Prevention of air leaks during thoracoscopic lung surgery

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Alveolar air leak, or alveolar-pleural fistula, is the most common postoperative condition that causes a prolonged hospital stay, for patients who undergo pulmonary resections. Although, most of the patients with pulmonary resections have some degree of air leak immediately after surgery, almost 15% of them experience prolonged hospital stay due to air leakage. Persistent air leak is defined as an air leak that fails to resolve before the scheduled day of discharge, which causes a significant increase in length of stay and cost. Prolonged air leak is an unwanted side effect or a complication because, chest tube remains longer, causes discomfort and pain, causes immobility, increases risks of pulmonary infections & empyema, increases risks of thrombo-embolism and other potential complications due to prolonged hospital stay. Prolonged air leak may be associated with an increased complication rate. It has been found that 30% of patients with air leak may develop another complication, but only 18% without air leak may develop another complication. This may have been a marker of extent of surgery or disease. It has been demonstrated that air leak lasting more than 5 days was associated with greater pulmonary morbidity, such as atelectasis, pneumonia, and empyema.

As with traditional lobectomy, prolonged air leak is the most common source of morbidity after VATS. The reported risk for an air leak that persists beyond 5 days after a wedge resection is 4.7%. The risk of an air leak after a VATS procedure for treatment of pneumothorax is reported to be 1.3 to 6.9%. VATS lobectomies are reported to carry similar air leak risk as with open lung
resections. VATS does not increase the risk of air leak after lung volume reduction surgery and is associated with 30% prolonged air leak.

Table 1: Factors that may contribute to persistent alveolar air leaks.

- **Preoperative risk factors**
  - Increased age, male gender
  - COPD, diabetes mellitus, steroid use
  - Infections
    - AIDS, pneumocystis carinii, malnutrition, tissue hypoxia

- **Perioperative risk factors**
  - Neoadjuvant treatment for lung cancer, lung volume reduction surgery
  - Upper lobectomy, fused fissures, lesser resections (segmentectomies)
  - The presence of adhesions, apposition of pleura and lung surface
  - Operative techniques to reduce air leak, staple lines, handling of tissues
  - Leak of size 4 or greater on the scale of 1 to 7 proposed by Cerfolio and colleagues

- **Postoperative risk factors**
  - Air leak magnitude
  - Chest tube management
  - High ventilation pressures
Emphysema has always been shown to be the primary risk factor. But exact degree of emphysema that places a patient at high risk for a prolonged air leak to merit the use of expensive prophylactic materials or time consuming intraoperative maneuvers remain uncertain.

Intraoperative management of air leak

Residual space after a subtotal resection is an under estimated complication that at times can lead to prolonged air leak. On the other hand, residual space may not cause any functional problems and may remain as a silent space in the radiological findings. Two determinants of residual air space, can be identified according to the presence of an active air escape from the paranchymal rough surface or from reduced lung compliance that may impair postoperative reexpansion. Postoperative residual spaces often result from a combination of active air leakage and reduced lung compliance appearing simultaneously or sequentially and contributing to incomplete lung reexpansion. Intraoperative management of air leaks should be directed toward the three primary endpoints: prevention, repair, and providing a favorable condition for early perioperative resolution. Certainly, techniques to obliterate the space by reducing the volume of the chest cavity through geometric remodeling of the anatomic boundaries of the lung exist. They could be named as; Pleural tent, adhesiolysis, decortication, muscle tent, intrathoracic muscle transposition, phrenic nerve paralysis, pneumoperitoneum, rib resection, thoracoplasty and flap transposition. Most of these procedures are beyond the scope of this presentation. The aim of this presentation is to discuss the potential maneuvers to overcome air leaks during VATS resections. It is important to stress that, there is nothing that can replace good surgical judgment in these circumstances, as a very large air leak after a complex wedge resection, or even LVRS, sometimes will be handled best with a completion lobectomy instead of attempted repair in emphysematous patients. The degree of lobar differentiation by completeness of the fissures influences the dissection, when the fissure is incomplete, direct dissection to define the fissure
to pulmonary vessels is necessary. Dissection through lung parenchyma inherently leaves exposed rough surfaces as potential sources for air leaks.

**Preventive maneuvers that could be done during VATS procedures**

- Gentle handling and gentle closure of parenchyma tears
- Buttressed staple closure of fissures in high-risk patients (emphysema patients)
- Use of pulmonary sealants: glues and fleece-bound
- Fissureless lobectomy
- Chest tube positioning and suction
- Decortication
- **Prophylactic space reduction**: infiltration of phrenic nerve, pleural tent,

**A: Gentle handling**: Sponge forceps and endoscopic graspers must be carefully used for the handling of the lung. A horizontal mattress suture to coapt a visceral pleural defect may be helpful. Autologous tissues including the pleura, pericardium, or pericardial fat pad, can be used as biologic pledgets. Teflon or felt pledgets also may be useful. These pledgets are particularly useful when the quality of lung tissue is poor and unlikely to support simple suturing. Denuding visceral pleural surfaces should be avoided by carefully lysing pleural adhesions.

**B: Buttressing of the parenchymal staple lines**: Various materials have been studied and none of them have been shown to have an obvious advantage. Buttresses reinforce the staple line, presumably reducing the chance of staple line dehiscence during reexpansion or vigorous cough, and reducing the possibility of leaking direct through staple holes. Another possible cause of air leak that could be prevented with buttressing is, high surface tension in the region immediately subjacent to the staple margin. Most surgeons prefer to use buttressing material in patients with moderate to severe emphysema.
Specific emphasis should be given to lung volume reduction (LVRS) patients. Several small studies offer conflicting data on this topic. In this circumstances patients with incomplete or difficult fissures undergoing lobectomy, or patients with segmentary resections might have benefits from buttressing staple line.

**C: Topical sealants:** They may be used as a preventive or reparative measure. Numerous biological and synthetic agents are available and they have been included in some randomized trials. There appears to be a general reduction of air leak with the use of sealants. Sealents can be applied to staple lines regardless of the leak testing (as preventive) or only after an air leak is identified (reparative). It is very difficult to speculate on the impact of sealents in a high risk population. Research on animals has shown great potential benefits from the use of such glues to reduce air leak. An ideal lung sealant should bind rapidly to lung tissue in the presence of air, blood, or moisture, be able to withstand inflation procedures of greater than -40 cmH2O, have sufficient flexibility and compliance to permit lung inflation and deflation, absorb without a trace, be nontoxic, and eliminate air leaks. Lung sealents are still evolving and this is the proof that the quest for the perfect sealent continues. There are biologic sealents and synthetic sealents. Fibrin sealents variably reduce the magnitude, occurrence, and duration of air leak following pulmonary surgery. These inconsistent improvements did not reliably translate into reduced duration of chest tube drainage and hospital stay. Compared with fibrin sealents, synthetic sealents more reliably reduce the magnitude, occurrence and duration of air leak. However, this does not result in reduced duration of chest tube drainage or hospital stay.

**D: Fissureless lobectomy:** Recently, single and multi-institutional studies have shown thoracoscopic lobectomy to be an accepted oncological procedure for patients with early stage lung cancer. Thoracoscopic lobectomy has been shown to decrease morbidity, including shorter length of postoperative stay, shorter chest tube duration, decreased postoperative pain, improved preservation of pulmonary function, reduced inflammatory response, and shorter recovery time, compared with conventional thoracotomy. Whereas most surgeons perform open lobectomy using dissection through the fissures, thoracoscopic lobectomy is
usually performed by addressing the hilar structures first, and by completing the fissure with a stapling device last. The avoidance of surgical dissection in the fissure is believed to minimize the risk of air leak. Mediastinal lymphadenectomy could be performed subsequent to resection or before the dissection of the hilar vessels as recommended by the author of this presentation.

**E: Chest tube positions and suctions:** Another simple strategy is to leave a basiliar and apical chest drains within the hemithoracic cavity. This serves to applying low suction (10-20 cmH2O) for 24 to 48 hours may help co apt the pleural surfaces.

**F: Decortication:** There are some particular situations that the residual lobe is restricted with a dense visceral pleural cortex. Decortication of the residual lung will definitely increase the size of the lung and would obliterate the potential residual space. Thereby, a decrease in the magnitude and duration of air leak is expected.

**G: Prophylactic space reduction techniques:** A simple technique to transiently reduce the functional size of pleural cavity is to anesthetize the phrenic nerve. This is recommended only for patients with near normal preoperative lung function. The phrenic neurovascular pedicle is grasped gently as it courses above the hilum with a babcock clamp and 1 to 2 cc of 0.5% bupivacaine without adrenalin are injected as a wheal around pedicle but not through pericardium. The nerve is not injected directly, and crushing the pedicle is not advocated. The elevated hemidiaphragm will promote early pleural-pleural apposition and will reduce the amount of free space within the hemithorax. Another technique to consider for space reduction after a VATS resection may be pleural tenting. Dense pleural adhesions may compromise the ability to create an intact tent. Hemothorax may be a possible complication after pleural tenting. Like other intra operative adjuncts, pleural tenting should be reserved for patients undergoing and upper lobectomy with a troublesome air leak.

References

