Medical Thoracoscopy (Pleuroscopy) Guidelines

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Message from President PCS

The world is undergoing a transformative change at the moment, more people are living in cities than at any point in the history of mankind, we are building parking spaces in place of green spaces and tobacco use still remains a major global problem. The rapid urbanization and pollution has lead to a sharp increase in pulmonary disease like COPD and cancer. The situation is further aggravated by the re-emergence of disease like tuberculosis, particularly in the low and middle-income countries.

It is estimated that one out of every six deaths globally, is caused by the respiratory diseases. Six percent of all deaths in Pakistan can be attributed to lung disease. Although the most suitable solution to majority of the lung disease lies in preventive measures and major lifestyle changes, the modern pulmonologist should be adequately equipped with the most advanced diagnostics and treatment modalities to help rid patients of the various pulmonary diseases endemic in our population. Pleuroscopy or thoracoscopy is one such modality that can be used for both diagnostic and interventional purposes, offering an efficient and effective alternative to more conventional methods that are time-consuming, costly, and often less effective.

However, as stewards of chest medicine practice, the PCS believes that in order to maintain quality and bring standardization to the practice of pulmonology, it is of utmost importance that guidelines are penned down for all major procedures and revised regularly to keep abreast with the latest developments. The first edition of the “Medical Thoracoscopy (Pleuroscopy) Guidelines”, is an effort to standardize the practice of thoracoscopy in Pakistan, in the light of international recommendations, tailored to our local context.

As the president of the PCS, I must congratulate the writing team to have come up with these comprehensive guidelines. The guidelines are in accordance with the latest recommendations and reflect the most up to date knowledge about thoracoscopy. I feel that pulmonologists from all over Pakistan and those from beyond will immensely benefit from these guidelines in the treatment of pulmonary diseases and that these guidelines, like the so many other guidelines developed by the PCS, will contribute in making Pakistan a more healthier place.

Professor Dr. Arshad Javaid

Preface

In the first place, I am thankful to Almighty Allah whose brilliance empowered me to accomplish the task of compiling the first PCS guidelines on medical thoracoscopy. It is a landmark to disclose that some centers across Pakistan have established medical thoracoscopic services and many are still motivated to initiate this brilliant modality. The guidelines reflect the international recommendations as well as local experience and practices. Pleuroscopy is predominantly a diagnostic tool but it has therapeutic extensions and if used precisely it can help patients to be managed in cost effective and less invasive ways in a country where cheaper access to thoracic surgery is not readily established. It is strongly believed that pleural diseases should primarily be dealt by pulmonologists utilizing least invasive tools including, but not limited to thoracic ultrasound, small bore pleural drains, Heimlich valves, indwelling pleural catheters, intrapleural fibrinolytics, sclerosing agents and medical thoracoscopy.

It is indeed an immense pleasure to avail this opportunity to assert my heartiest indebtedness to all the members of this guideline committee for their scientific contribution to undertake this work and to compose this monograph. The authors have tried to put all updated information in this national guideline which can facilitate novices to read and learn through this document and utilize the information to perform procedures under supervision and then independently. The guideline covers almost all aspects of pleural disorders requiring pleuroscopy including patients' selection, steps for performing pleuroscopy in complicated benign and malignant pleural processes, patient's prerequisites for the procedure and post-procedural care.

I am also grateful to my family members for their continuous support and encouragement throughout my work. It will be a remiss if I don't pay my regards to our patients whose images are also posted in this guideline. Thanks to all the teachers for their inspiration and thank you very much in advance to all interested readers of this document. May we all learn more to perform better today than our yesterday and take respiratory and pleural medicine to great heights in our homeland.

Dr. Talha Mahmud

Contents

List of Abbreviations

APC	**Argon Plasma Coagulation**
ACEP	**American College of Emergency Physicians**
CXR PA	**Chest Radiograph-Posteroanterior Projection**
CT	**Computerized Tomographic**
EF	**Ejection Fraction**
FB	**Foreign Body**
F	**French**
G	**Gauge**
I/M	**Intramuscular**
INR	**International Normalization Ratio**
IV	**Intravenous**
IM	**Intramuscular**
MT	**Medical Thoracoscopy**
NSCLC	**Non Small Cell Lung Cancer**
NPO	**Nil Per Oral**
Nd:YAG	**Neodymium-doped Yttrium Aluminium Garnet**
NSAIDs	**Non Steroidal Anti Inflammatory Drugs**
$PaCO_2$	**Partial Pressure of Carbon Dioxide**
PPE	**Parapneumonic Effusion**
PSA	**Procedural Sedation and Analgesia**
SpO_2	**Saturation of Oxygen on Pulse Oximeter**
S/C	**Subcutaneous**
TB	**Tuberculosis**
TUS	**Thoracic Ultrasound**
VTE	**Venous Thrombo-embolism**
VAMT	**Video Assisted Medical Thoracoscopy**
VATS	**Video Assisted Thoracoscopic Surgery**

Introduction

The term endoscopy was coined from Greek language endo (inside) and skopein (to observe with care). Exploration of living human body has always been an inspiration for physicians. However, until nineteenth century it was not possible to gain access to living body because of lack of knowledge and unavailability of appropriate instruments. Endoscopy was first done by a French urologist Desormeaux in 1865, who designed a cystoscope to look into the bladder. Medical thoracoscopy (pleuroscopy/pleural endoscopy/white light thoracoscopy) is passage of an endoscope through the chest wall for direct visualization of the pleura by a pulmonary physician and can be carried out in the bronchoscopy room. It is not a new procedure as in 1910, a Swedish physician (professor of medicine) Hans Christian Jacobaeus (father of modern thoracoscopy) used a modified cystoscope to evaluate pleura and lyse tuberculous adhesions to induce artificial pneumothorax (Jacobaeus operation) as part of treatment of tuberculosis.[1] Thoracoscopy was continued for adhesiolysis by surgeons until the discovery of streptomycin in 1945. [2] Interest in medical thoracoscopy (MT) gained momentum from 1990 onwards with the invention of sophisticated video systems to evaluate the pleural space. [3] The success of laparoscopic surgery gave the impetus to thoracic surgeons to take up thoracoscopy, for pulmonary or biopsy, treatment of pneumothorax, decortications in empyema and even lobectomy and pneumonectomy by the use of video assisted thoracoscopy surgery (VATS). This was followed by pulmonary physician-led video assisted medical thoracoscopy (VAMT) which has become the procedure of choice not only for diagnostic purposes but also in some therapeutic extensions. Equipment and some applications of MT are similar to VATS but it is limited in its diagnostic and therapeutic functions and its utility varies among clinicians and countries. [4]

Thoracoscope Systems (equipment)

MT is typically performed using white light to illuminate pleura utilizing both rigid and semirigid scopes. Rigid thoracoscope (figure 1) is the most common instrument used worldwide because it is less expensive, has longer life and provides excellent optical quality & maneuverability within the pleural space.[4, 5] Semirigid fibreoptic flexible video medical thoracoscope (Olympus®) is comparable in diagnostic efficacy to that of rigid thoracoscope with appearance similar to a bronchoscope (figure 2). Its proximal shaft is rigid and distal part is flexible. It has a handle, suction, and a working channel and is compatible with bronchoscopic light sources and video processors. MT is an invasive procedure that should be pursued only when indicated. Scope insertion technique resembles chest tube insertion by blunt dissection through the intercostal space, but is slightly more invasive and also allows visualization of the pleural cavity. As with all medical procedures, appropriate training is mandatory before full competence can be achieved.[6, 7] Most newer systems contain a light source, working channel, and video port all in a single instrument, allowing for a single point of entry procedure. Other instruments fulfill just one of these needs which necessitates a multi-port procedure.

Besides the above two systems other techniques include bronchoscopes, autofluorescent pleuroscopes and three dimentional instruments. Flexible bronchoscopes have been used rarely

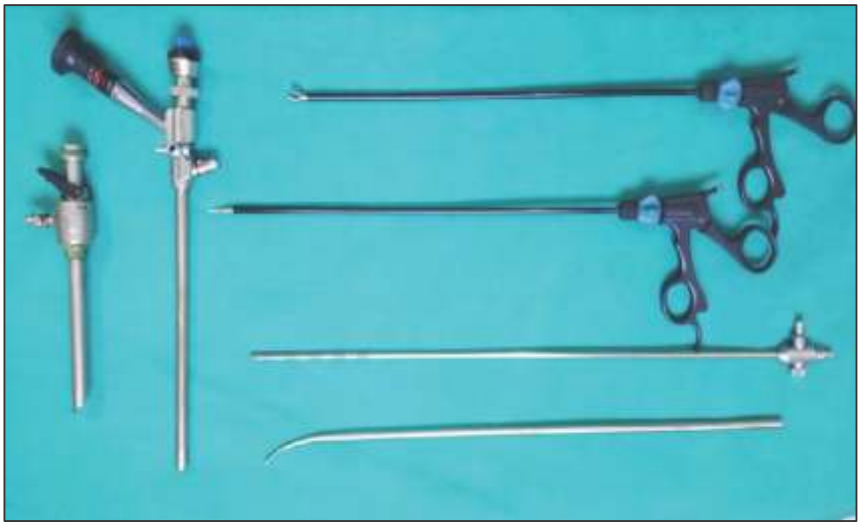

Figure 1. Rigid thoracoscope (Richard Wolf®) and trocar (left), biopsy forceps, scissors forceps (middle) spray catheter and a curette bougie (right top to bottom).

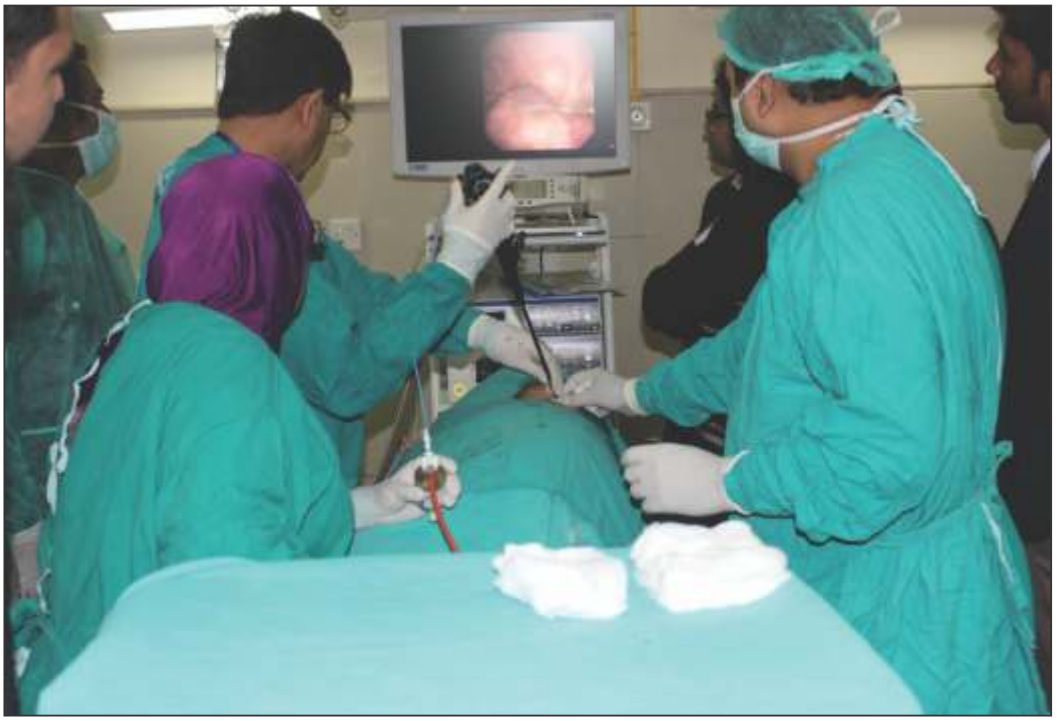

Figure 2. Semi-rigid thoracoscope (Olympus®) with design similar to a bronchoscope having rigid shaft and flexible tip introduced through disposable trocar, maneuvered in pleural space with video image on monitor, mounted on a trolley with light source and processor.

but they are difficult to manipulate within the pleural cavity and are subject to equipment damage. In autofluorescent videothoracoscopy, areas of malignancy appear a different color changing from white or pink (under white light) to red using a fluorescent light. Newer pleuroscopes that have three dimensional imaging capacity are available but are not widely vailable.

Indications

Diagnostic:

1. **Diagnostic evaluation of an exudative pleural effusion of obscure origin**: Thoracoscopic biopsy has high diagnostic accuracy in this situation compared with closed needle or image-guided biopsy.[8]
2. **Suspected malignant pleural disease (with pleural effusion/wet pleura)**: Carries up to 98 percent diagnostic yield in pleural carcinomatosis due to metastatic cancer.[4] Thoracoscopic characteristics of pleural malignancy may include nodules, polypoid lesions, candle wax drops like lesions and yellowish flat deposits due to malignant infiltration of lymphatics (figure 3 a and b).
3. **Suspected malignant pleural disease (without pleural effusion/dry pleura):** Uncommonly patients may present with pleural metastatic disease in dry pleural space. Pleura can still be visualized after creation of an artificial pneumothorax followed by pleuroscope insertion and biopsies of metastatic lesions (figure 4 a and b).
4. **Diagnosis and staging of lung cancer:** Pleural effusions due to lung cancer (usually non-small cell lung cancer (NSCLC) represent unresectable (M1a) disease. Repeated thoracocentesis is nondiagnostic in about one-third of individuals with NSCLC, thereby necessitating pleural biopsy. Thoracoscopic biopsy is preferred since it has a higher diagnostic sensitivity (up to 98 percent). [9,10]
5. **Diagnosis and staging of malignant mesothelioma:** Mesothelioma has been diagnosed thoracoscopically in 60 to 75 percent of patients but results of newer studies with larger specimen size may be comparable with open biopsy in the 90 percent range.[11]
6. **Suspected pleural tuberculous disease:** Grossly TB pleuritis is characterized by extensive grayish-white granulomas involving the parietal pleura or there may be simple patchy inflammation (figure 5a). Medical thoracoscopy, has the highest diagnostic rate for tuberculous pleuritis, 100% compared with 79% for Abrams' pleural biopsy. [12] It is specifically useful when Abrams closed pleural biopsy is negative or when adhesiolysis is required or if larger pleural tissue is needed for histopathology and drug sensitivity testing in a patient suspected of MDR pleural TB. [4,12]
7. **Other benign pleural disorders:** If appropriate pleural fluid studies are non-diagnostic, thoracoscopic biopsy may help establish the diagnosis of benign diseases (e.g asbestos plaques in asbestos associated pleural disease and granulomatous inflammation in rheumatoid pleuritis) and, more importantly, helps to exclude malignancy or tuberculosis in such situations.[8,13]

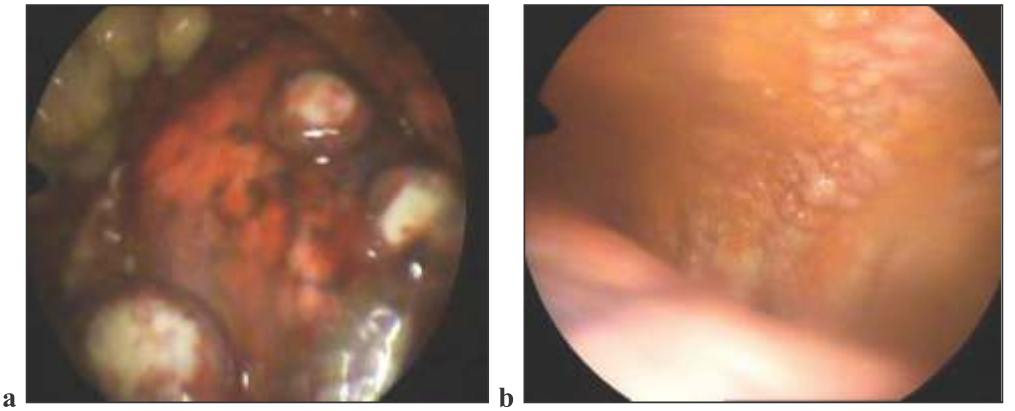

Figure 3 (a) rounded and polypoidal metastatic pleural nodules in a patient with renal cell carcinoma and (b) candle wax like lesions in a patient with metastatic adenocarcinoma lung.

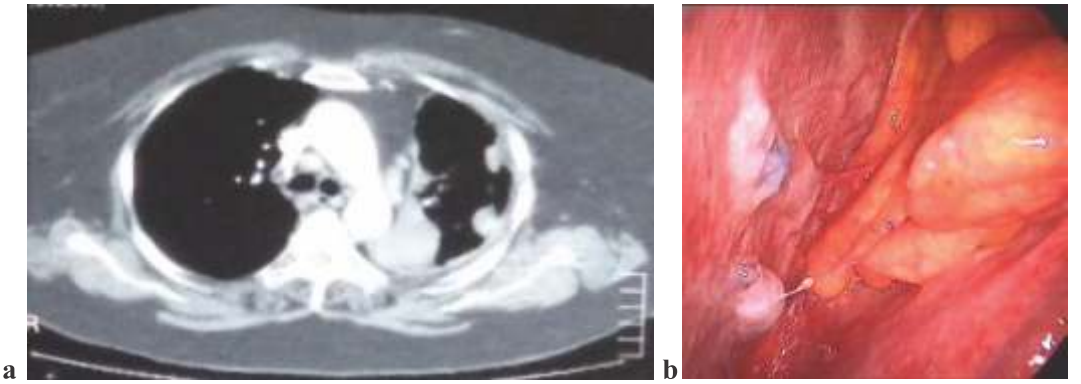

Figure 4 (a) contrast enhanced CT scan chest in a 65-year-old-lady showing left sided pleural nodules and thickening and (b) thoracoscopic visualization of nodules- confirmed as adenocarcinoma on biopsy.

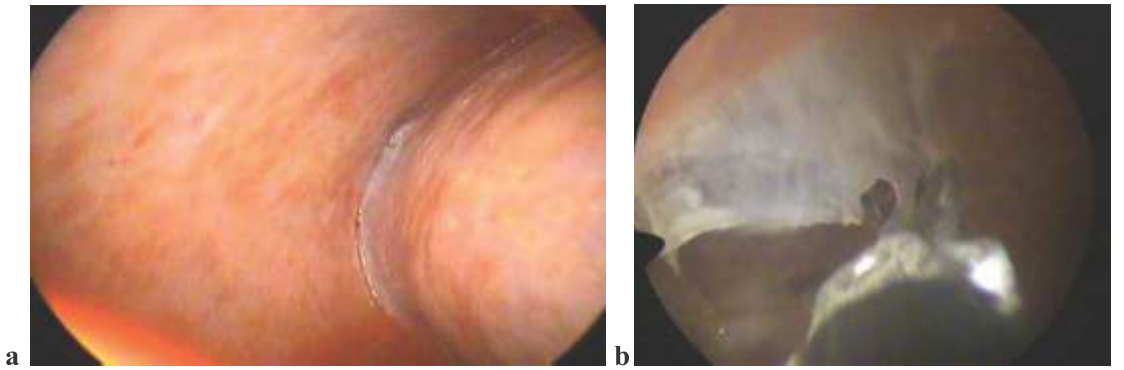

Figure 5 (a) thoracoscopic image of parietal pleura (left) and diaphragm (right) showing various raised and flat nodular deposits in a hepatitis C related liver cirrhosis patient with pleural tuberculosis (granulomatous inflammation with caseation necrosis on biopsy) and (b) a middle aged man with TB pleuritis and extensive adhesions undergoing adhesiolysis.

8. **Lung biopsy for parenchymal disease or peripheral nodules biopsy:** Yield of up to 75% has been reported from centers experienced in performing such procedures utilizing staples or cautery or cryoprobe to seal biopsy site.[14,15]
9. **Diagnostic evaluation of a transudative pleural effusion:** Parietal pleural biopsy is rarely needed for transudative effusions of unclear etiology but may be considered on a case-by-case basis (eg, borderline exudative effusions).

Therapeutic:

1. **Chemical pleurodesis:** Most often with talc (poudrage), primarily for recurrent malignant pleural effusions or pneumothoraces and rarely for refractory benign pleural effusions.[16]
2. **Management of spontaneous pneumothorax:** Blebectomy (small {<2 cm} blebs can be successfully obliterated using APC, Nd:YAG laser, or electrosurgery). This is usually followed by talc pleurodesis and pleural abrasions. [17]
   usually require open surgical or VATS resection.
3. **Management of complicated parapneumonic effusion (PPE) and empyema:** Interventional procedure post chest tube is frequently indicated in patients with complicated PPE and empyema. The role of MT is controversial since reports are mixed and lysis of adhesions can sometimes be challenging (figure 6). Success rate of 79-91% have been reported with MT with or without fibrinolytics in patients with free-flowing or multiloculated PPEs/empyemas. [18, 19, 20]
4. **Adhesiolysis**: Other than patients with thoracic empyema, adhesiolysis may also be required in pleural space complicated by adhesions due to TB pleuritis (figure 5b), uremic pleurisy and malignant pleural disease.[21]
5. **Sympathectomy for palmer hyperhidrosis:** Difficult procedure usually done under general anesthesia in specialized centers having full thoracic surgery support. [21,22]
6. **Foreign body (FB) removal:** Intrapleural FB is an uncommon condition, usually encountered in the setting of thoracic trauma, but can rarely complicate procedures like diagnostic pleurocentesis. Although surgical extraction using thoracotomy or VATS remains the preferable management approach, intrapleural FB can also be removed utilizing MT. [23]

**For uncommon thoracoscopy applications like blebectomy, adhesiolysis in empyema, sympathectomy and FBs removal, practice may differ among clinicians and regions both at national and global level depending upon the availability of expertise, appropriate training and thoracic surgical back up support. VATS has well established role for these indications.*

Procedures NOT Generally Performed By Medical Thoracoscopy

- Resectional surgery like lobectomy or pneumonectomy.
- Decortication or pleurectomy.
- Resection of benign or malignant peripheral pulmonary nodules.

- Bronchopleural fistula repair,
- Creation of a pericardial window.
- Transthoracic vagotomy.
- Evaluation of mediastinal lymphadenopathy or tumors.

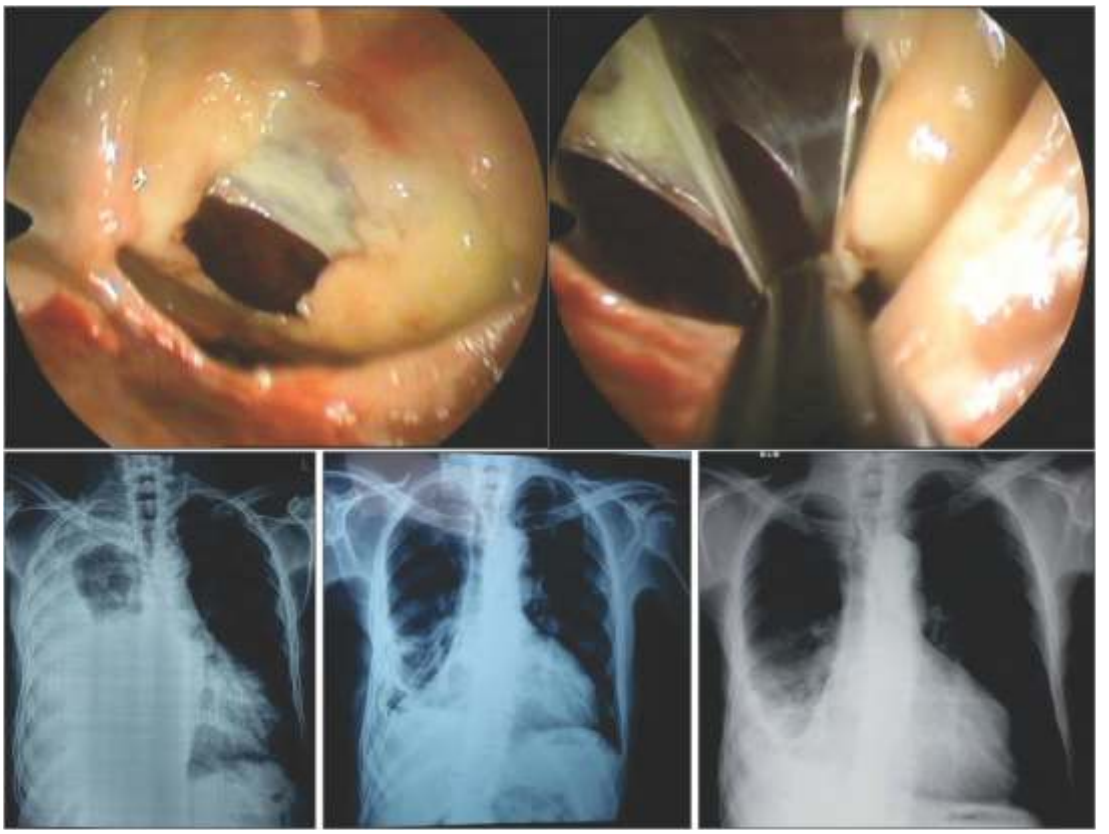

Figure.6. Top: Thoracoscopic images showing thick pleural adhesions (left) and adhesiolysis (right) in a 70-year-old male with thoracic empyema, having advanced renal disease and stable coronary heart disease (EF 30%); Bottom: Serial of chest radiographs of same patient with large multiloculated pleural effusion/empyema (left), post medical thoracoscopic adhesiolysis (middle) and follow up after 2 weeks (right) showing right lower zone opacity (pleural thickening on ultrasound).

Contraindications

Absolute:

Uncorrectable bleeding disorders.
Extensive pleural adhesions.
Severe cardio-respiratory compromise.
Inability to tolerate a pneumothorax.

Severe pulmonary arterial hypertension.

Relative:

Intractable cough.

Hypoxemia.

Inability to lay supine.[4, 24]

Requirements

Following are the basic requirements for performing medical thoracoscopy: [24, 25]

An endoscopy/bronchoscopy suite (figure 2).

Operation table.

Area for surgical scrubbing, sterile gowns, sheets, and gloves.

Mayo stand/surgical trolley covered with sterile sheets for placing instruments.

Monitoring equipment including pulse oximeter and blood pressure apparatus.

Full resuscitation facilities including defibrillator and crash cart with necessary equipment like laryngoscope, endotracheal tubes and medication like epinephrine and atropine etc.

Illuminators for radiographs.

Oxygen source and portable oxygen cylinders.

Ultrasound machine.

Needles – 24G and 21G for the administration of local anesthetic agents.

5, 10- and 50-ml sterile syringes.

Surgical swabs.

Scalpel and disposable blades.

Clamps.

Grasping forceps and a swab holder.

Diathermy to divide adhesions and control hemorrhage.

Sterile covers for the cables used to attach the optics and camera to the lighting source.

Plastic sterile aspiration tubes, 4 and 6 mm in diameter.

Suction tubing and collection bottles of at least 2 liters capacity which can be connected to negative pressure.

Cupulas for local anesthesia (LA), hot saline – used to prevent fogging of the optics.

Chest tubes ranging from size 20 to 32 Fr and chest drainage bottles.

Major equipment (figure 1):

- Trocars: Metal (rigid scope) and plastic (semirigid scope) with different sizes.
- Flexirigid pleuroscope (figure 2) or rigid thoracoscope/telescopes (figure 1); 0-degree telescopes used for direct viewing while oblique 30- and 50-degree, and 90-degree telescopes offer a panoramic view of the pleural cavity. Thoracoscopes (7 mm or 10 mm) offers a single point of entry (working channel) for suction catheter, grasping forceps, and coagulating forceps.

- Video camera and light source are attached to the eye piece and light transmission portion lens of telescope respectively. Image capturing and video recording facilities should be available so that proper medical record of the patient can be maintained.
- Biopsy forceps: 3 and 5-mm optical biopsy forceps are used during the procedure.

2 well trained staff nurses (or trainee doctors) including a scrub nurse and the second one to monitor patient and give procedural sedation and analgesia.

Prerequisites of the Procedure

Although MT is a simple procedure, the interventionist must possess a sound knowledge of surface landmarks and pleural anatomy. He/she should be familiar with the instruments and their handling. It must be checked prior to starting the procedure that all necessary equipments and drugs are in hand. Under water chest drains should be prepared before starting the procedure and electrocautery equipments should be ready. Sterility of the operating room and equipments should be well maintained.

Patient information and consent:

As with all other medical procedures fully informed written consent should be obtained from the patient or accompanying close relative (if the patient is unable to give consent). Thorough discussion should be considered regarding the procedure, its likely benefits, risks and potential complications.

Patient's pre-procedural assessment:

Proper history and examination is mandatory prior to the procedure. Keep patient's comorbid illnesses in view and take a full drug history (especially antiplatelet drugs). All co-morbidities should be well controlled. Great care should be exercised for patients with hypoproteinemia, malignant involvement of the chest wall, and poor functional status. Procedure should be postponed if patient has uncontrolled cough as excessive coughing may lead to subcutaneous emphysema.

As opioid medications are needed during the procedure patient should be advised nil per oral (NPO) 2-3 hours before the procedure as they delay gastric emptying. Patient's vital signs and oxygen saturation should be recorded before the procedure and an intravenous line should be secured.

Pre-procedural investigations:

All patients enlisted for medical thoracoscopy should have the following basic investigations (table 1) done prior to the procedure:

Premedication for thoracoscopy:

- Prophylactic antibiotics are not recommended routinely but they must be used in patients with asplenia, prosthetic heart valves, prior endocarditis or in patients with empyema as part of treatment.
- Oral anticoagulants (warfarin, rivoroxaban) should be stopped at least 3 days before the procedure.

- Clopidogrel should be stopped at least 5 days prior to the procedure.
- Aspirin can be continued.
- Discuss regarding discontinuation of anticoagulants or antiplatelets with the cardiologist if the patient has any strong indication for their use.
- Patients should be encouraged regarding early mobility and physiotherapy but if the patient is immobile due to any reason venous thromboembolism (VTE) prophylaxis should be given.
- Bronchodilators, antibiotics and corticosteroids are continued if the patient is already taking these before the procedure.
- To prevent vasovagal shock atropine 0.4 – 0.8 mg S/C or I/M can be used prior to or during the procedure.
- During procedure SpO_2 should be maintained > 92%; and most patients receive supplemental oxygen.

Table 1. Pre-thoracoscopy investigations.

Investigations	Comments
Complete blood count	Hemoglobin should be more than 8g/dL Platelet count should be >60,000/mm^3 Manage pancytopenia prior to enlisting for the procedure.
Renal function tests and blood glucose	All these should be optimized before the procedure.
Coagulation profile	INR should be less < 1.2
Arterial blood gas analysis	Important in patients who are in respiratory distress/failure. Care should be taken if $PaCO_2$ is > 55 mmHg.
Electrocardiogram	Recent angina, myocardial infarction and arrhythmias are contraindications to the procedure.
Chest X-ray	Pre-procedure CXR PA and lateral view helps in localizing the diseased area and screen the status of contralateral lung. Post-procedure CXR helps in comparison regarding success of the procedure.
Ultrasound chest	On site thoracic ultrasound before the procedure to localize the safe entry point and avoid trauma to other organs like diaphragm or lung.
CT scan chest	This may give clue to the underlying etiology of the disease process, like nodules, lymphadenopathy, pleural loculations and thickenings. Can assist in selection of entry point/s for MT.

Table 2. Medications used for procedural sedation and analgesia during thoracoscopy.

Drug	Dose (adults)	Onset of action	Duration of action (nonelderly adults with normal renal and liver functions)	Comments
Midazolam	0.02-0.1 mg/kg IV initially; if further sedation is required, may repeat with 25% of initial dose after 3-5 min; not to exceed 2.5 mg/dose (1.5 mg for elderly persons) and 5 mg cumulative dose (3.5 mg for elderly persons)	1 – 2 min	30 – 60 min	Respiratory depression or hypotension may occur, particularly when rapidly administered or combined with fentanyl (may need to decrease midazolam dose); does not provide analgesia; action reversed by flumazenil
Morphine	0.05 to 0.1 mg/kg/dose IV, may repeat dose in 5 minutes	5 to 10 minutes	20 – 60 min	Respiratory depression, Drowsiness or hypotension can occur; action reversed by nalaxone
Nalbuphine	10 – 20 mg/70kg IV/IM/SC	15 min (IM) 2 – 3 min (IV)	3 – 6 hours	Not to be used in patients with bronchial asthma; may cause respiratory depression; cause hypotension
Fentanyl	1-2 mcg/kg slow IV push (over 1-2 min); may repeat dose after 30 min	1 – 2 min	30 – 60 min	May cause chest wall rigidity, apnea, respiratory depression, or hypotension; elicits minimal cardiovascular depression; may cause dysphoria, nausea, vomiting, or EEG changes; actions reversed by naloxone
Etomidate	0.1-0.2 mg/kg slow IV push over 30-60 sec	< 1 min	3 – 5 min	Commonly causes myoclonus, pain upon injection, adrenal suppression; may cause nausea, vomiting, and lower seizure threshold; does not alter hemodynamics; causes a slight to moderate decrease in intracranial pressure for a few minutes; does not cause histamine release; useful for patients with asthma and hypotension
Propofol	0.5-1 mg/kg IV loading dose; may repeat by 0.5-mg/kg increments q3-5 min	< 1 min	3 – 10 min	Has anticonvulsant properties; can rapidly cause deep sedation; causes cardiovascular depression and hypotension

Procedural Sedation and Analgesia

The procedure is done under “conscious sedation”, now more commonly known as “procedural sedation and analgesia (PSA)”. It is defined by the American College of Emergency Physicians (ACEP) as "a technique of administering sedatives or dissociative agents with or without analgesics to induce a state that allows the patient to tolerate unpleasant procedures while maintaining cardio-respiratory function". PSA is intended to result in a depressed level of consciousness that allows the patient to maintain oxygenation and airway control independently. The drugs used for procedural sedation and analgesia are enlisted in table 2 below; the most commonly used agents are midazolam with or without fentanyl or morphine. Commonly used reversal agents and their doses are given in table 3 below.

Table 3. Commonly used reversal agents during thoracoscopy.

Reversal Agent	Indication	Adult Dose	Comments
Naloxone	Reverses opioids	Postanesthetic or opioid dependent: 0.1-0.2 mg IV; may repeat q2-3min prn until desired response occurs. Opioid overdose: 0.4-2 mg IV; may repeat q2-3min prn	Onset of action for IV is 1-3 min vs 10-15 min for IM; rebound sedation may occur; if used in patients with chronic opioid use, will precipitate acute withdrawal and abrupt sympathetic discharge possibly leading to acute pulmonary edema
Flumazenil	Reverses benzodiazepines	Partial antagonism (for sedation reversal): 0.1-0.2 mg IV infused over 15 sec; may repeat after 45 sec and then every min; not to exceed total cumulative dose of 1 mg. Complete antagonism (for overdose): 0.2 mg IV infused over 30 sec; may repeat 0.5 mg over 30 sec at 1-min intervals; not to exceed a total cumulative dose of 3 mg	Rebound sedation may occur; if used in patient with chronic benzodiazepine use, will precipitate acute withdrawal; may precipitate seizures unresponsive to benzodiazepines

Thoracic Ultrasound Prior to Medical Thoracoscopy

One of the main reasons of inability to perform a good thoracoscopy is failure to select the safest site of entry into the pleural space. This can be secondary to pleural adhesions, minimal pleural effusion or prior pleurodesis. [26] Thoracic ultrasound (TUS) use prior to thoracoscopy allows the thoracoscopist to identify the safe access site, apprehend any procedural difficulties he/she may face during the procedure, reduce the risk of complications and length of hospital stay. Ultrasound examination reveals the nature of pleural effusion and helps in applying the right management strategy. The following TUS characteristics may be seen:

- **Anechoic effusion:** It appears as black area between visceral and parietal pleura. This may be a transudate or an exudate (transudates are always anechoic and half of the exudates are also echo free). May require drainage depending upon the pretest probability of an underlying disease.[27]
- **Echogenic effusion:** It appears as cloudy or echogenic area between visceral and parietal pleura (figure 7). This may an exudative effusion (a complicated PPE or empyema) and needs tube thoracostomy along with management of the cause, infective or malignant etc. Diffusely echogenic effusions are usually hemorrhagic or empyema, while if there are swirling particles seen they can be due to high protein content, fibrin or blood.[18, 26,27]
- **Septated or multiloculated effusion:** It appears as echogenic or hypoechoic areas interspersed in between linear threads of fibrin giving honeycomb or spider web appearance; or there may be free fluid seen having fibrin bands which have to-and-fro motion on TUS. These septations are best visualized by ultrasound (figure 7) having high sensitivity compared to CT. The lung is seen collapsed and trapped in between the septations. Earlier in the course of disease, medical thoracoscopy may aid in the diagnosis as well as adhesiolysis in these situations. [18, 26]
- **Other important findings** which can be of help for a thoracoscopist apart from identifying a good entry site are visualization of pleural or diaphragmatic thickening, pleural or diaphragmatic nodularities (figure 7) and later success of medical pleurodesis. [27]

During the medical thoracoscopic procedure, on-site-thoracic-ultrasound can help visualizing complete evacuation of the pleural space and removal of all loculations, setting the lung free to expand. Post-procedure thoracic ultrasound helps in ongoing assessment of complications like re-accumulation of pleural fluid, air leak or trapped lung.

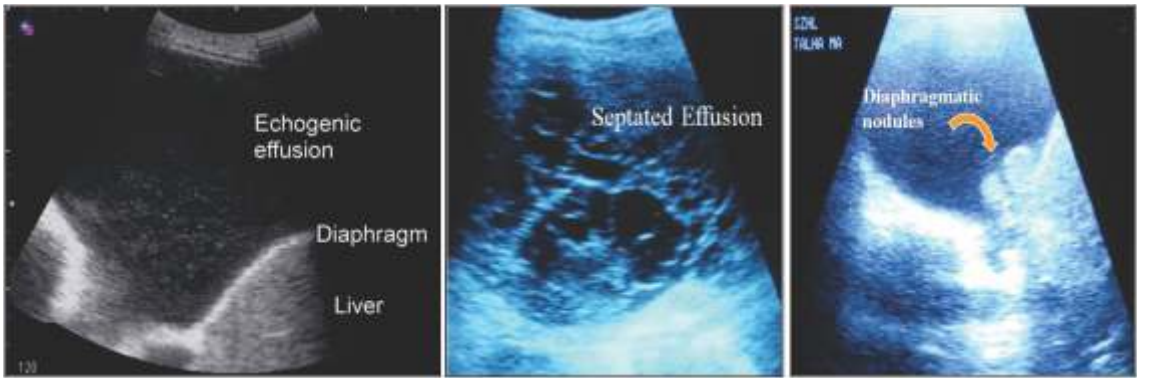

Figure.7. Ultrasound images showing chest wall on the top, echogenic pleural effusion in the middle and diaphragm and liver below (left sided image);
septated effusion (honeycomb or spider web appearance) in a patient with multiloculated (thoracoscopically confirmed) empyema (middle image);
malignant pleural nodules (thoracoscopically/biopsy confirmed) over the diaphragm (right sided image).

The Procedure

MT is performed using standard surgical sterile technique and drapes, gowns, and gloves. Thoracoscopic procedures typically performed under local anesthesia are inspection of the pleural space, removal of pleural fluid, biopsy of parietal pleura, and talc pleurodesis. The complete procedure is explained step by step below with illustrations (figure 8).

1. Patient's positioning:

Patient is kept in the lateral decubitus position with the affected side up. It should be confirmed by examination, checking radiographic and ultrasound images. Rest the patient's head on the pillow and hands in front of his face. Keep patient as comfortable as possible. A pillow can be placed under the patient's chest thus arching the vertebral column to help spread the contra-lateral ribs, making it easier to insert the trocar.

2. Skin preparation:

On site chest ultrasonography should be used to locate the safest and most appropriate site of trocar insertion. Ultrasound-guided selection of the entry point may optimize the chance for success by avoiding adhesions and may reduce trocar access failures and pneumothorax rates.[26, 28] For pleural inspection, the mid-axillary line of the 4th or 5th intercostal space is preferred since it allows optimal inspection of the pleura. Aseptic measures are of utmost importance. The skin over the examining side and axilla should be prepared with an alcohol-based skin sterilizing solution (e.g povidone iodine). A sterile drape should be placed over the patient, having a small uncovered area (through eye sheet) through which the procedure can be performed.

3. Local anesthesia and site of entry:

At the specified point of entry local anesthesia is induced by 10-20 ml of lidocaine 1-2% (maximum dose 3mg/kg body weight). Lidocaine can be combined with 1: 100,000 adrenaline (epinephrine), this preventing blood from oozing onto the thoracoscope tip and hampering vision. The correct method is to first make an intra-dermal anesthetic bleb and then proceed with infiltration of the soft tissues, intercostal muscles, parietal pleura and rib periostium. If there is pleural effusion aspiration of pleural fluid can be done at this stage for confirmation of appropriate site. Following local anesthesia, procedural sedation is administered usually utilizing a combination of intravenous narcotic [morphine (2mg) or fentanyl (25 mcg)], plus a benzodiazepine [usually midazolam (1-2 mg)], for analgesia, sedation, and amnesia. If propofol is used instead of a benzodiazepine, it is recommended to be used only in the presence of an anesthesiologist or a trained nurse anesthetist. In author's experience sedation may be avoided altogether in patients with advanced liver or renal disease.

4. Introduction of trocar and thoracoscope:

A small 1 cm incision is given in the orientation of the ribs usually at the level of upper border of the lower rib. This follows blunt dissection through the soft tissues and intercostal muscles using artery forceps (hemostat). Slight pressure is placed on the hemostat and it is slowly moved

through the intercostal space until it 'gives way' through the intercostal muscle-parietal pleura complex followed by emergence of pleural fluid. It is safer to create a hole using index finger and passing it into the pleural space to check for adherence of lung with the chest wall due to adhesions. With creation of hole in the intercostal space, air enters the chest cavity with inspiration. The lung will deflate slightly using this method. Gently introduce trocar into the pleural cavity.

5. Induction of pneumothorax:

Safe procedure requires sufficient space between the lung (visceral pleura) and chest wall (parietal pleura). Sometimes, there is minimal pleural effusion/ dry pleura and visible pleural based nodules/disease on CT thorax (figure 4). In such circumstances, a pneumothorax must be induced to create a safe space to insert the trocar and thoracoscope in to the pleural space.[5] This can be done using the Boutin needle; the sharp 'cutting' outer needle is used to penetrate through the chest wall, and the blunt inner needle is used to puncture the pleura. The blunt inner needle is then removed and air should be heard to hiss in to the pleural cavity for confirmation. [24, 25] Alternatively angiocatheter can be used to access the pleural space and drain pleural fluid (if present); a pneumothorax is induced by leaving the angiocatheter open to air (air enters the pleural space naturally during respiration). Otherwise the same blunt dissection can be followed through intercostal space until the pleura is punctured and air gains entry with the induction of a pneumothorax.[25] Furthermore, a small suction catheter can be placed after dissecting open the pleura and asking the patient to take a few deep breaths to let the air to enter the pleural space thus pushing lung away from the chest wall.

6. Visualization of pleural cavity:

After introduction of trocar, semirigid pleuroscope is introduced in the pleural space through the trocar and suctioning is done to remove the pleural fluid. During aspiration allow entry of air into the pleural space to minimize rapid lung re-expansion and hence the risk of pulmonary edema. In case of rigid pleuroscope use, a suction catheter is introduced though the trocar and almost all pleural fluid suctioned out. The trocar cannula of rigid scopes contain a sealed side port which can be transiently opened to introduce air during suction of pleural fluid so the lung remains collapsed thus minimizing chances of re-expansion pulmonary edema.

After introduction of thoracoscope, the pleural cavity is visualizedmaneuvering the telescope in a methodical manner. The scope is slowly maneuvered from apex to diaphragm and medially towards the hilum so that the entire parietal pleural surface is examined. Visceral pleura covering the lung is also examined for the presence of any abnormalities. Identify fibrin membranes and detect loculations as well as possible neoplastic nodules, or intrapleural bubbling.

7. Adhesiolysis:

Adhesions, which may interfere with complete examination of the pleural cavity, can be lysed with either a blunt probe or cautery forceps or the thoracoscope itself (figure 5 and 6). Caution should be exercised to avoid vascularized adhesions and perforation of visceral pleura/lung.

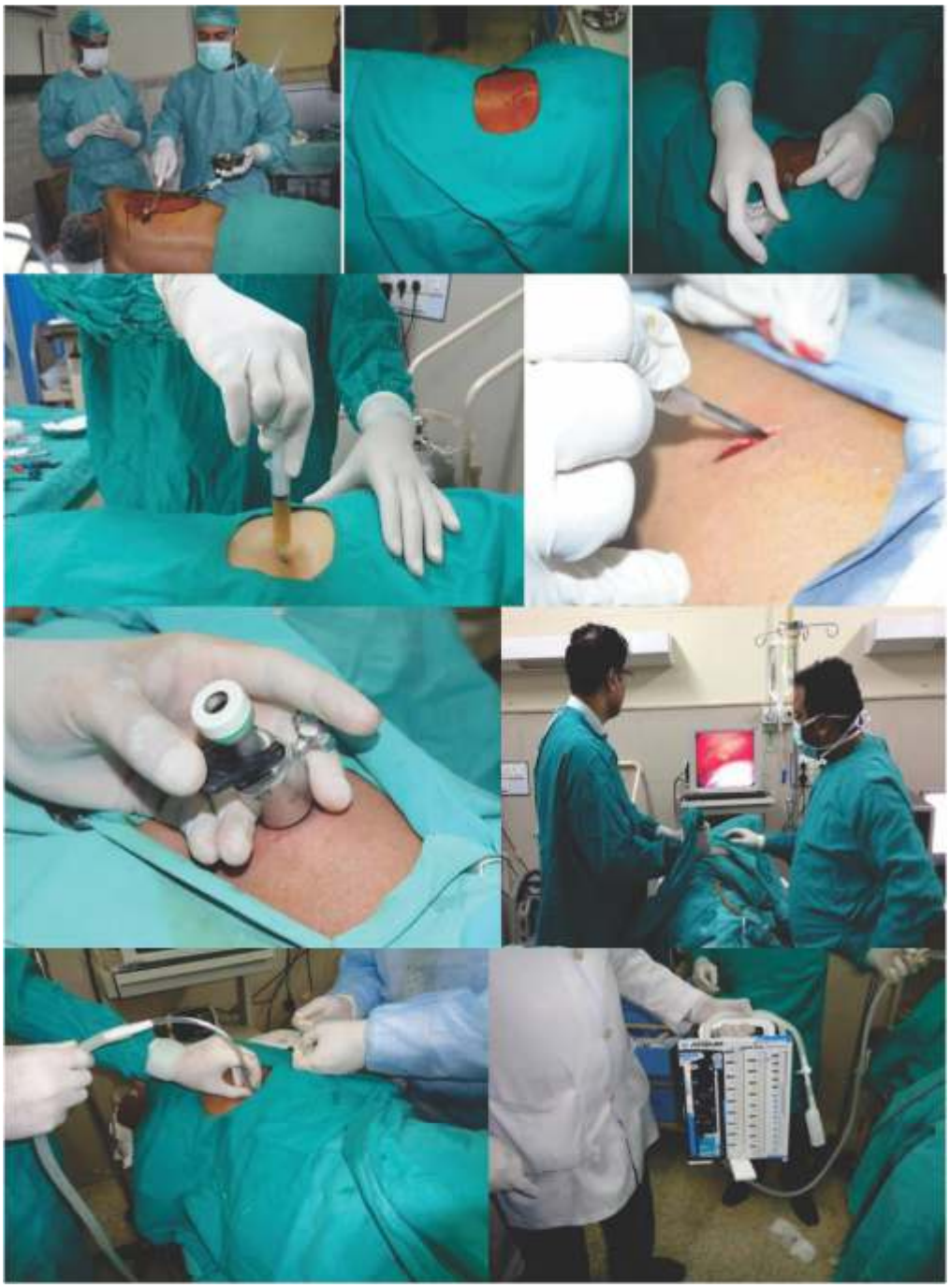

Figure.8. Top left to bottom right: povidone iodine painting on the affected hemithorax in a patient placed in lateral decubitus position, eye sheet placed over the chest leaving a small area to be operated, local anesthesia using lidocaine, confirmation of fluid aspiration, incision over the skin, insertion of trocar, thoracoscope insertion with image seen on the monitor, chest tube placement and attachment with the underwater seal bottle.

If cautery is available, then vascular adhesions may be cauterized before lysing. Rigid thoracoscope and rigid instruments are preferable for adhesiolysis.

8. Intrapleural lavage with saline:

In patients with empyema, flushing pleural cavity with saline and suctioning can make the pleural space clear of debris and allows better pleural visualization.

9. Taking parietal pleural biopsies:

Multiple pleural biopsies should be taken from suspicious areas under direct visualization. The forceps are opened, abnormal tissue grasped and forceps closed. Two methods used to biopsy pleura include 'grab and pull' (like in bronchoscopy) for nodular or polypoidal lesions and second technique is 'pinch and peel' especially when pleura contains flat lesions like in TB or malignancy (figure 9a). The forceps should be withdrawn in a "stripping" or "tearing" motion by slightly angulating the scope after the tissue has been grasped and then withdrawing the forceps. Specimens should be taken against the rib (after palpating with the biopsy forceps) to avoid injuring the intercostal neurovascular bundle. Once a small section of pleura is peeled always look at the initial site of biopsy to ensure there is no excessive bleeding. If excessive bleeding occurs and coagulation is required, a second port of entry should be made. Biopsies should be sent in formalin for histopathology and saline for TB culture. Other pleural biopsy methods include using an insulated tip diathermic knife and cryobiopsy.[29, 30]

10. Talc poudrage (optional):

Talc poudrage can be performed safely through a single portal MT with direct visualization of pleural surfaces being sprayed using spray catheter attached with atomizer. Alternatively, talc can be sprayed from a second port or the same port followed by reinsertion of the telescope to ensure that all pleural surfaces are sufficiently coated with talc. The goal is to obtain a light coating of talc on all pleural surfaces, both parietal and visceral, using a dedicated device and avoid mass collection of talc which makes the procedure inefficient. There is snow storm appearance during talc spray and pleura post talcage resembles the first light fall of snow (figure 9b).

11. Second port of entry (optional):

The clinician should decide in advance (looking at ultrasound or CT images) whether a single point or two points of entry will be required during a particular procedure. The second site of entry is created under direct video guidance (ie, with the telescope inside the pleural cavity) to simplify visualization or sampling of difficult to reach areas such as the costovertebral angle, mediastinal pleural surfaces, and the lung apex. A well-trained interventionist can quickly create a second point of entry if proper visualization of pleural cavity is not achieved by single port or if additional instrumentation is needed to facilitate adhesiolysis, take pleural biopsies (site not accessible through the single puncture procedure), talc pleurodesis and sometimes to coagulate bleeding regions.[5, 18]

12. Chest drain placement:

At the end of the procedure, a chest tube is placed, with a caliber large enough (>24 F) to remove remaining air and pleural fluid/dense and viscous pus and fibrinous debris. Attach chest tube with under water seal bottle. This can be performed, if necessary, under visual control. Apply sutures and a sterile dressing.

Complications

Sedation and analgesia-related — may include hypotension, hypoxemia, respiratory depression or arrest and arrhythmias.

Procedure-related — Procedure-related complications are mostly minor and range from 2 to 6 percent.[5, 24, 31, 32]

Pain — All patients experience some sort of pain ranging from mild to severe during or after the procedure. Vasovagal syncope can accompany pain. Pleural pain, cough and dyspnea may occur when fluid is rapidly suctioned.

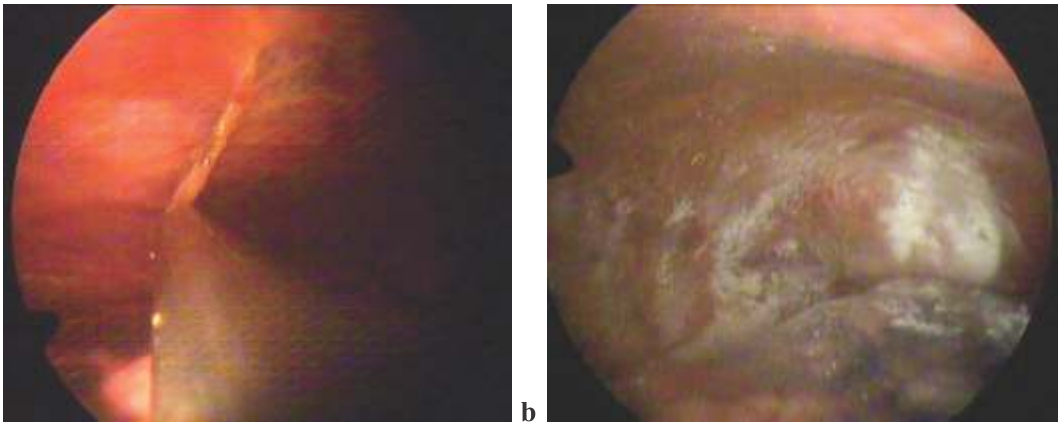

Figure.9. (a) Pinch and peel pleuroscopic biopsy in a patient with TB pleuritis and (b) post talc poudrage image showing dispersed talc particles on the parietal pleural surface.

A persistent air leak (>7 days) is likely to occur when the visceral pleura or lung is injured or biopsied.

Laceration of the lung may occur during insertion of the trocar or scope if lung is adherent to chest wall.

Subcutaneous emphysema usually occurs at the time of trocar insertion and fluid suctioning during which time patient may experience excessive coughing leading to entry of air in subcutaneous tissues. Can also occur in case of excessive visceral pleural air leak in the presence of a bronchopleural fistula.

Fever — Fever is not infrequent particularly after talc pleurodesis and usually resolves within 48 hours.

Hemorrhage – Pleural hemorrhage is unusual since local hemostasis is achieved during the procedure but may be noted with chest tube drainage. It rarely necessitates re-exploration (significant hemorrhage requiring surgical support never occurred in author's experience).
Infections– Wound infection, pneumonia, and empyema are unusual.
Pleural-cutaneous fistula or broncho-pleural fistulaare rare complications.
Air embolism – An extremely rare serious complication.
Re-expansion pulmonary edema – Although large volumes of fluid can be removed, re-expansion pulmonary edema is rare, possibly due to the equilibration of pleural pressures when the pleural space is open to air.
Tumor seeding at portal site– Possible in patients with malignant pleural mesothelioma.
Death is rare, ranging from 0.09 to 0.34 percent.[33, 34, 35]

Prevention of Complications

- Use ultrasound for getting safe access site.
- Insert a chest tube (at least till the lung expands) to prevent subcutaneous emphysema.
- Mobilize the patient and start physiotherapy (incentive spirometry, breathing exercises and cycling) on the day of thoracoscopy to facilitate lung expansion, exercise the diaphragm & avoid accumulation of secretions & obstruction.
- Postpone thoracoscopy if patient is excessively coughing and try minimizing it.
- Measure blood gases & monitor cardiac status by simultaneous ECG.
- Oxygenate the patient during thoracoscopy.
- Avoid taking biopsy samples from internal parts of the fissures or from mediastinum.
- Coagulate & ensure hemostasis if hemorrhage occurs.
- Apply external suction if lung is collapsed post procedure at -10 to -20 cmH_2O.
- Daily PA chest radiograph to identify position of drain, look for lung expansion and any complications like pleural collections or subcutaneous emphysema.
- Remove drain if underlying lung remains collapsed (entrapped/trapped) and does not at all expand after 3 days of external suctioning and physiotherapy to reduce the occurrence of empyema that will further deteriorate the condition/quality of life of a patient with a pleural disease like malignancy.
- Have a close liaison with thoracic surgery team and consider early referral in case of failure of medical thoracoscopic intervention or in case of complications like uncontrollable hemorrhage.

Post-Procedural Care

Drain management:

Gentle step by step suction should be applied to the chest drain post procedure for gradual lung re-expansion. Daily drain output should be recorded precisely. Chest tube removal should be considered when fluid/clear fluid (not pus in patients with empyema) drainage falls below 150 ml/day, there is no evidence of air leakand the lung is fully

expanded to the chest wall.[4, 33, 36] Tubes sometimes require saline flushing or intrapleural fibrinolytics to address smaller post procedural collections and removal of debris.[37] In such circumstances, tubes should not be disconnected from under water seal bottles, rather interconnecting valves with injection ports should be placed between chest tube and underwater seal bottle. This helps to prevent post-procedural pleural infection/empyema.

Post-thoracoscopy pain management:

Depending on patient's pain threshold, pain is common following MT. It can be controlled in most cases with the use of paracetamol or nonsteroidal anti-inflammatory drugs (NSAIDs). In patients where the pain is inadequately controlled by mild analgesics, other methods should be used, for example, intravenous analgesics (NSAIDs/opioids).

Post-procedure physiotherapy(figure 10)**:**

Patients should be encouraged to be mobilized before MT and avoid excessive bed rest to reduce the onset of deconditioning and physical dependence. Post-procedural physiotherapy is frequently needed in patients with thoracic empyema in the presence of collapsed/folded lung. Mobilize the patient (corridor walking) and start physiotherapy preferably on the day of thoracoscopy to facilitate lung expansion, improve configuration of diaphragm & avoidance of secretions accumulation & tube obstruction. Benefits include facilitation in re-expansion of the lung and clearing of the fluid, cardiovascular stability, wound healing, regaining the arm and trunk movement, maintenance of good posture and conditioning of muscles with improved exercise tolerance and confidence.[38]

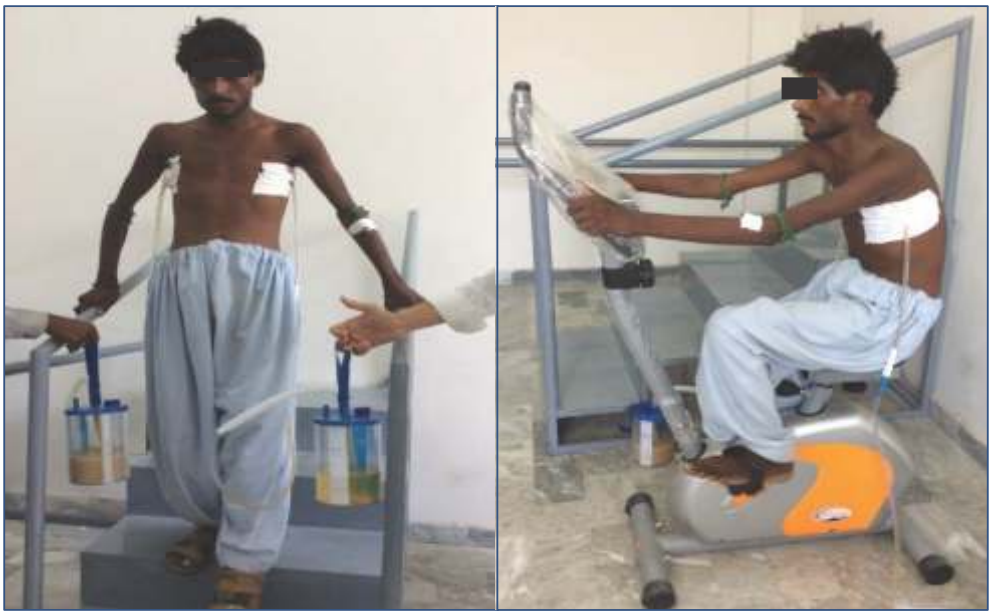

Figure 10. A patient with bilateral empyemas undergoing post thoracoscopy physiotherapy using stair stepper and cycling exercise.

Patients' Follow Up

Follow up visits depend on the underlying disease state and thoracoscopic intervention taken place during hospitalization. Patients having empyema who underwent MT for adhesiolysis may require early follow up within 1-2 weeks to look for any recurrence of fluid collections. Patients with malignant pleural diseases may be consulted again after 2-4 weeks to look for sustained success of the procedure (talc pleurodesis) or occurrence of effusion on the contralateral side. Follow up visits also ensures evaluation of any late complications of the procedure. If symptomatic, patient should be advised to follow up immediately.

Conclusion

MT is a safe and easy to learn procedure but like all technical procedures, there is a learning curve before full competence is achieved (figure 11).[6, 7] Currently, its predominant use in endoscopy room is diagnostic with some extension into the therapeutic roles, compared to surgeon-led VATS carried out in the operating room under general anesthesia.[4] As progress continues in both fields, and as pulmonary physician's thoracoscopic experience broadens, it is presumed that some pleural techniques currently performed by surgeons will come under the domain of pulmonologists.[39]

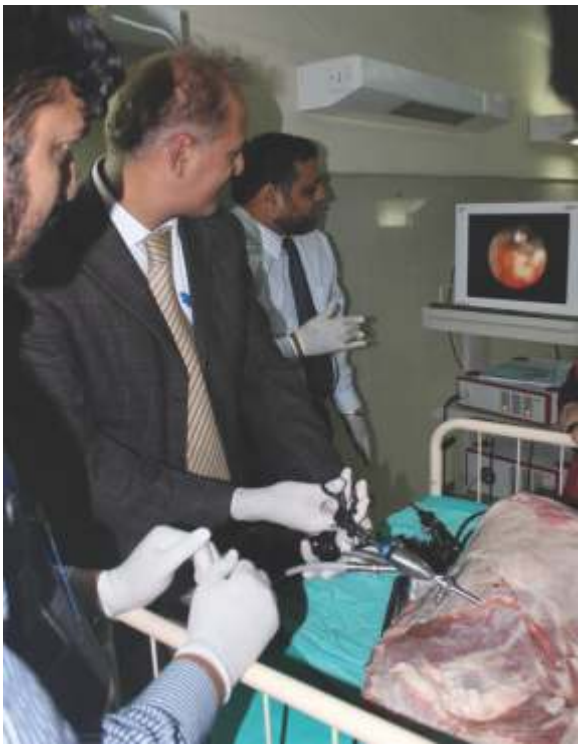

Figure 11. Simulation training using cadaver sheep chest during a course on medical thoracoscopy; rigid thoracoscope is introduced in the sheep thorax with imaging on the monitor, mounted on trolley equipped with light source and video processor.

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