Basic Principles and Advanced VATS Procedures

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Introduction

In the era of growing enthusiasm for minimally invasive surgical approaches, many general and thoracic surgeons have fostered a resurgence of interest in thoracoscopy. Over the last two decades, surgeons have expanded the use of thoracoscopic or video-assisted thoracic surgery (VATS), procedures to address a variety of thoracic pathologies classically managed through open thoracotomy. The goal of this chapter is to guide minimal invasive surgeons who are trained in open thoracic procedures, and thoracic surgeons beginning their thoracoscopic experience with the basic operative setup for thoracoscopic (VATS) surgery.

Historical Background

The evolution of VATS can be traced back to the early nineteenth century when Bozzini used an endoscope to examine the urinary bladder (cystoscopy) [1]. Driving in the same direction, a couple of years later Carson induced artificial pneumothorax for the treatment of pulmonary Kochs [2]. Almost a decade later, in the early 1900s, Jacobaeus introduced thoracoscopic examination and use of thoracoscope for releasing pleural adhesions [3]. Further research and development of microcameras in the 1980s led to the arrival of Video-assisted thoracoscopic surgery in 1990s [4].

VATS has since been used and different modifications for the same are being done all over the world from VATS under GA, to awake VATS [5]; from three ports to single port surgery (uniportal) [6]; further developments are anticipated.

Basic Principles of VATS

The primary operative strategy is to orient the thoracoscopic instruments and the camera in triangulation, so that all are being used in the same general direction facing toward the target pathology [7] (Fig. 1).

To accomplish the basic maneuvers of thoracoscopy and to conduct effective VATS operations, several basic principles should be applied.

1. The trocar sites and thoracoscope should be placed keeping the target pathology and following in mind.

   - Ability to achieve a panoramic view and provide room to manipulate the tissue.
   - Strategic positioning of the thoracoscopic camera and the endoscopic instruments is vital to the success and efficiency of the procedure.

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D. Lomanto et al. (eds.), *Mastering Endo-Laparoscopic and Thoracoscopic Surgery*,
https://doi.org/10.1007/978-981-19-3755-2_30

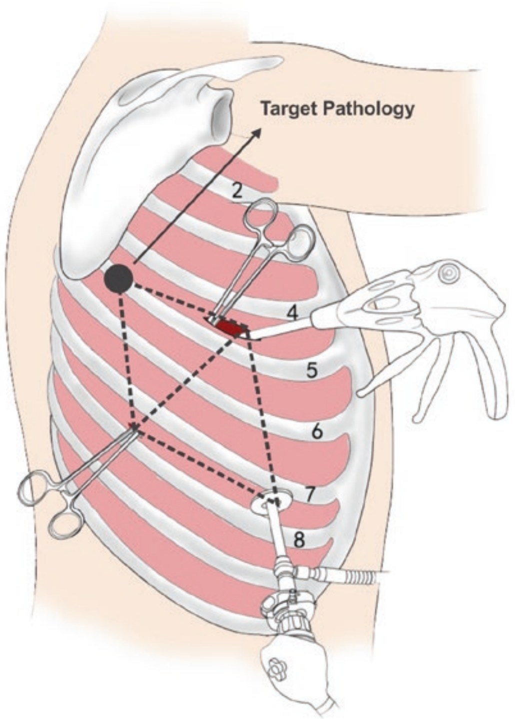

Fig. 1 Baseball diamond: Principle for port placement

- Avoid instrument crowding, which may otherwise result in “fencing” during instrument manipulation.
- Avoid mirror imaging by positioning instruments and thoracoscope (approach the lesion in the same general direction with instruments and camera).

2. To avoid operative chaos, move or manipulate instruments or the camera one by one, rather than randomly or synchronously.
3. Instruments should be manipulated only when seen directly through the thoracoscope.
4. All instruments should have a long working length to avoid operative struggle.

Anesthesia

Anesthesia used most commonly is General anesthesia along with single lung ventilation using Double lumen endotracheal tube or bronchial blocker (Fig. 2).

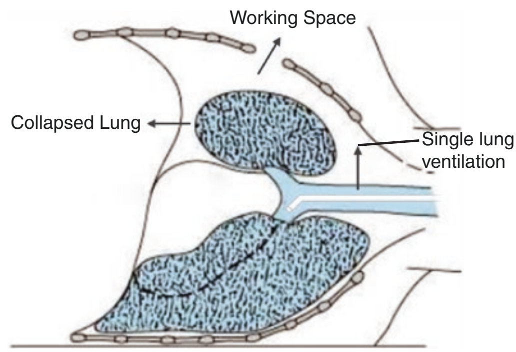

Fig. 2 Doube lumen single lung ventilation

The indications for double lumen tube intubations mainly are:

- To prevent cross-contamination of a noninvolved lung from blood or pus.
- To control the distribution of ventilation in cases where there is a major air leak—such as Broncho pleural fistula, tracheobronchial trauma, or in major airway surgery.
- To perform Broncho pulmonary lavage.
- Pneumonectomy.
- Lobectomy.
- Thoracic aneurysm repair.

Use of a single lumen tube is done in procedures like esophagectomy or mobilization of esophagus, thymectomy, thoracic spine access, sympathectomy, and diagnostic procedures using insufflation of carbon dioxide into the thorax at the beginning of the procedure to facilitate a more complete and expeditious collapse of the lung. In such cases, the intrapleural pressure is measured and kept lower than 10 mm Hg to avoid mediastinal tension and hemodynamic compromise. It is necessary to use air-tight valves (reusable or disposable) trocars to seal the gas within the thorax when this carbon dioxide insufflation technique is used.

Preoperative Work Up

The role of the preoperative evaluation is to determine the risk and morbidity associated with the proposed procedure. The assessment should focus on pulmonary and cardiac conditions, as these represent the most common complications after thoracic surgery.

Cardiac Risk Assessment: The American Heart Association recommends noninvasive testing as a minimum for such patients, with additional invasive testing and intervention as indicated.

- History of a cardiac condition prior to myocardial infarction, congestive heart failure, diabetes, and cerebrovascular disease and cardiac medications.
- Unable to climb more than two flights of stairs.

Pulmonary function test: Adequate pulmonary reserve is assessed through the use of pulmonary function testing, with occasional use of perfusion scanning and exercise testing when appropriate.

This algorithm evaluates pulmonary function in three areas:

- Respiratory mechanics (forced expiratory volume in 1 s [FEV_1]).
- Parenchymal function (diffusing capacity for carbon monoxide [DLCO]).
- Cardiopulmonary interaction (Vo_2max).
- Laboratory studies: Standard blood work should include:
- Complete blood count.
- Electrolyte panel.
- Clotting parameters.
- Liver function tests.
- Preoperative imaging studies: they help to confirm the planned extent of resection and the suitability of a VATS approach.
- Contrast-enhanced computed tomography (CT).
- Positron emission tomography (PET) in suspicious malignancy or malignant cases.

Indications

Indications are as below according to organ/tissue involved:

Lung

- Lung cancer.
- Bronchiectasis.
- Aspergilloma and other fungal infections.
- Hydatid cyst in the lung.
- Emphysema.
- Destroyed lung: tuberculosis.
- Complications of Tuberculosis.
- Spontaneous pneumothorax.

Pleura

- Undiagnosed/complex/recurrent effusion.
- Empyema.
- Pericardial effusion.
- Diagnostic biopsy.
- Pleurodesis and pleurectomy.

Mediastinum

- Mediastinal mass.
- Disease of thymus.
- Parathyroid adenoma excision.

Esophagus

- Benign esophageal tumors.
- Esophageal cancer.
- Esophageal diverticula.

Diaphragm

- Eventeration.
- Hernia.

Thoracic duct ligation

Sympathectomy.

Positioning

The patient is positioned in lateral decubitus position (Fig. 3) with the thorax surgically prepared in case conversion to an open thoracotomy is necessary during the course of the operation. This is accompanied by flexion of the operating table at the level of the tip of the scapula to widen the intercostal space [8–11]. The flexion is achieved either by putting a bolster or flexing the operating table, with the operative lung facing up and nonoperative lung in the dependent position. The lateral decubitus posi-

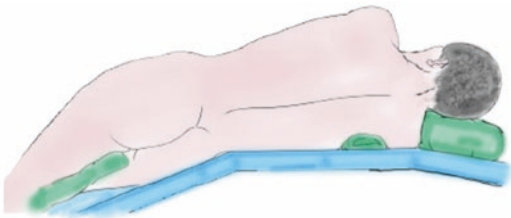

Fig. 3 Position of VATS: Lateral deubitus

tion provides adequate access to most thoracic structures which include the lungs, pleura, esophagus, and pericardium among other mediastinal structures. Care must be taken at all times to avoid nerve injury by adequately padding pressure points The patient's shoulder and arm are extended and secured to a side rest.

Port Placement

Using sterile techniques, the port site is created by making incisions in the intercostal space. The incisions are parallel to the long axis of the intercostal space. The surgeon must take care that these incisions are in the center of the space to avoid injury to the intercostal nerves that run in a groove at the lower border of the ribs. Then using a hemostat bluntly spread the fascia and muscle layers until the pleural cavity is entered.

The first port incision should be at the maximum distance from the target site of dissection or inspection to allow better visualization. Mostly the choice of incision is at the seventh or eighth intercostal space at the anterior to midaxillary line. This incision is best suited for the placement of chest tube at the end of the procedure. Surgical interventions are made over the rib to prevent any injury to the neurovascular bundle.

The second incision site is the anterior fourth and fifth intercostal space between the midclavicular and anterior axillary line.

The third incision is posterior, at the fifth and sixth intercostal space adjacent to the scapula (Fig. 4).

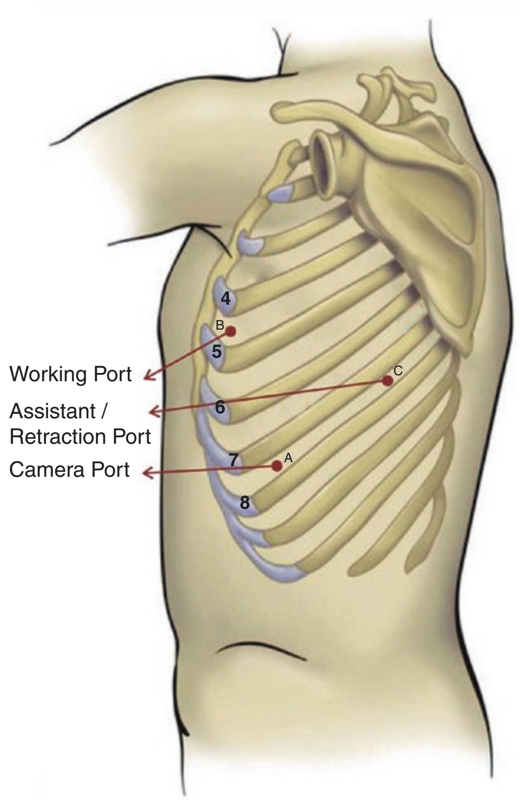

Fig. 4 VATS: Port placement

There are many different port placements in VATS being used throughout the world. The earliest established was referred to as "baseball diamond" which consist of 10–12 mm incisions with the placement varying from surgeon to surgeon according to their preferred approach for the particular patients. Multiple different variations of the above have been seen now including the two port and even single port technique. With two port technique using an anterior and an inferior port, and single port technique using the camera and multiple instruments through the same port.

Instruments

The instruments generally used in VATS have salient features like long working length which provides the familiarity of traditional handles for

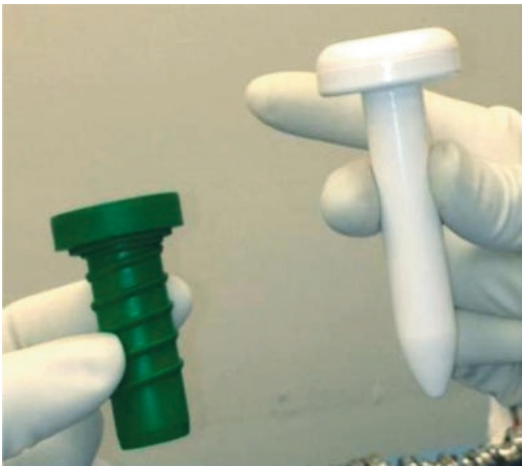

Fig. 5 VATS: Short trocars

Fig. 6a VATS Instrument: Thin Shaft and Curved shape Instruments

Fig. 6b Decortication Forcep

secure manipulation and superior tactile response. The Sliding Shafts enable the instrument to be fully functional when placed through a port or very small incision and also minimize Patient Trauma. Continuous technical advancements in vats instrumentation have happened in the last decade.

Commonly used instruments during VATS procedure are:

- Short trocars (Fig. 5).
- 30/45 telescope
- Usual range of 5 mm thoracic/endoscopic instruments (grasping forceps, decortication ring forceps (Fig. 6b), DeBakey forceps, small and large dissectors, scissors, suction) (Fig. 6a).
- 5 mm bipolar shears.
- 5 mm vessel sealing device.
- 5 mm endo peanuts.
- 10 mm clip applier.
- Endo-stapler, preferably with curved tip.
- Large retrieval bag.
- Conventional open thoracic instrumentation ready on a separate table.

The OR Setup

The operating room should be fully equipped that allows the surgeon at any immediate potential to convert to open thoracotomy. Video-assisted thoracic surgery (VATS) requires a high definition (HD) video monitor, together with VATS instruments allowing the surgeon to view a sharp, high-resolution image within the chest cavity. The organization of the operation room is done based on the surgeon's surgical approach.

There are two types of approaches:

- Anterior (Fig. 7a).
- Posterior (Fig. 7b).

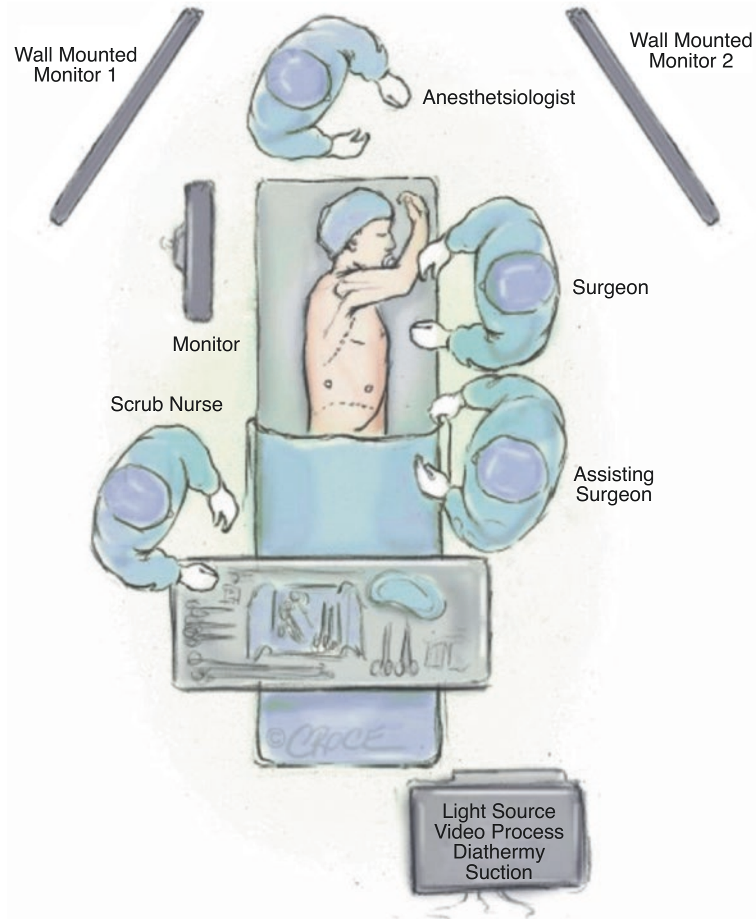

Fig. 7a Anterior appoach: Video-assisted thoracic surgery

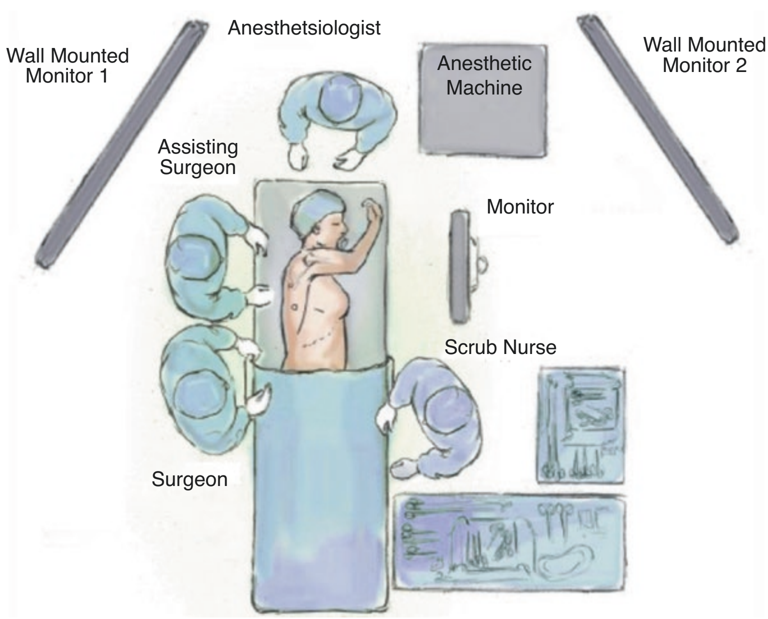

Fig. 7b Posterior approcah: Video-assisted thoracoscopic surgery

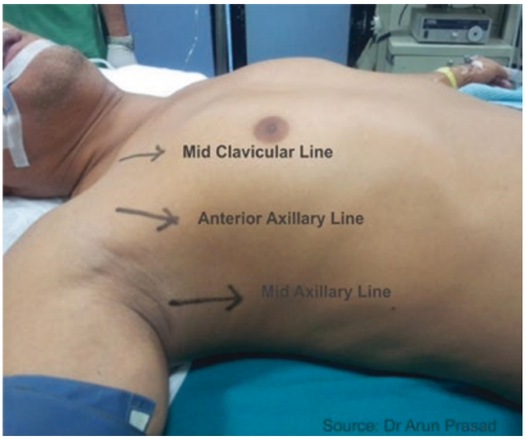

Fig. 8 Anatomical landmark for port placement in sympathectomy

VATS Sympathectomy

It is a surgical procedure in which a portion of the sympathetic nerve trunk in the thoracic region is destroyed [1, 2]. The most common area targeted in sympathectomy is the upper thoracic region, that part of the sympathetic chain lying between the first and fifth thoracic vertebra (Fig. 8).

Indications

- Hyperhidrosis [12].
- Splanchnic pain.
- Reflex sympathetic dystrophy (RSD).
- Upper extremity ischemia is also appropriate when nonsurgical treatment fails.
- Prolonged QT interval.

Position

The patient is positioned supine with both arms outstretched on arm boards and the trunk in a 30° Fowler position. The position helps the apex of the lung to fall apart.

Anesthesia

General anesthesia, along with single lung intubation [13], a bilateral two port VATS approach is performed.

Technique

- The sterile field includes the neck, both axillae and upper arms down to the costal margin bilaterally.
- At fourth or fifth intercostal space with an anterior axillary line, approximately 1 cm incisions are made for camera port (Fig. 8).
- Insufflation of carbon dioxide for active lung collapse using intra pleural Pressure up to 8 mmHg.
- The zero-degree thoracoscope is introduced through the port.
- The thoracic chain is readily identified and covered by the thin layer of the parietal pleura.
- A diathermy hook is inserted through the third midclavicular line intercostal space (Fig. 8).
- The sympathetic chain is visualized behind the parietal pleura, which is then scored on either side using the cautery to delineate the position of the chain and the extent of the planned cauterization which corresponds to the extent of the chain destroyed.
- Using the ribs as reference, the sympathetic chain is then cauterized and divided from T2 to T3 for patients with predominantly palmar hyperhidrosis and from T2 to T4 for patients with predominantly axillary hyperhidrosis [14]. Possible anatomical variations such as the Kuntz nerve, a transverse dissection along the rib is performed (Fig. 9).
- The thoracoscope is then removed and replaced with a small red rubber catheter. With positive pressure ventilation, the catheter is then removed under suction to allow expansion of the lung.

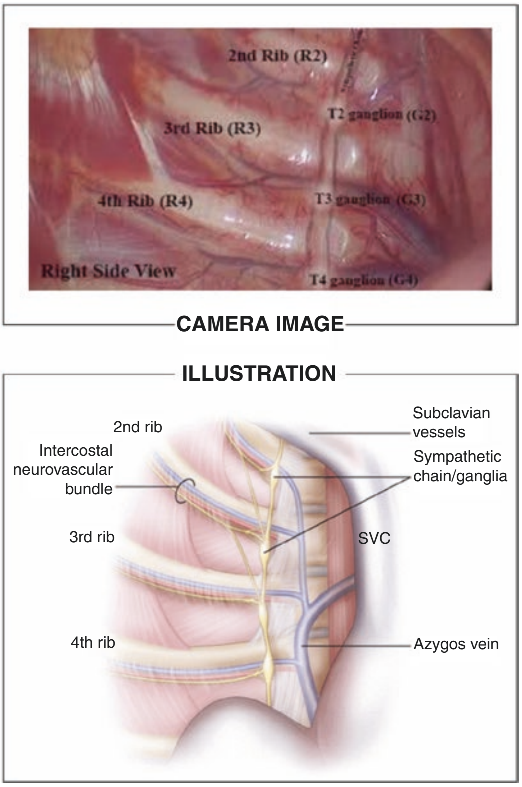

Fig. 9 Thoracic sympathetic chain

- The skin incision is closed with a single absorbable 3–0 suture followed by the placement of skin types.
- Contralateral sympathectomy is performed in a similar manner without changing the patient's position.

Postoperative

- No chest tubes are routinely placed at the end of the procedures.
- All resected sympathetic chain specimens are sent for histopathology.
- Patients are generally discharged the same day.

Complications

- Compensatory sweating.
- Horner's syndrome.
- Bleeding.
- Pneumothorax.
- Recurrence.

Vats Wedge Resection

It is a minimally invasive technique for nonanatomical limited resection of a lung. It is preferred over open as it is muscle sparing non-rib spreading and does not involve thoracotomy [15]. It is better suited for peripherally located lesions compared to deep-seated central pathology which is very arduous and difficult to secure sufficient surgical margin [16] (Fig. 10). To attempt such deep-seated resections can cause prolonged air leak and delayed recovery. Lesions at the periphery or outer one-third of the lung are considered the most suitable indications for wedge resections.

Indications

It has both diagnostic and therapeutic roles.

Therapeutic

- Early-stage (NSCLC; T1N0M0) and early-stage in patients with limited cardiopulmonary reserve (although lobectomy is preferred).

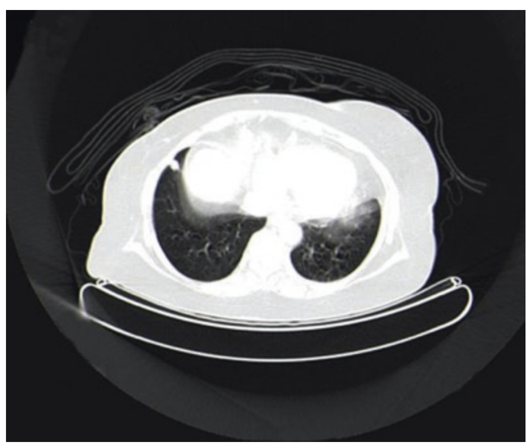

Fig. 10 High-resolution computed tomography of solitary lung lesion

- Metastasectomy for pulmonary metastases due to renal, breast, colon malignancy, melanoma, sarcoma.
- Ground-glass opacification lesions on chest CT scan in patients with past or present cancer [16].
- Localization and excisional biopsy of ill-defined or small pulmonary lesions [17]
- Resection of hamartoma.
- Resection of pulmonary sclerosing hemangioma.
- Resection of intralobar sequestrated lung.
- Resection of localized peripheral bronchiectasis.
- Lung volume reduction surgery in end-stage emphysema.
- Resection of pulmonary arteriovenous malformation (PAVMs) [18, 19].
- Infectious tubercular granulomas, aspergilloma, and focal organizing pneumonia.

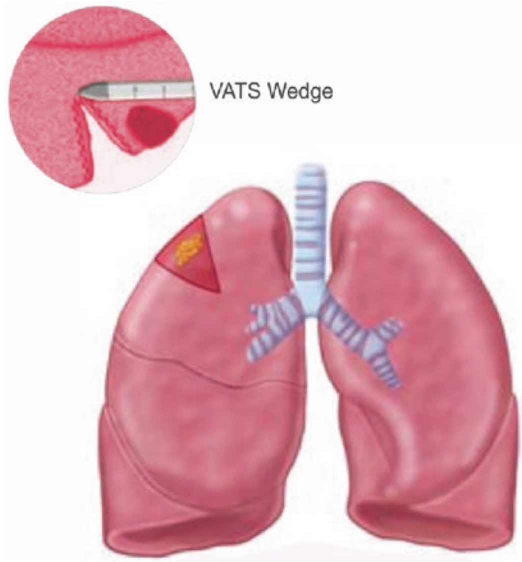

Fig. 11 Wedge resection

Diagnostics

- Excision biopsy of solitary/pulmonary nodules.
- Excisional biopsy of ill-defined or small pulmonary lesions [17].
- Interstitial lung disease (ILD), wedge resections for diagnostic purposes, the lingula or the middle lobe are usually preferred, although alternative segments may be selected.
- Pulmonary fibrosis.
- Resection of ruptured/bullous lung.
- Resection of pulmonary sclerosing hemangioma.

Surgical Technique

- In lateral decubitus and ports, placement are done as described above.
- Localization of the pathologic site is done based on visceral pleural changes such as puckering, dimpling, raised lesions over a deflated lung, increased vascularity, or overlying pleural adhesions (Fig. 11).
- Gentle handling of the lung parenchyma to avoid unnecessary air leak or bleeding due to tear.
- Since there are limitations of finger palpation of the target site other techniques used to identify target site are preoperative CT-guided needle placement, hook-wire localization, or placement of radio-opaque dye (methylene blue). These can be used for guidance and lesion detection intraoperatively with fluoroscopy.
- After localization resection is done by using endostaplers, larger lesions require planning with numerous staple runs. The deflated lung tissue can be rotated from the apex or base to lie over hilum to allow alignment for straight staple cuts.
- Tissue is delivered using endo bag from the anterior working port.
- Before closing the ports lung is inspected for any air leaks.
- Chest tube with underwater seal is placed from inferior port and lung is allowed to expand completely.

Postoperative

- Postoperative pain management consists of narcotics and/or NSAIDS.
- Chest physiotherapy and early ambulation are recommended.

- Chest tube is removed when the pleural effusion is lower than 200 mL/day and air leak flow <40 mL/min for more than 8 h (and without spikes of airflow greater than this value) [20].

Complications

- Wound infection.
- Persistent air leak.
- Subcutaneous emphysema.
- Hemothorax.
- Pneumonia.
- Atelectasis.
- Broncho pleural fistula.
- Local and port-site recurrence of malignancy [8] (more common with wedge resection than with lobectomy).

VATS Bullectomy and Pleurodesis

VATS bullectomy is a minimally invasive surgery to remove bulla, i.e., dilated air space or air-filled pockets from the lung parenchyma (Fig. 10). Pleurodesis is the procedure of sticking together the coverings of the visceral and the parietal pleura of the lung together.

VATS bullectomy and pleurodesis together have been seen in various studies to improve the outcomes in patients with spontaneous/recurrent pneumothorax or emphysema [21, 22].

Indications

- In asymptomatic cases: Large bullae occupying more than 30% of lung volume (with underlying lung comparatively nonemphysematous).
- Symptomatic cases: after ruling out other causes of dyspnoea.
- When patient presents with complications due to ruptured bulla such as pneumothorax, infection, chest pain, or hemoptysis (refractory to treatment).
- The controversy arises in cases of giant bullas in which some surgeons prefer operating early [23] in asymptomatic patients whereas some prefer to wait for the occurrence of symptoms before surgery to avoid the risk of complications in otherwise clinically asymptomatic patients [24].

Preoperative

CT should be done to record the progress, size of bulla or bullae, identify the proper anatomy of the bulla as well as its surrounding tissue, and therefore help the surgeon to plan the procedure (Fig. 12).

Anesthesia

Single lung ventilation by use of a double-lumen endotracheal tube or bronchial blocker. Placement of a thoracic epidural catheter for postoperative pain control.

Procedure

- The first step in the surgery is the placement of the ports in the lateral decubitus position described above. The first incision should be taken very carefully after accessing the computed tomography imaging as the lungs might be adhered to the chest wall. Adhesiolysis lead

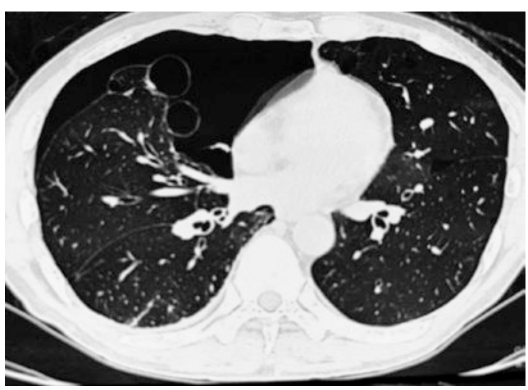

Fig. 12 High-resolution computed tomography of bullous lung

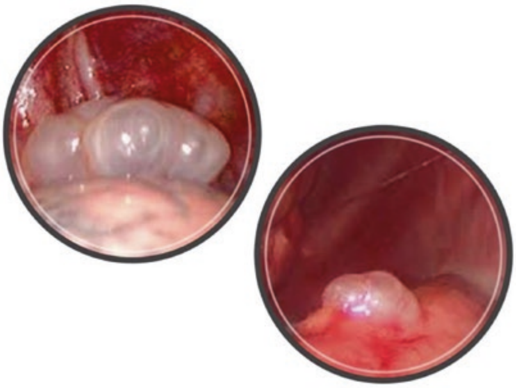

Fig. 13 Camera view: Bullous lung

to space for removing the bulla and increases the visibility of the lungs (Fig. 13).

- Next step is to locate and grasp the bulla and fire the stapler across the base. In case of large bullas which are difficult to manipulate, the bulla is punctured and deflated for effortless handling. The staple line should be put in normal lung tissue to avoid air leak.
- Sizing should be carefully planned, otherwise inadequate sealing due to small stapler or leakage in case of too large stapler, some surgeons prefer buttressing of the staple lines is also done to prevent air leakage.
- Chest cavity is reinstalled with normal saline and reinflation of the lungs to check for any visible leak.
- Pleurodesis is done with mechanical abrasion along with talc or with the help of other chemicals.
- Placement of pleural drains to avoid air or fluid collection in the operated area and to ensure complete expansion of lung.
- Pleurodesis works when the lung is completely expanded. Closure of the ports.

Post-op Management

- Drain placed can be attached to negative pressure suction as per the surgeon's choice. There have been controversies regarding the use of negative pressure suction as few authors believe it continues to have air leak and hence delay in healing however the author has preferred using negative pressure suction as it helps pleurodesis by increasing lung volume and decreasing chances of atelectasis.
- NSAIDS or opioids.
- Chest physiotherapy and incentive spirometry.

Complications

- Air leak: Inside the lungs can lead to pneumothorax and collapse of healthy lung tissue. To avoid this we place the drain connected to negative suction, It should be checked routinely that the drain is patent.
- Atelectasis: Incomplete expansion of lungs can lead to atelectasis. Pre-op and post-op physiotherapy helps prevent the same.
- Pneumonia: Chances of infection due to an invasive process possible. Use of empirical antibiotics should be considered. Proper post-op care with vitals, i.e., temperature, pulse, and BP should be monitored hourly.
- Sputum retention: This can also be prevented with help of chest physiotherapy and nebulization if and when needed.

Vats Decortication

The ability to completely drain the thoracic cavity, break up pockets of pleural fluid, completely visualize all aspects of the pleural space, by thoracoscopy and avoid the morbidity of a thoracotomy. VATS drainage of empyema and decortication has become an attractive procedure in the management of empyema and hemothorax.

Indications

- An effusion which is loculated or occupying 50% of hemithorax [25].
- An infected pleural effusion.
- An empyema of less than approximately 3 weeks, in the exudative or fibro purulent stage 4 [25].
- Hemothorax.

- Descending mediastinitis.
- When the nature of the pleural process is undiagnosed, this allows for a directed pleural biopsy that is likely to make the diagnosis while avoiding the morbidity of a thoracotomy.

Contraindications

- Prior thoracotomy.
- Prior talc pleurodesis.
- The inability to tolerate single lung ventilation.
- Fibrothorax.

Surgical Technique

- The first incision should be taken very carefully after accessing the computed tomography imaging as the lungs might be adhered to the chest wall. The camera port is placed in the seventh or sixth intercostal space in the line of the anterior superior iliac spine or just anterior to this. Rest of the ports are placed as discussed above; generally, 2–3 ports are made for drainage of empyema and hemothorax [26]. However, in cases of dense adhesions at the primary camera port, different positions can be chosen for insertion of first port.
- After entering the chest wall, a Yank Auer suction is used to drain the chest of effusion or blood. The suction along with a finger is then used to break up simple loculations while continuing suction if necessary. The preoperative CT scan (Fig. 14) helps guide this "blind" initial drainage and creates a working pleural space for the thoracoscopic instruments. Gelatinous fibrinous deposits and blood clots are removed with a curved ring forceps/decortication forceps (Fig. 6a). The visceral pleural peel can be debrided if needed using ring forceps, a curette, and a peanut dissector as in an open decortication.
- Once a pleural space has been created the removal of fibrinous material is performed over the lateral part of the pleural cavity starting from the apex of the lung and proceeding to the diaphragm or vice versa.

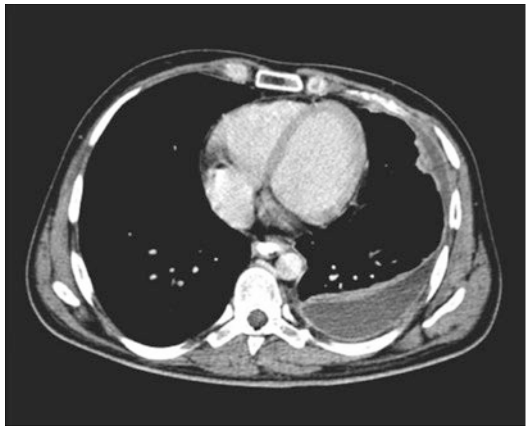

Fig. 14 High-resolution computed tomography of empyema

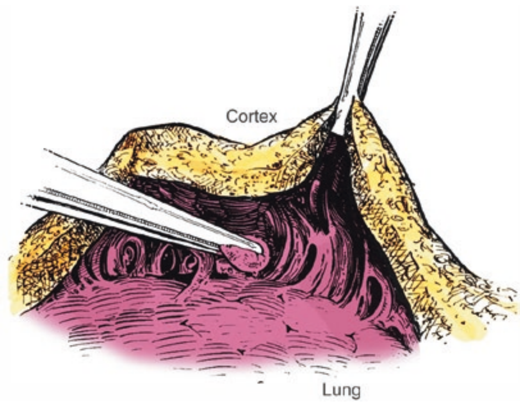

Fig. 15 Technique to peel of cortex

- The suction and ring clamp/decortication forceps are used together to remove the fibrinous material from the pleural cavity and the curette, peanut, and ring clamp are used to dissect the cortex on the lung (Fig. 15).
- At the inferior aspect of the pleural cavity, it is helpful to identify and separate the lower lobe of the lung from the diaphragm. This plane is developed posteriorly and anteriorly allowing for the lung to fill the cost diaphragmatic sulcus once the decortication is complete [27]. Next, the posterior aspect of the pleural space is debrided and the underlying lung is decorticated.
- Intermittent ventilation of the lung is used to assess the completeness of the decortication as the dissection proceeds [28] (Fig. 16).

- Particular care should be taken with hemostasis both on the parietal and visceral pleura [29].
- If adequate progress is not being made or there is inadequate expansion of the lung to fill the chest, then conversion to open decortication should be performed. Conversion to open is performed when necessary and should not be considered a failure of thoracoscopy [30].
- Once adequate debridement has been accomplished, irrigation is performed and the lung expansion is visualized to ensure the pleural cavity is filled by the lung [31].
- Chest tubes can be placed anteriorly and posteriorly for air and fluid drainage.

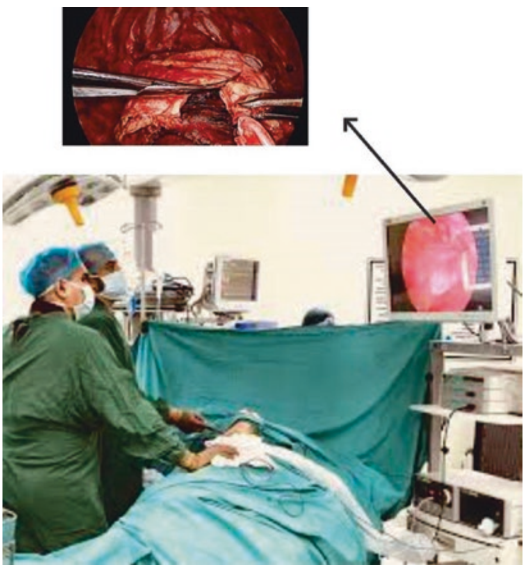

Fig. 16 VATS decortication

Postoperative

- Chest physiotherapy and incentive spirometry.
- The chest tubes are maintained on suction to make sure there is complete lung expansion and adequate drainage of the pleural space.
- Once the drainage is less than 200 cc/24 hrs and the air leak has been reduced to minimum, the tubes can be removed.
- For patients with empyema, intravenous antibiotics are continued during postoperative period and for 14 days of oral antibiotics once the patient is discharged [32].

Complications

- Inadequate lung expansion.
- Infection and recurrence [33].
- Prolonged air leak.

Basic Principles: Vats Anatomical Lung Resection

Types of Anatomical Lung Resection (Fig. 17)

- Pneumonectomy: complete removal of affected lung
- Lobectomy: resection of one of the lobes of either lung along with their respective blood supply.

Fig. 17 Anatomical lung resection

- Segmentectomy: lung segment has a separate group of bronchi, arteries, and segmental veins shared with the adjacent segments. A resection based on their anatomy will not damage other lung segments. Therefore, for certain lesions that are restricted to one lung segment, especially benign lesions, a segmentectomy may be considered [34].

Anesthesia

General Anesthesia with Single lung ventilation [13] by use of a double lumen endotracheal tube or bronchial blocker. Placement of a thoracic epidural catheter should be done for postoperative pain control.

Position: Lateral decubitus position.

Approach: depends upon where surgeon choice while operating.

- Anterior (Fig. 7a).
- Posterior (Fig. 7b).

Procedure

- The surgical procedure is facilitated by aligning the view of the camera with the general direction of the dissection. Use of angled, either at 30 or 45 from the long axis of the scope.
- Thorough knowledge of the hilar anatomy (Fig. 18) greatly enhances the safety of all of these techniques. Vital structures such as the phrenic nerve or recurrent laryngeal nerve should be identified early and preserved.
- Use of sharp, blunt, or cautery techniques is also at the discretion of the surgeon's comfort, as long as the individual dissection and ligation of the lobar and hilar structures are observed.
- Pulmonary vessels and bronchi within the hilum are ligated separately using endoscopic staplers.
- Bronchial arteries may be cauterized or clipped, or stapled in rare cases involving long-standing pulmonary infection.

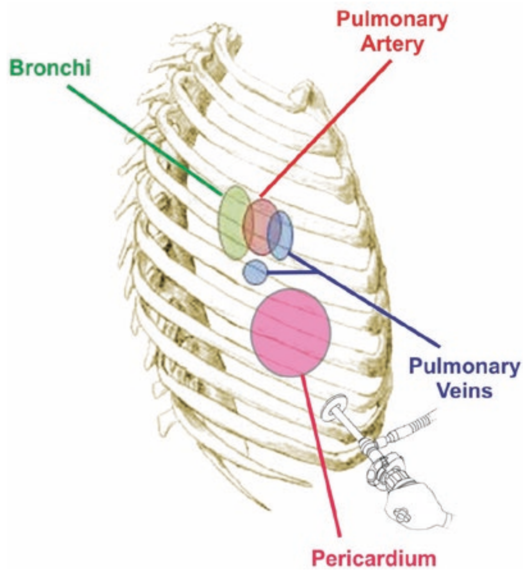

Fig. 18 Illustration of the hilar structure

- It is important to introduce the stapler into the chest such that, once around the vessel or bronchus, it exits freely on the other side and not encumbered by other structures. This will avoid injury to other tissues, and assure a secure closure of the target.
- Specimen removal is achieved with the use of a specimen bag, to minimize contact with the soft tissues at the access incision site which reduces recurrence at port sites.
- In malignant cases, nodal dissection may be performed either before or after completion of the pulmonary resection.

Conclusion

It is imperative that minimal access surgeries such as VATS be taught to a surgeon in the early training period to shorten the learning curve as multiple studies done on the same show the improvement in the prognosis of patients needing thoracic surgery. The morbidity and mortality have drastically decreased and hence it has been widely accepted all over the world. VATS has progressively replaced open thoracotomies in most thoracic surgery centers around the world because of its safety profile in elderly patients, better pain control, faster recovery times, and better access to apical structures. It has been shown to decrease the length of hospital stay compared to open thoracotomy.

More improvements in the same are bound to happen with time with help of young surgeons and creative minds like Bozzini's.

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