Accurate staging is essential to predict the prognosis and guide the treatment in patients with lung cancer. Recent developments of the interventional tools, like endobronchial ultrasonography (EBUS) and endoesophageal ultrasonography (EUS), and the introduction of new technologies of metabolic imaging like fluorodeoxyglucose positron emission tomography (FDG-PET) and positron emission tomography-computed tomography (PET-CT) did not help to confirm the clinical staging at 100% rate by the operative findings. Common problems are occurrence of distant metastases only a few months after the operation or intraoperative findings of N2 disease, or pleural metastases during resection. Classically, thoracoscopy was known to be the tool of evaluation of pleural effusions in patients with lung cancer. Some recent reports demonstrated the efficacy of VATS in surgical staging. Here in this study, you will meet the reasons, technique, problems and complications of the systematic videothoracoscopic staging.

Reasons to perform VATS for accurate staging

Preoperative staging consists of defining the local extension of the primary tumor, and searching for mediastinal lymph node status and possible metastases. Computed tomography has a key role in defining loco regional staging, however, in some certain situations it may be difficult to differentiate the surrounding structures from the primary tumor. It was reported that T parameter was correctly
staged in 24 to 85% of patients with CT findings. Patients should not be denied for curative surgery based on the CT findings only. CT has been confirmed to be a semi-sensitive tool for mediastinal staging and demonstrated to have a sensitivity of 57%, specificity of 82%, positive predictive value of 56% and negative predictive value of 83%. FDG-PET and PET-CT have been a reliable tool in negative patients if the CT confirms no enlargement. Mediastinoscopy has long been gold standard. Mediastinoscopy is a wonderful technique to evaluate the bilateral paratracheal and anterior carinal lymph node stations. However, positivity of stations 5 - 6, posterior part of station 7, and 8 and 9, as well as, hilar and interlobar lymph nodes could change the predicted surgical plan and amount of lung to be resected. More often, pleural dissemination with very small nodules and without pleural effusion may be undetected. Staging with VATS technique is based on identifying these lesions. Therefore, it may avoid an unnecessary thoracotomy and a possible high risk resection. On the other hand, not very infrequently, a thoracotomy may result with an unexpected cause of inoperability, due to metastatic pleural or pericardial deposits. VATS exploration for accurate staging and evaluation prior to a surgery may ensure thorough exploration of the cavity and may permit adequate staging. This is more important in patients with poor cardiopulmonary reserve. VATS has features as a diagnostic method that other methods lack. Its most outstanding feature is that it is the only modality that allows for the complete visualization of the pleural space. This is important if small amount of effusion is suspected on CT scan. VATS may allow for biopsy of the suspected pleural lesion and suspected lymph node and aspiration of a small amount of effusion. VATS exploration is safe to be performed in some surgical candidate except for those with extensive adhesion or markedly reduced pulmonary function who cannot tolerate single-lung ventilation.

**Technique**

*Systematic evaluation, staging and lymph node dissection with VATS*
A VATS exploration is performed in a lateral decubitus position, with single-lung ventilation. Two trocars were usually placed for exploration. An additional trocar was placed only when wedge resection, segmentectomy and lobectomy and lymph node staging and dissection was indicated. A 0” or 30” rigid thoracoscope is inserted from the first trocar site in the 7th intercostal space on the midaxillary line (Author always prefers 30 degree). The second trocar was just at the anterior edge of the predicted posterolateral thoracotomy line. Systematic exploration from the apex to the diaphragm requires the lysis of pleural adhesions and the complete mobilization of the lung by dividing the pulmonary ligament. Videothoracoscopic exploration can also imply more complex surgical maneuvers such as (1) exploration of the fissure to verify the feasibility of intrafissural vascular preparation, (2) opening the pericardium to verify the possibility of an intrapericardial ligature of the great vessels, or (3) thorough exploration of the mediastinum to dissect mediastinal lymph nodes. To allow for the full inspection of the pleural space, especially at the upper, anterior, posterior, and lower mediastinum, at the hilum, and of the tumor lesion itself, the collapsed lung mobilized and retracted. Nodules on the pleural surface which suggest pleural implantation, are biopsied. Pleural effusion is aspirated for rapid cytological examination regardless of its amount. Mediastinal lymph nodes, if looks pathologic, are also biopsied, especially at Botallo’s and subcarinal (posterior) locations because of the difficulty of accessing these situations by mediastinoscopy. For nodules of undetermined histology, wedge resection with endstaplers is performed.

2 R and 4 R

The parietal pleura is opened over 2R/4R area from the azygos vein up to the right brachiocephalic artery. The azygos vein is not divided (Some authors may prefer division, but I do not). The fatty tissue and lymph nodes are dissected en bloc along the anterolateral side of the trachea by giving extreme care to the right vagus nerve. The paratracheal tissue including nodes and fat is then dissected along the
posterior wall of the superior vena cava, by retracting it anteriorly. The packet is passed through under the azygos vein and removed in a bag (glove).

7 (Right)
Dissection of station 7 nodes is performed by tilting the table towards operator’s side and retracting the lung anteriorly. Hyperinflation of the contralateral lung pushes the carina toward the surgeon. The bronchus intermedius is retracted in the anterior and upward direction with the lung. An incision with cautery is made parallel to the esophagus all the way from the azygos vein to the inferior pulmonary vein. The esophagus is retracted posteriorly with an endopeanut. Subcarinal nodes are dissected by dividing the bronchopericardial ligaments and capsule surrounding the level 7 nodes. After developing a space for the dissection of level 7 nodes that is inferior and anterior to the intermediate and main bronchus, the pericardium of the left atrium becomes visible. The nodes are dissected starting at the lower rim. Dissection near the pericardium releases half of the subcarinal nodes, although these nodes are still attached to the tracheal carina and left main bronchus. One bronchial artery arising from the aorta feeds the nodes. Careful clipping is needed to prevent intra and postoperative bleeding.

7 (Left)
To expose the carina and right main stem bronchus, the posterior mediastinal pleura is divided from the upper edge of the left lower pulmonary vein to the lower edge of the aortic arch alongside the left vagus nerve. Simultaneously, the branches of the left vagus nerve to the bronchus are divided. The descending aorta and esophagus are retracted posteriorly, (the esophagus is pushed away with a peanut dissector) and the bifurcation of the trachea is exposed. All of the lymph nodes around the upper and lower lobe bronchus (i.e., the “lymphatic stump of the left lung”) are removed. By increasing the ventilation pressure and pulling the lung up and anteriorly, the right main bronchus can be dissected. The endobronchial tube may dislodge during this maneuver and lung may begin to inflate. All of the level 7
nodes are resected free from the pericardium and both main bronchi. It is generally necessary to divide the left bronchial artery.

**4 L**
The left paratracheal (4 L) lymph node dissection is performed after transverse division of the parietal pleura overlying the aortopulmonary window. The left vagus nerve and recurrent laryngeal nerve are identified, and the branches of the left vagus nerve to the left bronchus are divided. The ligament of Botallo is rarely divided during this procedure. The left main pulmonary artery is retracted to the caudal side with a peanut dissector (and/or the aortic arch is pushed to the cranial side), and the left vagus nerve distal to the origin of the left recurrent laryngeal nerve is retracted backward with a peanut dissector.

**5 and 6**
Lymph nodes in stations 5 and 6 must be removed, by giving extreme care to the left phrenic and vagus nerves. The pleura overlying the aortopulmonary window is divided longitudinally along the left phrenic nerve. During the procedure, the left phrenic nerve and left vagus nerve are retracted. In addition, left-sided rotation of the table might optimize exposure if the left upper lobe is in place.

**Complications**
Pain related to this procedure, although incomparable to the thoracotomy, is still a major problem and needs to be managed carefully. Pleural adhesions may necessitate to conversion to open procedure but in the experienced hands, pleurolysis is possible. Hemorrhage although an uncommon complication, may occur due to extensive dissection of hilar vessels and may need to convert to open surgery to repair. Ductus thoracicus injury and chylous leak may not be noticed during procedure and may cause an additional exploration afterwards. Air leak due to
parenchymal laceration generally heals spontaneously. Arrhythmia generally occurs in supraventricular type could be treated with antiarrhythmic medication. The most problematic complication is an airway injury due to calcified lymph node dissection over the one of the main bronchi. The author of this chapter punched the left main bronchus due to misevaluation of the distal cuff of the left sided endotracheal tube, as a swollen lymph node, during dissection of station 7 from the right side. An open conversion was needed to repair the left main bronchus.

Results
The efficacy of videothoracoscopic exploration has been demonstrated for evaluating small-nodule pleural dissemination, for evaluating the infiltration of the mediastinum, the artery within the fissure, or to reliably assess mediastinal lymph nodes. Video exploration proved to be useful in evaluating causes of inoperability and unresectability, with a negative predictive value of 97%. Thoracoscopy has been found to correctly stage the lesions (73.3%), significantly (P<.0001) superior to CT (48.7%). In describing T indicator, thoracoscopy proved very accurate (96.2% of correctly staged cases), although it was less accurate (77%) in evaluating N status.

Conclusions
The efficiency of VATS staging prior to a planned thoracotomy and lung resection may be debatable due to prolongation of operative time. However, some certain patients like patients with minimal pleural effusion, with suspected pleural or extralobar nodule, and with suspected invasion to fissure in compromised patients and lymph node staging particularly 5-6 7 posterior part,8 and 9 may have a major benefit from this procedure. The value of this procedure should not be discounted. Author of this manuscript omitted mediastinoscopy in candidates of right VATS lung resection for lung cancer by starting the procedure with mediastinal dissection and frozen examination without opening an access thoracotomy. For left sided VATS candidates if lung nodule is T1 lesion, I still prefer to begin with VATS mediastinal
staging. This helps to gain time for repositioning after mediastinoscopy and certainly decrease cost.

Reading references

