

Surgical Treatment of Tuberculosis, Yesterday and Today

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INTRODUCTION

Pulmonary Tuberculosis (**TB**) is the disease that spawned Thoracic Surgery and Respiratory Medicine; in the recent past was called the “Insidious Disease” or “consumption” or “white death” and can now also be defined “the phoenix of Thoracic Surgery”. This Comparison highlights the resurgence of a disease that was never completely eradicated. Today, many doctors think it is incredible that TB was the disease that created and forged, the Thoracic Surgeon and yet this fact is evident in all the centers where surgery for TB was a routine daily practice. On the other hand, the great enemy “Lung Cancer” is not even “old enough” if we consider that at the beginning of the 19th century it was considered amongst the rare tumours. The beginning of its explosion coincided with World War I, with the spread of cigarette smoking amongst soldiers and with all issues related to urbanization and air pollution.

Many folk remedies existed for the treatment of TB. One of the most popular myths was of a change of climate and diet. Ultraviolet light had been found to kill acid-fast bacilli in the laboratory, and therefore patients were encouraged to spend time exposed to sunlight, it is only in recent years that we have been able to prove that it is sunlight effect on vitamin D levels which improves immunity against TB. Physical activity in children supposedly conferred resistance. The first Sanatorium for TB was established at Gobersdorf in Germany and another famous sanatorium was in Davos, Switzerland, the highest town in Europe. Between 1932 and 1940, at 1,000 m above sea level in the Alps of Northern Italy, the largest sanatorium in Europe (Eugenio Morelli Hospital) was built in Sondalo with its 9 blocks each with 8 floors, covering an area of 350,000 m² on a road network of 12.5 km and occupying a volume of 650,000 m³ it was aptly called “The Sanatorium City, with its 3,500 beds, cinema, shops and a post office, had a larger population than its nearby towns and was immortalized in Vittorio De Sica’s film “A short holiday”. The fresh mountain air, the picturesque Alpine landscape with its green forests and alpine meadows and its south facing orientation was described as being in a bright amphitheatre. High altitude, bed rest, exposure to the sunlight and good nutrition were pursued as therapeutic options. In the pre-antibiotic period, therapies against TB were ineffective and a major role was played by the surgery and largely by preventing the disease. Despite the hundreds of sanatoria built around the world, no tangible scientific proof that sanatorium therapy had any influence on the disease exists. Sanatorium therapy, however, concentrated patients in one place and so contributed to the study of the disease. The annals of Morelli Hospital are full of descriptions about surgical operations that were routine and today would just make us cringe. The techniques of thoraco-myoplasties, buckling and iatrogenic pneumothorax are just some examples of how and in what measure the surgeon could “demolish” a patient. The basic idea was valid, reducing the supply of oxygen to the tuberculosis cavities to make survival difficult for the obligate aerobes organisms that are mycobacterium. Various methods of collapse-therapy, like the “therapeutic pneumothorax of Forlanini” introduced in 1906 and the “intracavitary aspiration of Monaldi” today are full of historic charm. Note however these methods were in apparent pathophysiological contradiction with other therapeutic convictions such as “air therapy” which consisted in forcing the patient to breathe outdoor mountain air (this also occurred during bitterly cold winters). The development of anti-mycobacterial therapy, in the second half of the last century, was a “godsend” for patients and a professional revolution for Thoracic Surgeon who had already understood the need to “sharpen the blades against cancer”, the new enemy whose incidence was increasing more and more! With the new medical therapy the role of the Surgeon gradually decreased to the treatment of complications of TB: destroyed lobes and lungs, tuberculosis pleural empyema with or without fistula, haemoptysis, etc. In our daily practice, we can confirm that the “new explosion” of TB, is due mainly to the migratory flows from highly endemic countries admitted to our hospital (mainly countries from Eastern Europe, South Asia and Africa). Cases of resistant infections are also increasing. In addition to Multi-Drug Resistant (**MDR**) and Extensively Drug Resistant (**XDR**) bacterial strains, we must now fight against infections that have very few

chemotherapeutic options, akin to the TB we saw in the pre-antibiotic era. The appearance of these resistant strains is due to a selection common to all germs and to an incorrect use of medical therapy (monotherapies, insufficient duration, poor patient compliance, drug stock outs, pharmacokinetic differences, etc). With the resurgence of TB and the development of resistant strains and more complex patients (elderly, co morbidities, HIV co-infection), the Thoracic Surgeon must learn to deal with the “phoenix reborn” again. The battle is increasingly complex and treatment of TB requires a close collaboration between the Phthisiologist (old name for TB doctor) and the Surgeon. Medical therapy of resistant forms must be handled by experts in the field and the corresponding surgical treatments cannot be improvised. Minimally Invasive Surgery has, at present, only a diagnostic role (for pleural tuberculosis empyema, speleoscopy for thoracostomies, etc) or therapeutic role in certain specific complications (rigid bronchoscopy for temporary or palliative treatment of broncho-pleural fistulas). One of the most important complications of TB is the pleural empyema for which the drainage is almost never sufficient and often we have to perform complex procedures such as packaging of Open Window Thoracostomy (**OWT**) that must be carefully managed. The closure of OWT may require several months. The presence of any broncho-pleural fistula is a real challenge for the Thoracic Surgeon who has to manage different demolishing and reconstructive methods to get the best possible final result. The probability of ultimate success depends on several factors: (I) “no less than optimal” management of antibiotic therapy; (II) maximum compliance of the patient who must really be “patient”; (III) effective multidisciplinary teamwork; (IV) experience in carrying out “non-routine surgical procedures”; and finally (V) ability to keep the patient hospitalized for a long time, sometimes months, without bureaucratic and economical problems. The probability of good patient outcome is higher when all of these criteria are satisfied.

BRIEF HISTORY

Remedies and Popular Beliefs

The folk remedies against the disease were manifold and were aimed in the first instance to reduce its transmissibility. One of the most important myths was “the change of climate and diet”; this because it was clear that rural populations were less exposed to the disease and, if infected, had improved survival (no urban overcrowding in slums, better food and less pollution). Ultraviolet rays were able to destroy the bacteria in the laboratory and so the patients were encouraged to spend hours and hours exposed to the sun. Physical activity in children was deemed capable of conferring resistance to the disease, while bed rest was recommended in adults. It was clear and evident that sanitation and hygiene had a significant influence on the incidence of the disease, causing a reduction in the incidence of disease in the pre antibiotic era. In the first half of the twentieth century disease prevention was not easy in a period plagued by wars and dominated by poverty and lack of education. One of the health policy objectives, that the political institutions of the period were trying to achieve, was the defeat of some of the most dangerous infectious diseases including TB. The poster in Figure 1 printed in 1937 and currently

exposed in the Phthisiology Department of our Morelli Hospital in Sondalo, represents one of the most practical and fascinating historical examples of the attempt to focus social awareness on the problem of prevention.



Figure 1: Poster showing the hygiene rules in order to prevent tuberculosis.

At the top left you can read: The messy house, neglected and untidy, away from the air and light, depresses the spirit and hatches germs of the saddest diseases; first and most insidious of all tuberculosis. At the top right you can read: The clean house, tidy, lovingly prepared and open to the pure air and to the beneficial sun, raises the spirit of those who live and keeps infections, contagions, the mortal dangers far away from the body. The text continues: Tuberculosis still kills 35,000 Italians every year. Yet, if it is discovered and treated in time, tuberculosis may be the most preventable and most curable disease. Tuberculosis is caused by the bacillus discovered by Robert Koch, which, finding favourable conditions in the human body, grow, multiply and destroy organs and tissues. These bacilli are found in the sputum expelled by coughing tuberculosis patients are really virulent and nefarious, especially when they act on children. When in a house with a person sick with tuberculosis, we must take these precautions: room aside, the destruction of the sputum, disinfection of table utensils. With all the forces it is necessary to fight the ridiculous fears that make a poor sick a being to be feared as a cholera victim, a pariah. But above all it is necessary

to subtract the children to infection and strengthen their bodies. In fact, while the bacteria that infect a weak body have the fate of a lit match falling on a pile of straw, the bacilli entering a robust body have the fate of a lit match falling on a marble table: extinguishes. To protect children from tuberculosis, you should: wash your hands before touching any food; at school, sitting with chest and head erect, so that the apices of the lungs can breathe; to live as much as possible outdoors and do respiratory gymnastics; not spitting and prevent others from spitting on the ground; do not eat foods already touched by others; do at least one bath a week; sleep, when it is not raining and not too moist, with the windows slightly open so that fresh air can enter the room; eat healthy foods and brush your teeth before going to bed. By following these hygienic rules, you can almost always prevent tuberculosis. However, tuberculosis, at the beginning, is almost always curable if treated immediately and with appropriate methods. When the first symptoms, which include slight fever persistent and intermittent, which does not exceed 38 degrees; weight loss; pallor; lack of strength; fixed pain in the chest; coughing light, tough and dry; tenacious disorders of the stomach and intestine; streaks of blood in the sputum, seek immediate medical attention or anti-tuberculosis institutions created by the Fascist Regime, which has made the fight against tuberculosis among the fundamental objectives of its businesses. Let all remember the words of the Duce (TN: Benito Mussolini): “it is necessary that scientists, policymakers, philanthropists constitute a kind of united front to lead the great battle against tuberculosis to a victorious end.”

HISTORICAL SURGICAL APPROACHES TO THE DISEASE

Drainage Therapy

It was one of the first procedures used, with the first attempts to drain tuberculosis cavities dating back before the discovery of X-rays in 1885. The publication by Monaldi in 1939 created enormous interest for such therapy, but its temporary benefits reduced enthusiasm for the procedure rather quickly.

Induced Pneumothorax

Carlo Forlanini in 1882 published his first article on Induced Pneumothorax (**IP**). He had noticed that some TB patients who developed pneumothorax improved clinically. Forlanini thought that induced pneumothorax and subsequent pulmonary compression could have an important therapeutic outcome. Forlanini therefore devised a device through which to blow “filtered air from the dust” into the pleural cavity (not oxygen because it is absorbed too quickly and not nitrogen because it could cause embolisms). The introduction of air was carried out with a needle inserted through the midaxillary line of the chest, up to the fourth-seventh intercostal space, to reach the pleural cavity. At that point the gas was injected up to a pressure around zero. The lung and the tubercular cavities remained collapsed, thanks to subsequent top ups of gas, for a prolonged period (at least two, three years). This procedure was interrupted and lung re-expanded when the cavities were considered healed Figure 2.



Figure 2: Forlanini Device currently exposed in the Thoracic Surgery Department of Morelli Hospital in Sondalo.

Lysis of Adhesions

In more than 50%, the presence of pleuro-pulmonary adhesions made for ineffective IP. The presence of such adhesions reduced the chance of healing and facilitated the recovery of the lesions already stabilized with IP. American and German surgeons were the first to try to dissect these adhesions in “open surgery” with not very good results in terms of mortality. A great effective contribution was led by Christian Jacobaeus, who first conceived and executed, in 1913, the “endoscopic section” of adhesions getting unexpected successes and negligible operative and postoperative complications.

Pleural “Plombage”

Pleural Plombage (**PP**) was an alternative to IP and was performed by filling the pleural cavity with inert material capable of maintaining the lung and and therefore also the tubercular cavities collapsed. The most advanced method involved the use of balls of “Lucite” (polymethylmethacrylate) about the size of the golf balls Figure 3,4.



Figure 3: Chest X-Ray showing lucite balls in left pleural space. Case courtesy of Dr. Jan Frank Gerstenmaier, Radiopaedia.org.

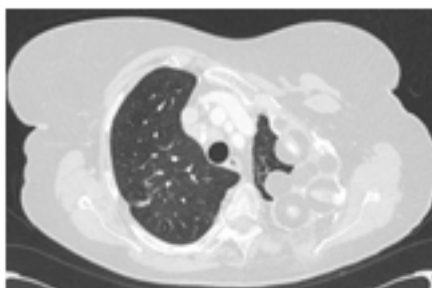


Figure 4: CT scan showing lucite balls in left pleural space. Case courtesy of Dr. Jan Frank Gerstenmaier, Radiopaedia.org

Thoracoplasty

Thoracoplasty was one of the most important methods of treatment for TB. In essence the purpose of a thoracoplasty was always “Lung and Cavities Collapse” (**LCC**). Two additional purposes were: abolition of respiratory trauma and permanent rest position. This method was used after failed attempts of previous methods and it provided a resection of 9 or 10 ribs, (from I or II to X) for the longest possible length; removal of the intercostal muscles and the periosteum. Such an operation was highly traumatic and extremely dangerous, because it could often cause threatening mediastinal fluctuations and disorderly paradoxical movements at the wall deprived of bone support. Changes and modifications were then made on the best techniques to be developed aimed at minimizing trauma. The concept of partial thoracoplasty was developed, governed by the following guides: large resection of the first three ribs; complementary pulmonary apical lysis; creating on the top of the lung a kind of muscle-periosteum diaphragm that could prevent its re-expansion.

Section of Scalene Muscles

The most important morphological effect of this operation is some flattening of the supraclavicular region. From a physiological standpoint, the action should have resulted in lowering of the upper ribs, decreased respiratory mobility, reduction of the intercostal spaces, reducing the volume of the chest cavity from the third rib to pulmonary apex. But the results were inconsistent and often unsatisfactory.

Phrenic Nerve Surgery

The operation on the phrenic had the aim to produce permanent or transient paralysis of the nerve with consequent lifting of the corresponding hemidiaphragm. There were different methods for the interruption of this nerve: crushing, section, alcoholic destruction.

Early Attempts of Pulmonary Resection

The first procedure of pulmonary resection for TB was recorded in 1883. The main difficulty of this type of surgery was the restoration of intrathoracic negative pressure after the procedure. The mortality rate was very high mainly due to septic complications and was around 25-30%. The appearance of streptomycin radically changed the surgical approach to the disease. Operation numbers decreased enormously and were practiced in only limited cases, so much so that in 1953, Chamberlain reported a mortality rate of 3% in the procedures he performed.

SURGICAL OPTIONS TODAY AND IN MDR AND XDR BACTERIAL STRAINS

Surgery was for two centuries the main therapeutic option in the treatment of TB. With the introduction of modern chemotherapy in 1952, surgery had been largely abandoned, because of frequent complications: infection, bleeding and erosion caused by parenchymal filling material. Drug therapy then became the primary method of treatment for TB, often also including drug-resistant forms. However, the emergence and global spread of MDR and XDR strains has led to a resurgence of cases almost incurable, often fatal. M/XDR-TB currently represents a fundamental challenge to the global control of TB because of the few treatment options available.

Indications for Surgery

Surgery today is limited to the management of complicated forms of TB (including massive haemoptysis, severe bronchiectasis, bronchial stenosis, bronchopleural fistula and aspergilloma) and, especially, in cases where medical treatment is ineffective such as M/XDR cases or in cases where there are multiple severe intolerances to anti TB drugs. Several authors, over recent years, have suggested the following guidelines for absolute need of surgery:

- High probability of failure of medical therapy in MDR/XDR-TB patients (due to persistent pulmonary cavities, destruction of lung or lobes), massive haemoptysis and/or pneumothorax.
- Sputum or culture persistently positive, despite adequate drug therapy.

- High risk of recurrence (according to radiological and drug resistance).
- Presence of localised lesion susceptible of resection.
- Progression of TB despite adequate drug therapy;
- Repeated haemoptysis or secondary infection.
- No radiological and/or bacteriological improvement during the first three or four months of drug therapy.
- Drug side effects (allergy, severe adverse events or both).
- Chronic diseases of the gastrointestinal organs that reduce the drug absorption and therefore efficacy.

The disease is considered advanced when the total diameter of the TB cavity is greater than 15 cm, or in cases in which the parenchymal infiltration has covered more than 75% of the total area of the lung. Resection is indicated in patients with cavitary disease because of the difficult penetration of the antibiotic and the high bacillary load. Additional important indications for surgery are the irreversible morphological alterations of the lungs due to the development of fibrotic tissue during the course of the disease, leading to long term/permanent squeal. Most authors agree in the “absolute surgical treatment” in cases of cavitary disease with persistent failure of drug treatment. Some authors believe that, despite negative sputum, MDR patients, which radiologically show persistent cavitation, fibrous tissue or destroyed lung (without clinical improvement) have indications for surgery, because of the high likelihood of relapse. TB cavities are indeed an ideal growing environment, as it’s “wall” reduces drug penetration, and probably protects the bacteria from the hosts immune system. Many patients, who have negative sputum and culture preoperatively, may later show positive cultures in the resected lung tissue. Furthermore, the cavities may be the main sites for the development of drug resistance. In a study of resected TB lung tissue, bacillary growth has proved to be more active in macrophages located on the surface of the cavity, in which most of the new drug-resistant mutations occur, the drug mutation rate is also proportional to the bacillary load which is proportionally higher with more larger cavities. The authors also reported no CD4 and CD8 T cells on the luminal surface, which may explain unchecked active bacillary proliferation. The incomplete resection of TB lesions is, therefore, one of the risk factors for recurrence of the disease. For this reason, lung resection, in combination with an appropriate chemotherapy for MDR-TB has achieved success rates of treatment of 88-92% of cases, as well as a strong reduction of mortality. Based on the review of the studies carried out, experts have set the following guidelines for the treatment of pulmonary MDR/XDR-TB tuberculosis.

Surgical intervention can be classified as:

- Emergency: (without surgery death is imminent and inevitable): Emergency signs include: profuse pulmonary haemorrhage and spontaneous hypertensive pneumothorax.
- Urgent: urgent indications include: irreversible TB progression despite adequate chemotherapy; relapsing haemoptysis that cannot be stopped by other less invasive methods.
- Electives: localised forms of TB cavities with continuous bacillary excretion, confirmed by a bacteriological examination after 4-6 months of chemotherapy; MDR/XDR-TB characterized by the lack of adequate therapy; complications and sequelae of the pathophysiological process of the disease, including:
 - Spontaneous pneumothorax and haemothorax
 - Pleural empyema with or without Bronchopleural Fistula (BPF)
 - Aspergilloma
 - Bronchial lithiasis
 - Pleuritis or pericarditis with respiratory and circulatory failure
 - Post-TB tracheal and bronchial stenosis
 - Post-TB and chronic symptomatic bronchiectasis;
 - Other indications, such as the elimination of the complications of previous surgical operations.

TYPES OF OPERATIONS

Proper patient selection and perfect timing of operations are crucial to provide a greater chance of recovery and to prevent relapse. Good cooperation between physicians and thoracic surgeons, as well as full respect for the patient in the pre and postoperative period increase treatment success rates.

The types of operations currently performed are:

- Lung resections (wedge resection, segmentectomy, lobectomy and bilobectomy);
- Combined resection (lobectomy plus minor resection);
- Pneumonectomy or pleuropneumonectomy;
- Lung resections with different methods of hemithorax volume correction (extrapleural pneumolysis; thoraco-mioplasty; pleurectomy and lung decortication;
- Bronchial Surgery (unblocking; resection; bronchoplasty; new stump resection;
- Thoracentesis;
- Thoracotomy;
- OWT (drainage of the pleural space through an Open Window Thoracostomy).

Pulmonary resection, when executed, represents the best therapeutic effect. Selective intubation is required and a posterolateral thoracotomy is usually practiced. The pleura, especially in cases of extended infection, are merged together making thoracoscopic access very challenging. The presence of pleuropulmonary adhesions is frequent especially at the apex of the lungs, in the dorsal segments and at the level of the apical segment of the lower lobes. For this reason it is often necessary to proceed along an extrapleural plane. During the dissection on extrapleural plane, attention must be paid to avoid injury of subclavian vessels, recurrent laryngeal nerve, esophagus and posterior intercostal vessels. Once freed the lung from adhesions, the hilum can usually be isolated without complications and bronchial closure can be carried out by manual suture or staples. Several authors indicate no difference in the incidence of bronchial stump disruption between the two methods. The mortality rate is about 2-3% for lobectomy and about 7-8% for pneumonectomy.

CONTRAINDICATIONS TO SURGERY

The following contraindications can be considered for lung resections:

- Large cavities on both lungs
- Impaired lung function tests (i.e. FEV1 less than 1.5 L in cases of lobectomy and less than 2.0 L when pneumonectomy is planned)
- Grade III-IV cardio-pulmonary insufficiency (according to the functional classification of the New York Heart Association)
- BMI 40-50% out of the normal range
- Severe comorbidities (diabetes failure, exacerbation of gastric and duodenal ulcers, kidney or liver failure, etc)
- Bronchial active TB
- Albumin level < 3 g / dl

It should be emphasised, however, that a multidisciplinary approach is essential in the treatment of these patients and important decisions should be taken jointly by physicians, surgeons, anaesthetists and other specialists. The majority of TB patients are generally underweight, often in a cachectic state, reason for which an additional nutrition via gastrostomy, jejunostomy or total parenteral nutrition could be necessary in order to ensure a sufficient anabolic state before the operation. The patient should take the best possible anti-mycobacterial therapy, based on culture identification and drug susceptibility testing, and ideally should be culture negative at least three months before surgery. In case the mycobacterial counts (from sputum) does not decrease and the patient is still culture positive, antibiotic therapy must be continued for longer, conversely, in case sputum is negative and culture conversion has taken place, surgery can be anticipated. In as much as 50% of MDR-TB patients, conversion of sputum smear and culture cannot be obtained,

therefore surgery is often undertaken in spite of a positive test. Complete and meticulous pre-operative examinations are: analysis of whole blood, biochemical tests (liver, kidneys, blood sugar, electrolytes, and coagulation), HIV tests, chest X-ray and CT scan, fiberoptic bronchoscopy (to exclude endobronchial TB, contralateral disease and malignancy). The cardiorespiratory reserve of the patient should be carefully evaluated using pulmonary function tests: FEV1 and pulmonary diffusion, electrocardiogram and echocardiography (to rule out heart failure and pulmonary hypertension), in addition to gas analysis of the arterial blood and routine cardiology consultation. In case of patients with poor spirometry and lung diffusion results, you may either use a perfusion lung scintigraphy. Respiratory function should be optimised through breathing exercises, postural drainage and aerosol inhalation. The use of nebulised bronchodilators and antibiotics has shown positive results. Smoking cessation should be encouraged tenaciously.

POST-OPERATIVE MANAGEMENT

The short and long term results of surgery are highly dependent on a meticulous postoperative management, which provides:

- Proper analgesia, including use of opiates;
- Physiotherapy and breathing exercises
- Daily chest X-ray for the first two or three days
- Bronchoscopy only when needed
- Removal of chest drains, when fluid production ends after pulmonary resection
- Managing the patient attentively with special focus on avoiding the development of postoperative complications, such as air leakage, BPF, presence of residual pleural space and empyema;
- Transfer of patients from the intensive care unit to the department of thoracic surgery once they are haemodynamically stable.

Patients restart the anti-TB therapy regimen orally after surgery, with possible adaptation as suggested by the bacteriological analysis of excised surgical material (lung tissue removed sent to microbiology for acid fast bacilli microscopy and culture). Postoperative care is essential, just as much as preoperative, because after resection of the primary lesion, scattered nodular lesions and small cavities may be retained. Long term post operative therapy is essential in order to kill any persisting bacteria that may be present in any remaining lesions.

RESULTS OF SURGICAL TREATMENT

Lung resection, in combination with a proper pre and post operative chemotherapy, enables success rates of treatment up to 88-92% of cases. The morbidity associated with surgical resection varies in the range between 12% and 39%. Bleeding, pleural empyema (PP) and BPF are the most

frequent complications. The mortality rate is between 1% and 5%, indicating the relative safety of such surgery.

A measurement used to evaluate the therapeutic success of the operation is the postoperative culture negativity. Sterilization of sputum is between 78% and 96%; the conversion of cultures is between 47% and 100% (median 92.5%). According to the WHO a patient can be defined cured after at least five consecutive negative cultures.

COMPLICATIONS REQUIRING SURGICAL TREATMENT

Complications requiring surgical treatment are due in the first instance to the progression of lung disease or to additional infections in TB affected areas.

Pulmonary Destruction

Lung Destruction (**LD**) is variable. In patients with adequate response the lung involvement is localised and can spontaneously resolve, in other patients the progression of disease can expand with parenchymal destruction (cavitation).

LD when predominant and left unchallenged, seriously reduces long-term survival. The destruction of parenchyma and subsequent diffusion through the bronchi, leads to development of bronchopneumonia or extensive dissemination by lymphatic or blood vessels (miliary TB). Super added infection by other pathogens may contribute to the worsening of symptoms and poorer outcome.

Bronchiectasis

Upper lobes and superior segments of the lower lobes are most affected. The left main bronchus, because of its length, is most frequently blocked by “extrinsic” pressures due to enlargement of mediastinal lymph nodes; also it is more frequently clogged with secretions or endobronchial TB disease, compared to shorter main right bronchus. The physiopathological mechanism leading to bronchiectasis in TB patients is due to a continuous traction on bronchi, to the parenchymal fibrotic process and to chronic systemic inflammation. The indications for resection include persistent symptoms or complications (haemoptysis, empyema, abscesses). Minimally invasive resection through the use of Video-Assisted Thoracoscopic Surgery (**VATS**) provides a viable alternative to the traditional thoracotomy approach. A major preoperative physiotherapy is essential to ensure a bronchial tree “dry.”

Massive haemoptysis

Massive haemoptysis is a serious threat to survival because it compromises gas exchange and can lead to haemorrhagic shock. Any pulmonary cavity may be complicated by haemoptysis due to the erosion of parenchymal or bronchial vessels (Rasmussen’s aneurysm). Haemoptysis is severe when you have an accumulation of blood at least 200 ml within 72 hours with the onset of acute respiratory failure. Emergency treatment involves execution of a flexible or rigid

bronchoscopy with the set of manoeuvres designed to stop or reduce bleeding (washing with cold saline, instillation of procoagulant or vasoconstrictor agents, adrenalin, buffering with glue agents). Once stabilized the vital functions, there are three options: 1) observation 2) bronchial artery embolisation, 3) surgical resection. Until the 1980s lung resection was the gold standard (with high morbidity and mortality). In the last two decades, embolisation has become the most widely used treatment.

Bronchial lithiasis

Bronchial Lithiasis (**BL**) is a condition characterized by the presence of calcified or ossified material within the bronchial lumen. It is more often attributable to a progressive erosion of certain bronchial/mediastinal calcified nodules, within a framework of infection or granulomatous inflammation. On rare occasions, calcified endobronchial tumors, as carcinoid and hamartomas, can mimic BL. These diseases are more frequent in the intermediate bronchus and the most frequent complications are: obstructive pneumonia, bronchiectasis and LD. Current treatments are bronchoscopy or open surgical removal.

Aspergilloma

One of the most typical long-term TB complication is the secondary infection of a lung cavity by saprophytic organisms of the *Aspergillus* species, leading to the development of a typical “fungus ball”.

The presence of this mycetoma can increase the size of the cavity, via the secretion of proteolytic enzymes. Depending on several factors, patients can be asymptomatic or present with cough and haemoptysis. Aspergilloma in the absence of bleeding can be treated conservatively with antifungals. There are two main surgical treatments: removing the cavity containing the fungus ball or the entire affected lobe. Segmentectomy and wedge resections are not recommended, due to a significant risk of opening of the cavity, with release of the contents into the pleural space. Pneumonectomy has a high risk of sepsis in the postoperative period, with a complication rate to develop empyema of around 25%. When the patient proves unsuitable for resection, the radical alternative is represented by a direct approach, with removal of mycetoma, immediately followed by a thoracoplasty that leads to cavity collapse. All these procedures are always associated with systemic (preferable) or intracavitary antifungal drugs.

Empyema with and without Bronchopleural Fistula (BPF)

Empyema without BPF can be treated with simple drainage or surgical evacuation of the Pleural Cavity (**PC**) while empyema with BPF is a more serious challenging problem. A good proportion of TB patients have BPF-associated empyema and the closure of BPF is mandatory and depends on three factors: the initial condition that created it, the caliber and the anatomical site. The treatment schedule should be clear; 1) evacuation of the empyema and exploration/study of the fistula; 2) cleaning and disinfection of the pleural cavity with the creation of an

OWT; 3) evaluation for the possible closure of fistulas, even temporary; 4) thoracomyoplasty procedures. After evacuation of empyema, bronchoscopy study of the fistula is essential. The BPF may be evident in a large caliber bronchus (main or lobar bronchus) or less evident in a sublobar bronchus. When possible it is always useful to prevent or reduce, even temporarily, the air leak from the fistula. Among the various experimental methods, the latest technique is the implantation of endobronchial one-way valves that can prevent the passage of air into the pleural cavity and at the same time prevent the centripetal migration of purulent secretions. The theoretical goal is to reduce the continuous infectious insult of the PC, and then to promote healing of bronchial stump. Anyway, these devices are quite effective and functional but rarely effective in promoting healing. The sterilization of the PC is a “sine qua non” condition, with a greater significance in cases of TB pleuritis. Rarely chest drainage may be sufficient, and in most cases we must create an OWT through which daily medication can be made by direct view of the PC. The OWT is the most important phase of the treatment program because it allows us to eliminate the chronic infection that is the cause of bronchial stump not healing. The OWT packaging Figure 5 must follow some basic rules: 1) must be created in a location that would allow the surgeon to easily perform the medications and allow the patient to perform the normal daily activities (unless the anatomy does not allow it); 2) must be generous in size such as to favour the dressings of all the cavity; 3) CT radiological study is mandatory. The anterior axillary region best meets the points 1 and 2 unless you are forced to do otherwise. Once identified, the right intercostal space, we resect two or three rib segments as to create a round or ovoid opening. The sterilization of the pleural cavity is the necessary condition without which you cannot proceed with the next phase of myoplasty. For this reason, the management stage and dressing of OWT should be adequately long (several months at home). Furthermore, in our surgical program, we do not proceed without at least three consecutive negative swabs. It would be a “crime” to perform demolishing (and disabling) manoeuvres with the knowledge of an ongoing infection that could hamper the efforts of the surgeon and the outcome of the myoplasty. Intermediate swabs should be considered positive. The intervention of myoplasty can have three purposes: 1) occluding a fistula; 2) filling a large pleural cavity; 3) both of the first two. The right choice of the muscle depends on the location and volume of the OWT. The muscles that we use the most are the “latissimus dorsi” for posterior OWT and “pectoralis major” for anterior OWT. These muscles can also be used in a sequential manner, in cases of large size fistulas/cavities. Other muscles used are the “pectoralis minor” and one or more “intercostal muscles”. The quality of these muscles must be good and must not have been damaged during previous surgeries. Technically the concept of myoplasty is the detachment of muscle from the original place, its rotation around a pedicle and positioning in the new location you want. During these phases we have to preserve the muscle vascular bundle by direct damage and from kinking during the phase of rotation and repositioning. The muscle is placed on the bottom of the pleural cavity and sutured all around the fistula. The more the muscle or muscles fill the pleural cavity, the greater the likelihood of ultimate success. We can decide to perform two sequential myoplasties and so we postpone the closure of the OWT after an appropriate period of study (ensuring negative cultures) and continue daily medications.

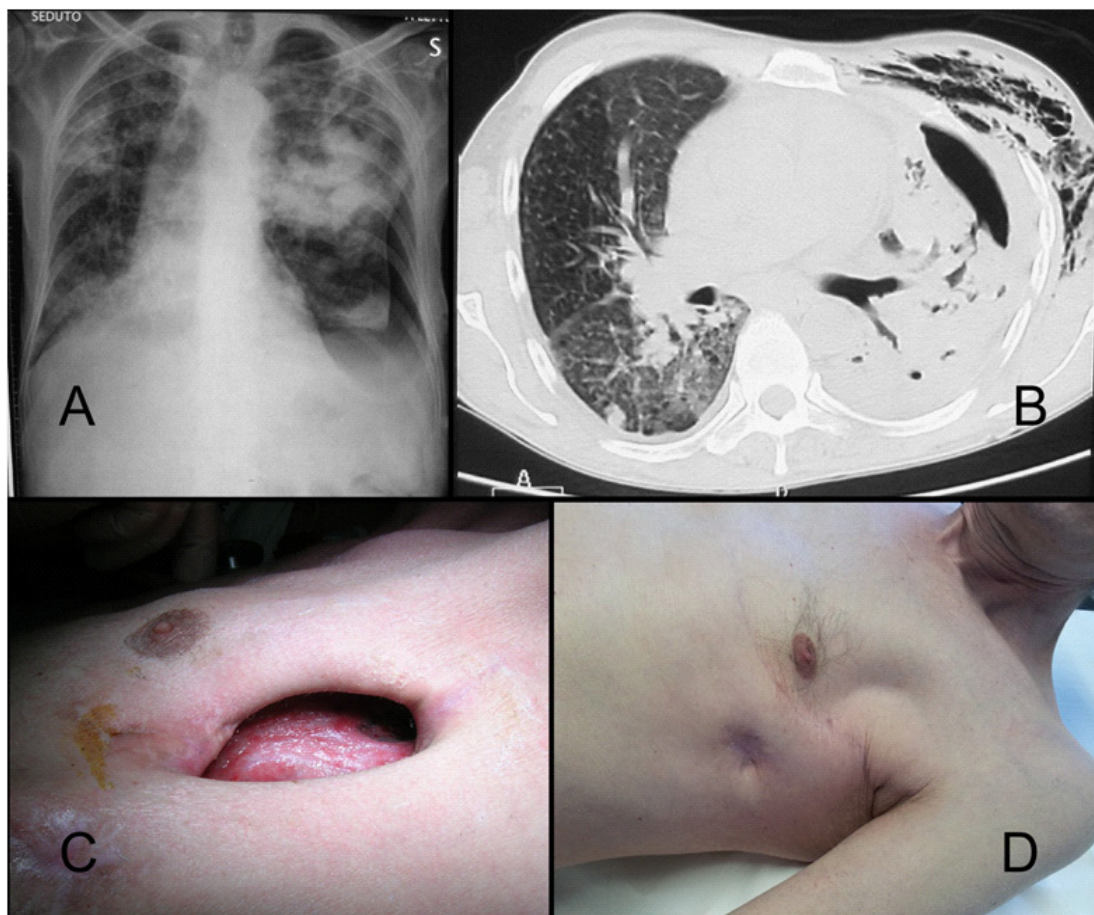


Figure 5: The OWT packaging in a 48-year-old man was admitted in the Department of Phthisiology, Sondalo Hospital, with severe respiratory insufficiency caused by left pleural empyema, pneumothorax with bronchopleural fistula, and bilateral lung destruction caused by tuberculosis; a) Chest X-ray at admittance. b) Computed tomography scan showing one bronchopleural fistula. c) The open-window thoracostomy after daily medication. d) The final result.

OWT Closure

The OWT closure can mainly be carried out through two techniques: Clagett method or through the creation of slip rotation planes. The first technique involves the simple juxtaposition of subcutaneous and cutaneous flaps after instillation of antibiotic in the cavity while the second technique involves the creation of muscle, subcutaneous and cutaneous flaps. The choice of the most appropriate method depends on several factors: type of OWT, previous use of muscle flaps, the anatomy of the chest wall etc.

CONCLUSION

We can conclude by saying that, after many years of attention given almost exclusively to cancer, the Thoracic Surgeon has to deal again with the old enemy who has made a powerful come back. Today's young surgeons should be familiar with a disease that, in the past, created the legend of the Thoracic Surgeon. The new threat of multi-drug resistance is pushing us back into the pre-antibiotic era and thoracic surgery is more frequently required to ensure a better outcome for our patients.

Close collaboration amongst teams using a multidisciplinary approach is essential and should be sought (between the two branches of Thoracic Surgery, Respiratory medicine/Phthysiology), the opportunity to make important choices without haste and enabling good patient buy in and compliance can enable patients to return home to independent living. Respect for the patient, the underlying disease, of time, and of the individual steps greatly contributes to increase the chances of success.

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