of the mediastinal lymph nodes should be examined, and if N2 disease is found, resection should probably be aborted.

Surgical resection

It is universally accepted that nodal status and completeness of resection of the chest wall have significant prognostic value in predicting disease-free survival and overall survival of lung cancer patients with chest wall involvement. For example, a series by Voltolini and colleagues in 2006 demonstrated through a multivariate analysis that node-negative patients with negative margins of resection have superior long-term survival (35). Likewise, others have demonstrated similar results (2,12,36).

It is simple to validate the nodal status determined preoperatively during surgery, because the correlation of frozen-section analyses and definitive pathology is very precise. In contrast, the evaluation of resection margins during surgery has limitations because it is based on the combination of microscopic and macroscopic analysis of the specimen. In chest wall resection, a 1-cm margin in all directions is generally accepted; however, some advocate for a margin of 1 intact rib above and below the tumor and a 3–4 cm lateral margin (13). Frozen sections are not performed on resected bone samples (37). R1 or R2 resection remain the most reproducible independent predictor of poor survival in all published series of lung cancer with chest wall infiltration (22). Because complete resection is the final objective, the surgeon and the pathologist should work together to achieve an R0 result.

There is some controversy regarding the best type of surgical resection for T3 tumors infiltrating the chest wall. The extent of surgical resection depends on the depth of invasion and the tumor location. For tumors limited to the parietal pleural, extrapleural resection keeping the chest wall intact is sufficient to achieve complete resection with long-term survival (2,38). In cases of isolated parietal pleura invasion, chest wall resection does not convey any survival advantage (2). When soft tissue and ribs are involved, extrapleural dissection should be avoided and upfront resection of the chest wall should be performed.

En bloc lung and chest wall resection is associated with a morbidity rate above 20% and mortality ranging from 3.8% to 7%, both are higher than expected rates for VATS lobectomy alone (39,40). In fact, a recent large database analysis demonstrated that patients who underwent lobectomy with *en bloc* chest wall resection experienced 90-day mortality comparable with that of patients who underwent pneumonectomy (11). Pulmonary complications were the most common cause of death in patients who underwent chest wall resection and reconstruction (41). We believe that less invasive procedures may help decrease early complications and, therefore, provide better short-term results (38).

Adjuvant and neoadjuvant therapy

The role of adjuvant therapy for T3N0 tumors that invade the chest wall is controversial (42). Based on most published data, complete resection should be the primary goal for proper oncological management of NSCLC invading the chest wall. In patients with node-negative tumors ≥4 cm in diameter, adjuvant chemotherapy might be offered based on a subset analysis of the Cancer and Leukemia Group B (CALGB) 9633 study, which found a statistically significant survival advantage of adjuvant chemotherapy after complete tumor resection of tumors ≥4 cm (43). If the surgical margins are positive, however, the patient should undergo further resection to clear the margins. If further resection is contraindicated, postoperative radiation therapy is recommended (44).

The role of neoadjuvant therapy in the treatment of T3 tumors is even less clear than the role of adjuvant therapy. There is scarce data to support neoadjuvant chemotherapy or chemoradiotherapy for lung cancer with chest wall invasion. Nonetheless, a recent, multi-institutional, phase II Japanese study of induction chemoradiotherapy followed by surgery in patients with NSCLC involving the chest wall showed that the treatment strategy was safe and effective with a high rate of pathologic response (45).

VATS

Regardless of the surgical approach, either minimally invasive or an open technique, there are 2 goals in the treatment of lung cancer patients with chest wall invasion: to properly stage the mediastinum preoperatively to avoid surgery in N2 disease and to attain negative surgical margins. Complete resection in the context of clear mediastinal lymph nodes is the most important independent predictive factor for survival (2,6,7).

Rationale

In high-volume centers, as surgeons gain experience in VATS lobectomy, they tend to manage more complex cases minimally invasively (46). This reflects the natural instinct of the thoracic surgeon to push the limits without compromising safety or the quality of the oncological resection. In our own series of VATS lobectomies, once the learning curve was achieved, we performed pneumonectomies, bronchoplasties, chest wall resections, and post-chemotherapy resections using a uniportal VATS approach with similar results as thoracotomy (46). Unfortunately, only a few retrospective series address the use of VATS in lung cancer with chest wall invasion (17,21,47-49). The rarity of the clinical presentation, 5% to 8% incidence (5), and the discouraging perception that in this setting a VATS approach cannot be applied or does not offer any benefit in terms of pain control are likely reasons for the limited literature.

Postoperative pain in thoracic surgery is directly related to the number of intercostal nerves injured during surgery and the intensification of central nociception caused by tissue damage and pleural irritation (50-54). In 2016, Bendixen and colleagues demonstrated through a randomized trial that VATS is associated with less postoperative pain and better quality of life than anterolateral thoracotomy for the first year after surgery, suggesting that VATS should be the preferred surgical approach for lobectomy in patients with stage I NSCLC (55). However, there are not any trials comparing VATS versus open approaches in the context of locally invasive lung cancer. Although, it is natural to believe that VATS is less painful, it is essential to validate that basic oncological principles are maintained when a VATS approach is used.

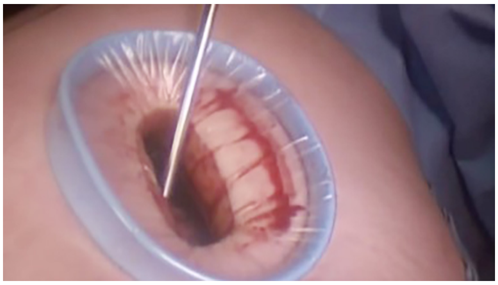

Figure 1 Right uniportal approach with a 3-cm incision at the fifth intercostal space and a wound retractor in place.

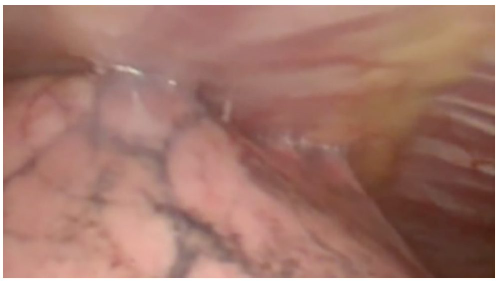

Figure 2 Tumor in the right upper lobe infiltrating the chest wall. Lobectomy is performed first in a standard fashion without detaching the lobe and then the chest wall is approached.

VATS procedures

Early 2000, Widmann and colleagues first reported VATS *en bloc* lung resection with resection of 2 ribs to treat a lung adenocarcinoma with chest wall infiltration (21). Through a multiple-port VATS approach and with the help of dedicated instruments, the authors described a sublobar procedure followed by chest wall resection. Combining the intrapleural and extrathoracic view, the chest wall resection could be performed in a very precise way (21). Demmy and colleagues described a completely minimally invasive procedure through multiple-port VATS (47). Their procedure starts with the chest wall portion. The intercostal muscles and vessels are dissected and divided with an energy-sealing device; no additional counterincision is performed. Once the compromised chest wall is delimited, the medial aspect of the affected ribs is transected through the 4-cm access incision with a typical rib shear. Subsequently, an endoscopic rib cutter is introduced through the access incision to transect the lateral borders of the ribs. Under direct vision, the macroscopic margins can be accurately defined. The lobectomy is completed last. Over a 7-year period, 15 patients between the ages of 73 and 90 years with NSCLC and chest wall invasion underwent this VATS procedure. There were no conversions to thoracotomy, and median hospital stay was 7 days. However, 90-day mortality was 26.7% for these elderly patients, and median operative time was 500 minutes (48). The benefits of the VATS approach over thoracotomy were highly questioned. Berry and colleagues reported a different minimally invasive strategy, named "hybrid thoracoscopy", in 12 patients. A standard lobectomy with radical lymphadenectomy is performed first. Then, after adding an intrapleural view to define the compromised chest wall area, a limited counterincision is made above the tumor. In this way, the ribs that need to be transected are precisely identified. The specimen is removed through the counterincision. Complete resection with negative margins was accomplished in all patients, with median hospital stay of 5.5 days, no mortality, and no conversions to thoracotomy. In fact, the postoperative results between this VATS approach and thoracotomy were similar (17).

These VATS techniques have the absence of rib spreading or scapular mobilization in common. Most series of VATS *en bloc* lobectomy and chest wall resection refer to tumors located posteriorly so the resected chest wall is protected by the scapula and overlying muscles with no need for reconstruction. When indicated, reconstruction can be performed with mesh sutured either thoracoscopically, as described by Abicht and colleagues (20), or directly through the counterincision (17).

Uniportal VATS

At our institution, we have adopted a uniportal VATS lobectomy with *en bloc* chest wall resection in patients with T3 tumors that are mediastinal node-negative. We perform the lobectomy with lymphadenectomy first and proceed to the chest wall resection. The utility incision for uniportal VATS is usually placed at the fifth intercostal space between the anterior and mid axillary lines (*Figure 1*). We find that the adherence to the chest wall keeps counter-traction on the lobar hilum, which facilitates broncho-vascular dissection and completion of the lobectomy (*Figure 2*). The chest wall margins are delimited with an electrocautery (*Figure 3*), then the limited counterincision is performed immediately above the chest wall infiltration (*Figure 4*). Under thoracoscopic guidance and direct vision, the intercostal muscles and neurovascular bundles are divided with an energy-sealing device (*Figure 5*). The ribs

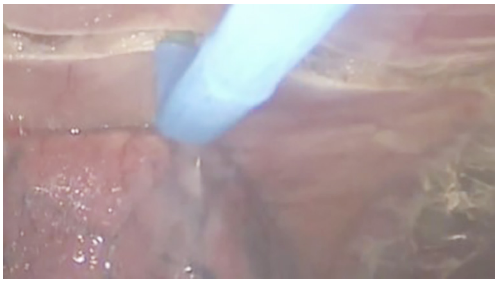

Figure 3 Margins of resection are delimited under thoracoscopic guidance avoiding unnecessary chest wall manipulation.

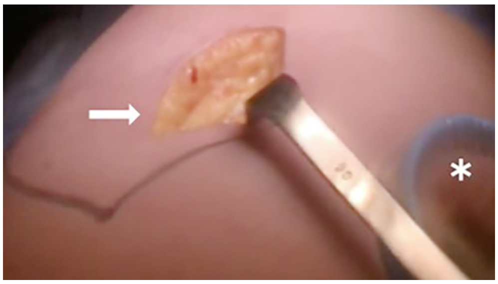

Figure 4 Longitudinal 6-cm counterincision (arrow) at the site of chest wall invasion and utility incision (asterisk).

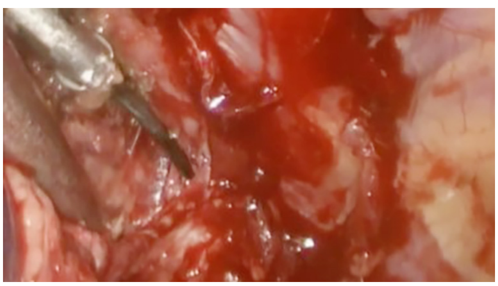

Figure 5 Intercostal muscles and nerves are divided with an energy-sealing device introduced through the counterincision under thoracoscopic guidance.

are transected (*Figure 6A,B*), and the specimen is removed through the counterincision. We believe this combined approach provides a safe and optimal oncological resection. For small defects, with preservation of the external musculature, there is no need for reconstruction (*Figure 7*). When the incisions are closed, a chest tube for drainage can inserted in the same intercostal space as the utility incision (*Figure 8*). However, our current preference is to place the chest tube in the posterior corner of the utility incision.

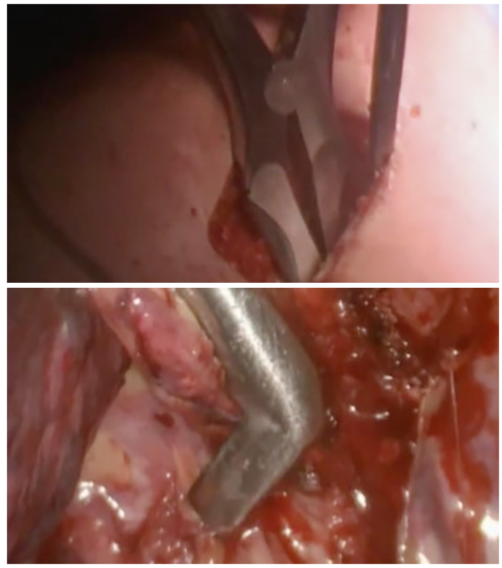

Figure 6 Rib transection. (A) External view; (B) thoracoscopic view.

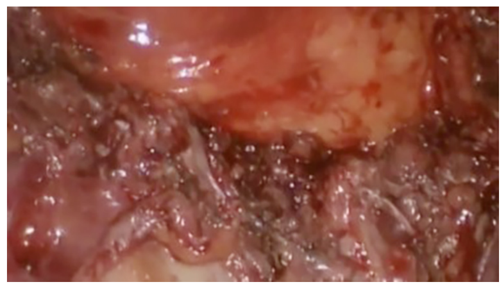

Figure 7 Chest wall defect after specimen removal with preservation of overlying muscles and without reconstruction.

Chest reconstruction

Chest reconstruction restores the rigidity and stability of the chest wall. Reconstruction is important to avoid flail, scapular tip entrapment, and lung herniation and to seal the pleura and prevent infection (56). Anterior chest wall defects are often reconstructed with rigid fixation given their proximity of the heart and vital structures. In general, chest wall defects <5 cm can be managed without reconstruction. Posterior chest wall defects under the scapula do not routinely require reconstruction unless the geometry will cause scapular tip entrapment (24).

There are several controversies regarding the ideal reconstructive material for chest wall defects (41), although the type of reconstruction does not influence postoperative pulmonary morbidity after chest wall resection (41). Two studies showed that a flexible material (such as mesh) can

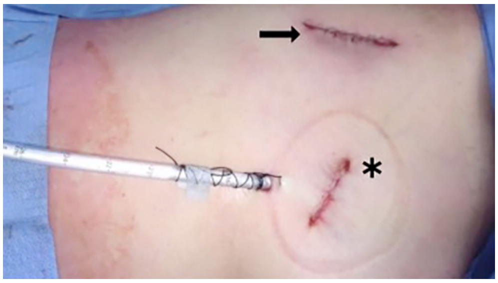

Figure 8 Utility incision (asterisk) and counterincision (arrow) after uniportal VATS right upper lobectomy en bloc with chest wall resection of the 4th and 5th ribs.

be used to manage most defects (41,56). The use of a rigid prosthesis is not routinely recommended due to the high probability of fracture with the continuous respiratory movements and subsequently the risk of penetration of the surrounding tissues (10).

Conclusions

VATS *en bloc* lobectomy with chest wall resection for NSCLC is a well-accepted and feasible oncological technique in thoracic surgery. Through a less invasive surgery, patients may benefit from short-term advantages such as less pain, shorter length of hospital stay, and superior preservation of pulmonary mechanics in older and frail patients. Over the last 5 years, several series from high-volume centers have validated VATS approaches as optimal for anatomic lung cancer resection in locally advanced NSCLC, and their acceptance has increased considerably. Surgeons interested in minimally invasive lobectomy with chest wall resection must be perseverant and dedicated to overcome the learning curve and then progress to more complex cases. Additionally, study of long-term outcomes is necessary to better establish the role of VATS in the surgical treatment of locally advanced lung cancer with chest wall involvement.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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