Review Article

‘Pandora’s box’ of the developing world-perioperative implications of pulmonary infections

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Abstract: Infective pathologies of the lung such as tuberculosis, aspergillosis, hydatid cyst, empyema thoracis etc. are quite prevalent in the developing countries of the world and their sequelae are the norm rather than the exception. Poor financial resources and lack of adequate healthcare facilities in the third world add to the compendium of healthcare problems faced by the general population. They have their unique share of pulmonary diseases not otherwise encountered routinely in the western world. Lack of screening facilities allows these diseases to progress unnoticed. Often the first presentation in the hospital is when the disease has advanced and the management is challenging. A significant percentage of these patients are then referred to the thoracic surgeon for definitive management. These include chest drain insertion, thoracoscopy, decortication, segmentectomy, lobectomy or pneumonectomy. Lung isolation and management of one lung anaesthesia are fundamental to thoracic surgery practice. But trained thoracic anaesthesiologists with expertise in dealing with such high-risk procedures and physicians with good ICU backup to look after the patient during the perioperative period are mainly concentrated in the large government and private hospitals of metro cities. Smaller hospitals and cities do not have access to a good thoracic surgeon. General surgeons perform most thoracic procedures. Due to mismatch of equity, straightforward cases that can be managed surgically are management conservatively with a trial of medical therapy. Referral for surgery is delayed leading to advanced cases with irreversible lung damage. Our article deals with the problem of infective pathologies of the lung especially in reference to the developing world and their perioperative management concerns and the role of video assisted thoracic surgery in such scenarios.

Keywords: Pulmonary infections; tuberculosis; empyema; aspergillosis; video assisted thoracic surgery (VATS); anaesthesia

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Case scenario

In the year 2012, a 10-year-old child with post tubercular lung pathology along with an intra cavitary aspergilloma in the right upper lobe was admitted under our care. He was scheduled for right upper lobectomy by video assisted thoracic surgery (VATS). Standard anaesthetic induction was planned followed by lung isolation with a 28 F double lumen tube (DLT). As we began mask ventilation post anaesthesia induction, the child started to desaturate, with increasing resistance to bag mask ventilation. Lung auscultation revealed bronchospasm and

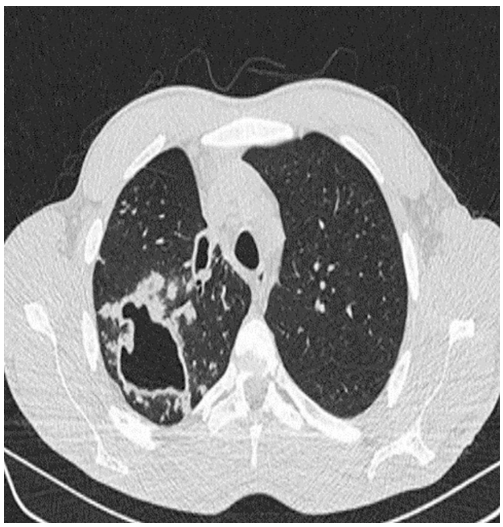

Figure 1 Tubercular cavitary lesion.

bilateral crepitations. SpO_2 decreased to 85% which was initially refractory to bronchodilator therapy, intravenous steroid and deepening the plane of anaesthesia with FiO_2 1. Gradually after 5 minutes time, SpO_2 showed signs of improvement and reached 100% with FiO_2 1. We intubated the trachea with DLT and inflated both the cuffs. SpO_2 remained between 90–100%. Bronchoscopy revealed soiling of the left lung field. A provisional diagnosis of spillage of the right upper lobar cavitary contents was made and broncho alveolar lavage was done in an effort to clean the bronchial tree. A decision was made to go ahead with the scheduled surgery as this was the best option for the child. The child had a stormy intraoperative course as one lung ventilation was replaced by intermittent low tidal volume two lung ventilation. The child was shifted to the ICU with the DLT *in situ* and he was kept on ventilatory support. He had a protracted post-operative course. This was a learning experience for us. Unfortunately, the child in the reference case is just the tip of the iceberg of large number of patients with similar pathologies. We often receive patients with such lesions from peripheral hospitals as there is a dearth of equipment, facility and trained thoracic anaesthesiologist and surgeons at such places. Occasionally, procedures have to be abandoned in these facilities at times even after anaesthesia induction as distorted bronchial anatomy precludes lung isolation. Fortunately, most of the times these patients are well managed in the high volume thoracic surgery set ups. However, complex infective pathologies and their sequelae make these surgeries and their anaesthetic management quite challenging.

Common pulmonary infective conditions presenting for thoracic surgery

A 2012 study published in Lancet observed that one of the leading causes of death in developing countries of the world is respiratory infections including tuberculosis (1). World Health Organization's 2012 estimate of tuberculosis infection stands at 8.6 million with a fatality of 1.3 million primarily in sub-Saharan Africa (2). India is endemic to tuberculosis with a very high mortality rate of approximately 1,000 individuals per day (3). Multidrug resistant tuberculosis is a growing problem, with about 450,000 new cases in 2012 that contributed to 170,000 deaths (4). Likewise, Aspergillus sensitization and allergic bronchopulmonary aspergillosis also have a very high prevalence in India (5,6). Unfortunately the health sector budgetary allocation in developing countries is not adequate (7).

Tuberculosis

Traditionally thoracic surgery was concentrated on management of tuberculosis (8,9). The magnitude of impact of tuberculosis on mankind was huge and techniques for surgical removal of the diseased lung and obliteration of cavities in the chest were developed to tackle these problems. Role of the surgical team in tuberculosis is mainly for diagnostic purpose, excision of troublesome disease in drug resistant cases, symptomatic relief in haemoptysis, empyema or recurrent chest infections or to deal with one of its long-term sequelae. But, even going by the advances of modern day healthcare, thoracic surgery in case of complicated tuberculosis is quite challenging for the surgeon as well as the anaesthesiologist. Takeda *et al.* identified aspergillus coinfection, major preoperative comorbidity, long duration of surgery, need of blood transfusion and male gender as risk factors for adverse perioperative outcomes (10). Worldwide, VATS has shown promising results and thoracic surgeons are increasingly confident of the fact that tuberculosis is not a contraindication for VATS. VATS intervention is quite effective in reducing the mortality and morbidity of tubercular sequelae of lung (*Figure 1*). As a precautionary measure, the preoperative team should take a serious note of any haemoptysis as it can be life threatening at times as the dead space volume of 150–200 mL can be easily filled by blood compromising the airway (11). Establishing the site of the haemoptysis is also important to decide upon lung isolation and bronchoscopy.

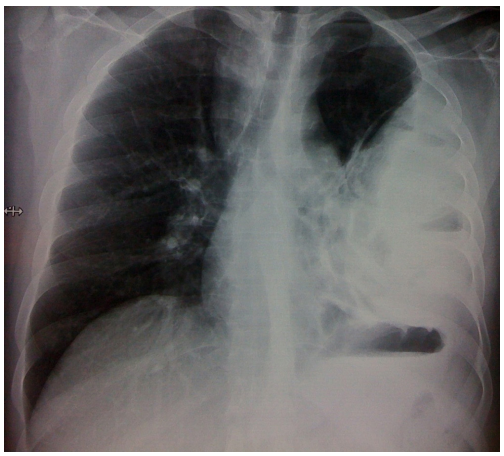

Figure 2 Empyema thoracis: before VATS.

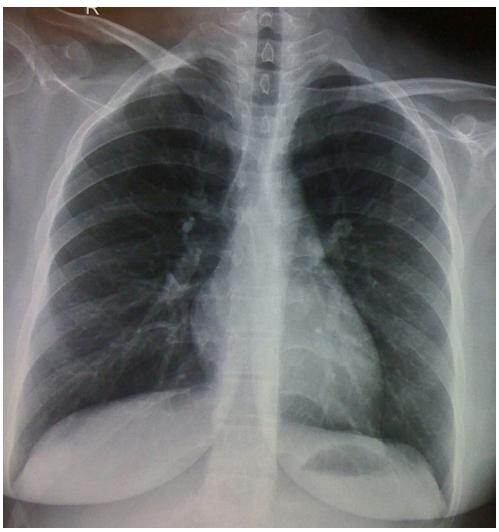

Figure 3 3 months after VATS decortications.

Figure 4 Aspergillus infection of the lung.

Figure 5 Lung tissue showing aspergilloma infection.

In areas where conventional lung isolation facilities are unavailable, anesthetist can advance a single lumen tube into the healthy side and continue with volume resuscitation process. The patient can then be shifted to a higher set up for definitive treatment like surgery or bronchial artery embolization.

Empyema thoracis

Empyema thoracis (*Figures 2,3*) can be a complication of pneumonia, tuberculosis or various iatrogenic pulmonary interventions. Despite widespread use of highly effective antibiotics, chronic empyema thoracis (CET) is common worldwide. Corrective procedures like tube thoracostomy, image directed catheters, thoracoscopic drainage, decortication and open drainage have all been employed with success rates varying between 10% to 90% (12). VATS has shown promising results in decortication and adhesiolysis. Perioperative bleeding and air leak are the main concerns in extensive adhesiolysis and decortication. Modern electronic chest drainage systems with suction capability are a boon as it gives the estimate of air leak, drain, helps in lung expansion and early mobility. Talc pleurodesis is employed in an effort to prevent recurrence in patients with repeated effusions.

Aspergillosis

Pulmonary aspergillosis can manifest as invasive aspergillosis, allergic bronchopulmonary aspergillosis (ABPA) or cavitary pulmonary aspergillosis (*Figures 4,5*). In tuberculosis endemic countries of the world, the healed tubercular cavities act as the much needed nidus for saprophytic colonization of Aspergillus fumigatus. The fungal toxins erode the tissues and can cause haemoptysis when a vessel

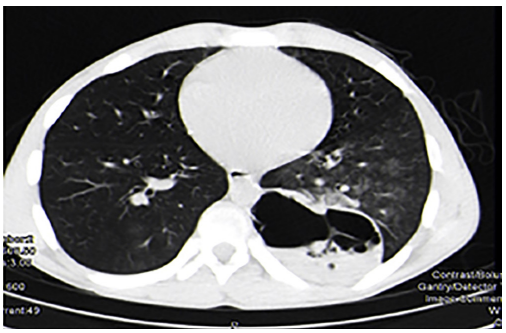

Figure 6 Hydatid disease of the lung.

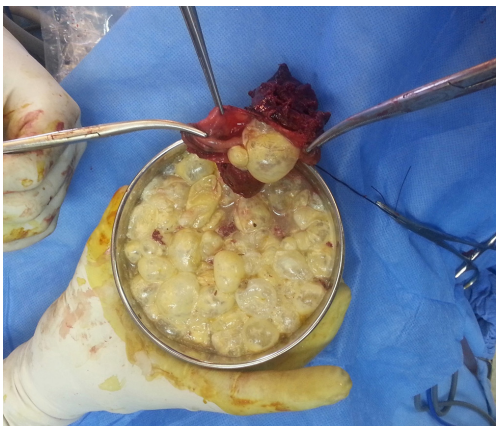

Figure 7 Echinococcus multilocularis.

wall is eroded. Presence of the characteristic fungal ball with 'air crescent' in chest X-ray or CT scan clinches the diagnosis. Surgery in the form of pulmonary resection is the mainstay of treatment although intraoperative period can be complicated by dense intra-pleural adhesions, hemorrhage, air leak, disruption of cavity and seeding of the fungus with high morbidity (13-15). Surgical mortality ranges from 0% to 22.6% and reported recurrence rate is 5% (16).

Hydatid cyst

Hydatid disease is a caused by the larvae of Echinococcus. Clinical presentation of cystic echinococcosis (*Figures 6*,7) varies from asymptomatic disease to acute life threatening emergencies when cyst becomes infected or ruptures. Multiple organ systems may be involved including the brain, lungs, liver, peritoneum, bones, ovaries etc. (17-20). Surgery is the definitive method of treatment. Intraoperative leakage of cyst contents can lead to anaphylaxis and dissemination of infectious scolices causing pleural or bronchogenic hydatidosis. Scolicidal solutions like 1.5% cetrimide–0.15% chlorhexidine (10% Savlon), 3% hydrogen peroxide, 95% ethyl alcohol or 10% polyvinylpyrrolidone-iodine (Betadine) are routinely used along with intravenous steroid. Other non surgical techniques can be image guided percutaneous aspiration, infusion of scolicidal agents etc.

These images demonstrate that the degree of complexity of pulmonary pathology is very challenging in the developing world. Late presentation to the clinician and non compliance to treatment regime are the main causes of such complex case scenarios. Due to late presentation the disease distorts the pulmonary anatomy and physiology. Lung collapse, atelectasis, adhesions, loculated effusions, thick cortex for decortications are frequently encountered. The amount of perioperative blood loss and risk of septicemia are very high.

Our approach at Medanta

Preoperative preparation

Preoperative evaluation and optimization of thoracic surgical patients with sequelae of pulmonary infections should be a team effort amongst the anaesthesiologist, thoracic surgeon, pulmonologist, cardiologist, radiologist and intensivist. Proper planning, coordination and communication are vital for the best outcome.

In developing countries like India, the concept of preventive health checkup is not very common. So, the patient might not have undergone any baseline health checkup for decades. Apart from the routine investigations like complete blood count, coagulation profile, kidney function tests, chest X-ray, ECG etc. thoracic surgery patients need specific systemic evaluation. Liver function might be deranged following anti tubercular therapy. Pulmonary function testing with diffusion studies is a must due to the long standing nature of the pathological process and the possibility of major lung resection to assess the postoperative lung functional capacity. The risk of major blood loss and haemodynamic instability exists in thoracic surgery along with the cardiorespiratory burden of one lung ventilation. A low threshold for cardiac work up is maintained at our Institute considering the demographic profile of the population. Cardiac work up can vary between a simple 2-dimensional echocardiography, exercise stress testing to coronary angiography. Although routinely not done, the use of cardiopulmonary exercise testing (CPET)

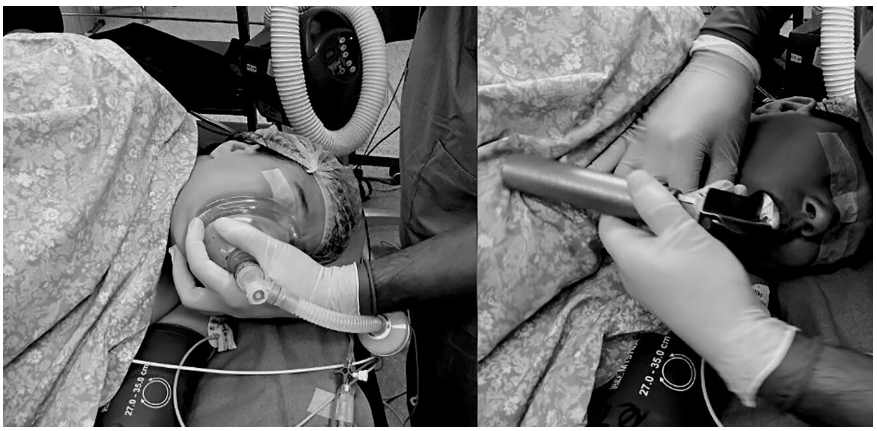

Figure 8 Mask ventilation and laryngoscopy in the lateral position.

can be a valuable aid in the perioperative risk stratification in selected group of patients. Ventilation perfusion scan in addition can give an insight into the functional contribution of various lobes and can predict the effect of lobar resection.

Adverse effects of surgery on lung and chest wall mechanics can predispose patients to atelectasis and respiratory infections. Preoperative attention to lung expansion maneuvers like incentive spirometry, deep breathing exercises go a long way in preventing post-operative pulmonary complications. In addition, continuous positive airway pressure (CPAP) therapy should be considered post operatively if necessary.

Pre-existing anemia because of nutritional deficiency, chronic pathology and haemoptysis are common. Extensive dissection also causes major perioperative blood loss, requiring infusions of large amounts of blood products. In our experience, a seemingly benign surgery like decortication can bleed around 800 mL on table and another 500-1000 mL thereafter from the raw surfaces. Adequate quantity of blood products therefore needs to be arranged beforehand.

Preparation for anaesthesia induction

As an additional measure to prevent spillage, we try to keep the affected lobe most dependent till the time the lobar isolation is complete. For this, careful patient and table positioning is required to prevent gravity dependent spillage. In this process, sometimes tracheal intubation in the lateral position might also be required (*Figure 8*). In our experience intubation in the lateral position is not very difficult in experienced hands. In fact, as the tongue falls down due to gravity, the laryngoscopic view is often better. However, in case of difficulty patient should be made supine immediately and managed further as per difficult airway guidelines.

Preoxygenation is a must in all such patients because of the poor pulmonary reserve. To avoid the risk of atelectasis with 100% oxygen, we generally preoxygenate with 0.8 FiO_2 (21). In potential cases of risk of spillage, adequate preoxygenation is followed by anaesthesia induction with use of succinylcholine or rocuronium as initial relaxant. Post induction, mask ventilation is not done. Once the DLT is secured and cuffs are inflated, only then gentle ventilation is started and tube is checked clinically. Final tube positioning and selective lobar isolation is carried out under fibreoptic guidance with blocker or Fogarty catheter. Once confirmed, nondepolarizing relaxant is continued.

Lung isolation and selective lobar isolation

Meticulous planning needs to be done on the mode of securing the airway and its segments. In this regard the anaesthesiologist and the surgeon need to arrive on a consensus, keeping in mind the best interests of the patient. A DLT is the basic lung isolation modality worldwide. In our experience, one area that needs to be addressed in any infective pulmonary pathology is the need for selective lobar isolation on top of standard left from right lung isolation. Sometimes the cavitary lesions of tuberculosis with or without aspergiloma growth communicate with the adjacent bronchial lumen and thereby risking the spillage of its contents to the adjacent lobe and beyond (22). The risk increases further during intraoperative handling. So, along

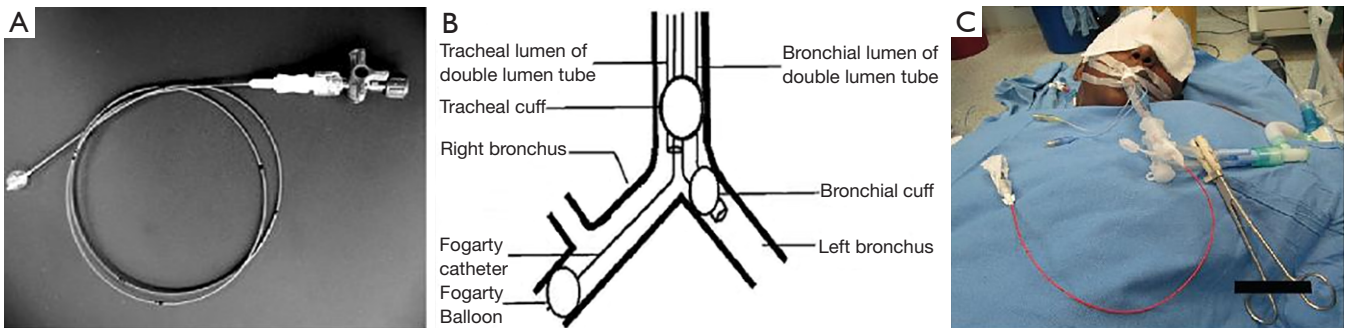

Figure 9 Selective lobar isolation. (A) Fogarty catheter showing the balloon tip; B) diagramatic depiction of the technique of selective lobar isolation; (C) placement of a Fogarty catheter through a double lumen tube.

with a DLT which basically isolates the lung, further lobar isolation can be done with the help of bronchial blockers (Coopdech by Smith Medical, Rosmalen, NL, Arndt bronchial blocker by Cook Critical Care, Bloomington, USA) or Fogarty Arterial Embolectomy Catheters by Edwards Lifesciences (23). For example, if the infected cavity is in the left upper lobe, than we can advance the blocker to that lobar bronchus and isolate it from the left lower bronchus. Likewise, a diseased right upper lobe can be isolated by a blocker placed beyond the bronchus intermedius (*Figure 9*). We routinely resort to selective lobar isolation in suspicious cases. These blockers are removed after thorough suctioning once the surgeon takes the lobar bronchus in the stapler.

Invasive lines and intraoperative monitors

Intraoperative use of invasive monitors like arterial or central venous lines is based on patient's co morbidities and anticipated volume shifts and loss. From an Indian subcontinent perspective, we tend to rely on a low threshold for invasive lines. Due to complexity of the cases, the duration of surgery and amount of blood loss is generally high. As a protocol we secure an arterial and a central venous line or two wide bore intravenous cannulae for any lung resection surgery beyond segmentectomy. Central venous line is generally not inserted in decortications. Risk of intraoperative arrhythmias is also high especially in the presence of anemia and extensive surgical manipulation due to adhesions. Correction of dyselectrolytemia is a must and antiarrhythmic drugs should be readily available. Advanced dynamic parameters like stroke volume, stroke volume index, cardiac output, extra vascular lung water, central venous oxygen saturation, systemic vascular resistance are helpful and their use should be encouraged in more and more thoracic surgeries (24-26). A word of caution here is that the variations in volumes like stroke volume variation will not be reliable in thoracic surgery or in situations of spontaneously respiration and arrythmias.

Pain management

In absence of contraindications, Paracetamol, nonsteroidal anti-inflammatory drugs and intercostal blocks or simple local infiltration of port sites are used as routine in VATS. Intravenous patient controlled analgesia (PCA) is tailored as per patient's requirement. In thoracotomies, a more intensive pain control modality like epidural or paravertebral block along with intravenous PCA should be used.

Risk to health care staff and precautions

Various infective conditions of the lung expose the healthcare staff at high risk of cross infection. Although tuberculosis patients coming for surgery are rendered non infectious after couple of weeks to months of antitubercular medicines, an occasional patient with sputum positive tuberculosis will present for segmentectomy or lobectomy. They are labeled as 'open case of pulmonary tuberculosis' as they are resistant to antitubercular therapy. Such multi drug resistant tuberculosis patients are a significant health hazard to the health care providers. Anaesthesiologists are particularly vulnerable to cross infection during laryngoscopy and intubation. All cases of tuberculosis must follow the universal barrier protection protocol. The contents of the hydatid cyst or fungal ball of aspergilloma can spill during surgery. This raises a serious biological

hazard for the patient and the health care providers. Post operatively operating rooms should be cleaned and disinfected as per local hospital protocol. Open cases of tuberculosis need to be kept in negative pressure rooms and barrier protection needs to be maintained.

Awake video assisted thoracic surgery (AVATS)

Patients with poor respiratory reserve undergo awake VATS under thoracic epidural anaesthesia. We have performed awake VATS including sternotomy for thymoma, segmentectomy, lung biopsy, decortication, evacuation of hemothorax, and retrieval of foreign body. Thoracic epidural anaesthesia was initiated at level T4,5. This was supplemented with intercostal nerve blocks and infusion of dexmedetomidine and fentanyl. With the technique of awake VATS, the benefits of surgery can be extended to the select group of patients with severely compromised cardiopulmonary status who would otherwise be unfit for general anaesthesia (27,28). However patient selection needs to be meticulous for AVATS. Preoperative and intraoperative communication and planning between the anaesthesiologist and the surgeon is a must. AVATS allows early expectoration as the respiratory capacity of the patient is maintained. This allows adequate lavage in case of a cavitary lesion communication with a bronchus. AVATS should be offered in high volume, tertiary centres.

The way forward

If as a country, we thrive to reduce the incidence of serious pulmonary diseases, primordial prevention should be the answer. Better understanding of the epidemiology, pathogenesis, improved public health and sanitation has tremendous role towards that goal. Budgetary allocation must go up to meet the need of healthcare expenditure. More and more numbers of specialized centres dealing with such complex surgeries in smaller cities is the need of the hour. Cost factor needs to be considered as a major chunk of the population of countries like India are poor and unfortunately such diseases have a special inclination to the socioeconomically downtrodden. As perioperative health care provider, the anaesthesiologist and the surgical team should understand the safety goals and know the various techniques of lung isolation and if necessary selective lobar isolation. We are happy that after the index case described earlier, we had our protocol in place and the event is still the only one clinically relevant perioperative spillage we have encountered. To conclude, we would like to recommend to the reader a few pearls of management:

(I) Infectivity of the patient should be considered in the preoperative work up;
(II) The anaesthesiologist should review with the surgical team whether the patient needs general anaesthesia or surgery can be done with regional blocks;
(III) The entire team should arrive at a consensus on need of broncho alveolar lavage, rigid/flexible scopy etc.;
(IV) Preoxygenation is a must;
(V) Mask ventilation before intubation may be done away with in select group of patients with risk of spillage;
(VI) Intubation in lateral position can be considered along with positioning of the patient in such a way that the affected lobe is in the most dependent position;
(VII) Selective lobar isolation should be considered in all patients with risk of spillage;
(VIII) Video assisted technique is very effective in the surgical management of infective lung pathologies.

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Footnote

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