

# Pulmonary abscesses – aetiology and treatment. Ten-year experience of the Department of General and Thoracic Surgery in Lodz, Poland

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## Abstract

**Introduction:** Primary lung abscess is a disease developing due to aspiration or embolization of the infected material from the lung tissue or on the basis of other diseases of different aetiology (secondary abscess). In the research, the authors referred to the aetiology and pathomorphology of lung abscesses and described modern methods of diagnosis and treatment.

**Material and methods:** We treated 89 patients with lung abscess for over 10 years. The main aetiological causes were pneumonia (30%), choking (16,8%), aspiration of the foreign object (10%), injuries (8%) and unknown (21%). We evaluated bacterial flora from the abscess in 61 cases (68.5%). In surgical treatment, we applied resection of the lung tissue – 67 (anatomical – 32, unanatomical – 35), transcutaneous drainage – 9, pleural drainage – 11, cavernostomy – 2.

**Results:** Positive results such as expansion of the lung, regression of the septic state and the possibility to discharge the patient home was obtained in 72 patients (80.9%). 26 patients developed severe complications, seven of which (7.9%) died in an early postoperative period (30 days from the surgical intervention).

**Conclusions:** Surgical treatment of lung abscesses requires an individual approach to each patient regarding his general condition, aetiology, dimensions and the location of the lung abscess, presence of coexisting diseases and possible postoperative course of the disease. Patients with lung abscesses directed to surgical treatment are a specific group because of their poor general condition and lack of possibilities of conservative treatment, which influence the unsatisfactory outcome of treatment.

**Key words:** lung abscesses, transcutaneous drainage, resection of the lung tissue.

## Introduction

### Pathomorphology

A lung abscess is a restricted area of purulent necrosis of the lung tissue, which is a complication of bacterial infection or rarely an infection of different

aetiology, such as viral, fungal or parasitic. A course of this disease is at first acute and then chronic. Its characteristic features are expectoration of purulent or mucopurulent sputum and recurrent high temperature. The bacteria penetrating the lung tissue cause its damage and necrosis with a quick destruction, which leads to purulent secretion rich in lytic enzymes from granulocytes and destroyed cells and bacteria. Chronic abscesses are surrounded by a capsule made of granulation and fibrous tissues. These pathological changes lead to creating a cavity in the lung tissue, which in an X-ray image is seen as a ball shaped shadow with an air-fluid level [1, 2].

### Etiology

The most frequent way of penetrating the lungs by bacteria causing abscesses is either the respiratory tract (aspiration of the infected material) or the circulatory tract (embolization of the infected material). The abscess may also develop on the basis of other diseases occurring in the lung tissue (secondary abscess). Secondary abscesses may form during the disease (synpneumonic abscesses) or after the regression of the symptoms (metapneumonic abscesses). Abscesses originating from spreading of the inflammatory processes from the neighbourhood: infections of the thoracic wall, mediastinitis, subphrenic and periesophageal abscesses and others are rare.

The most frequent etiological factor evoking lung abscesses are infections with aerobic bacteria (*Streptococcus pneumoniae*, *Streptococcus pyogenes*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Proteus vulgaris*, *Escherichia coli*, *Neisseria meningitidis*, *Haemophilus influenzae*) and rarely with anaerobic bacteria (*Clostridium histolyticum*, *Bacteroides fragilis*). Mixed bacterial flora is often present in lung abscesses. Fungal infections are seldom and usually occur in chronic abscesses. In our geographic conditions, protozoic abscesses (*Entamoeba histolytica*) are rare. Primary lung abscesses develop usually by aspiration and remaining of secretion from the oral cavity and throat or chyme in the bronchial tree. It is caused by the states leading to impairment of cough reflex and aspiration into the airways: during the loss of consciousness, alcoholic obtundation, neurological disorders (epilepsy), during general anaesthesia, pulmonary oedema. The cause of developing secondary lung abscesses may be pneumonia, constriction of the bronchial tree, tuberculosis, infected embolism transported in the circulatory or lymphatic tract, vasculitis, decaying neoplastic tumour. Abscesses can also occur because of aspiration of the foreign object into the respiratory tract or its penetration into the lung tissue from the outside (gunshot wound, shrapnel). There are some factors favourable of lung abscesses leading to decrease of natural immunity, such as diabetes,

neoplastic disease, chronic alcoholism, malnutrition, drug addiction, immunosuppressive treatment (leucopenia), irradiation (damage of the bone marrow), chemotherapy, HIV infection, elderly age. Lately there have been reports of multiple lung abscesses in victims of tsunami in Southeast Asia due to aspiration of salt water [3].

### Symptoms of lung abscess

Clinical symptoms of lung abscess do not always create one characteristic pattern. The course of the disease depends on a number of factors, such as virulence of the bacteria, the state of the immune system, coexisting diseases, the location and size of the abscess and the effectiveness of treatment. The most frequently mentioned symptoms of the lung abscess are hectic fever, shivering, coughing fits, expectoration of purulent sputum, chest pain, and loss of weight, dyspnoea and sometimes haemoptysis. The factors of unfavourable prognosis are: large dimensions of the abscess cavity, location in the inferior lobe of the right lung, poor general condition (anaemia, low protein level, alcoholism), impairment of the immune system, infection with virulent bacteria (*Pseudomonas aeruginosa* – death rate approximately 83%, *Staphylococcus aureus* – approximately 50%, *Klebsiella pneumoniae* – 44%) [4].

In the course of lung abscess some serious complications may occur, either general or topical. Topical complications are spreading of the infected material to other bronchial tubes (multiple abscesses), development of pyothorax, development of bronchial fistula with pneumothorax, soft tissue inflammation, phlegmon of the thoracic wall, bleeding to the bronchial tree, development of lung mycetoma. The general complications are haematogenous damage of the heart muscle, multiple abscesses of the liver, haematogenous abscesses of the brain tissue, nephritis, renal amyloidosis, sepsis, organ insufficiency. The death rate among the patients with lung abscesses is still high and is estimated at about 15–20% [5].

### Diagnosis

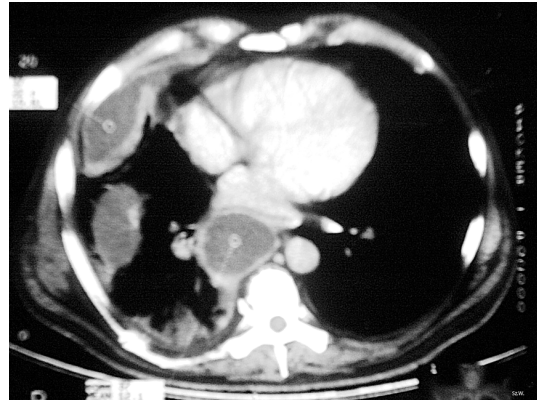
In spite of the new diagnostic techniques available, the diagnosis is still made on the basis of the patient's medical history and classical imaging studies. In the first stage of the disease, the x-ray image shows a ball-shaped, oval or irregular, badly delineated shadow. As the disease progresses the border between the abscess and the lung tissue becomes more visible which corresponds with the development of the capsule. If in the course of the disease communication between the abscess and the bronchus is achieved the image is characteristic and shows a cavity surrounded by a thick wall with an air-fluid level. The lung abscess in an x-ray image may resemble of the cyst, tuberculosis cavity, mycotic cavity or decaying

lung cancer. Pneumothorax can develop due to perforation of the abscess to the pleural cavity. Hydrothorax or thoracic empyema may develop as a result of either spreading of the abscess or its perforating into the pleural cavity. Other significant methods used in the diagnosis of the lung abscess and establishing of the treatment are: computer tomography, fiberoptic bronchoscopy, bacteriological evaluation of expectorated sputum, bronchial washings (BAL) as well as the puncture material from the abscess cavity evaluation, isolation of the bacteria from patient's blood and other laboratory tests (increased OB, high leucocytosis, evaluation of the immunoglobulin level) (Figures 1 and 2).

### Treatment

Recently most cases of lung abscess may successfully be treated preventively by means of antibiotic therapy based on targeted antibiograms from biological cultures from the bronchial tree or directly from the abscess cavity. Preventive treatment is completed by using mucolytics, bronchodilators, anti-inflammatory drugs, effective cleaning of the respiratory tract (including bronchoaspiracy), positional drainage and physiotherapeutic procedures, dietetic treatment and drugs stimulating the immune system of the body. In case of failure of the preventive treatment or development of any complications, an appropriate surgical treatment should be considered.

It is believed that in 20-30% cases the lung abscess may spontaneously recover in an early stage. It is estimated that approximately 11-21% patients, in whom the antibiotic therapy proved ineffective, require surgical treatment either with using the drainage or not [6].



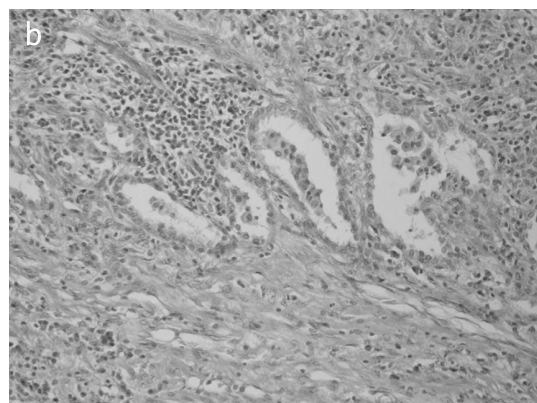
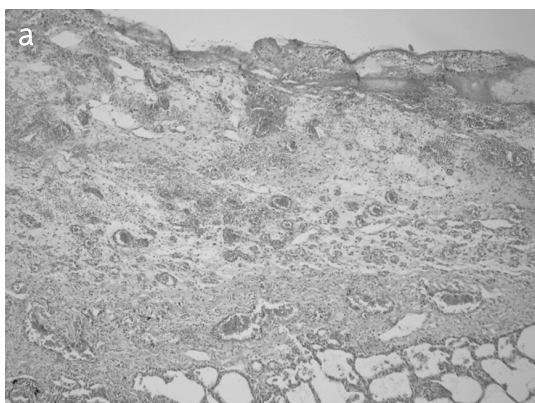
**Figure 1.** CT scan – multiple abscesses of the lung tissue and restricted pleural empyema

The methods of surgical treatment are based on the fundamental rule of the surgery of purulent states – “ubi pus ibi evacuo”, which leads to performing all activities enabling emptying the abscess from the infected material and rinsing the abscess cavity with the solutions of antiseptic drugs and antibiotics. Surgical treatment involves removing of the lung tissue together with the abscess during thoracotomy.

Below there are techniques of surgical treatment of the lung abscess.

### Intracavenous application of drugs

Involves puncture of the abscess through the thoracic wall and application of antibiotics into its cavity. This method is used in case of large, peripheral abscesses with the adhesion of the lung and parietal pleura. There is a risk that pneumothorax or pleural empyema develop.



Fragments of surgically removed tissues from the pleural cavity (after decortication of lung with pus evacuation) from a 64-year-old man who several days ago had a lung tumor diagnosed, which proved to be an abscess. The patient had high fever and dyspnoea and his condition worsened beside intensive antibiotic therapy.

Notice:

- Numerous dilated blood vessels (granulation tissue creating pyogenic membrane),
- Abundant inflammatory infiltrations consisting of neutrophil granulocytes and mononuclear cells,
- Protein (eosin absorbing) masses – remaining after purulent exudates.

**Figure 2.** Chronic pleural empyema (hematoxylin and eosin stain)

### Endoscopic drainage of the abscess

If the cause of the abscess is pathology in the bronchial tree causing its obstruction and remaining of the infected secretion in the bronchus distally from the obstruction an effective method of treatment is emptying the abscess from the liquid by a fiberoptic bronchoscope. The procedure may be completed with injecting an appropriate antibiotic into the cavity of the abscess.

### Cavernostomy

Pneumonostomy or cavernostomy (Monaldi's procedure) used to be a recognised method of treatment of the lung abscess and in some cases is also applied nowadays. Achieving obliteration inside the pleural cavity, which means the adhesion of the lung and the parietal pleura, is a necessary condition of safe procedure. The abscess cavity was open in the place where it was the closest to the thoracic wall after resection of 2-3 ribs and revealing the lung tissue. Next, the chamber of the abscess was tamponned with a gauze pad soaked with an antiseptic drug. Secondary healing and contraction of the defect in the lung tissue was obtained by changing dressings for several weeks [1].

### Transcutaneous drainage of the abscess

Transcutaneous drainage of the abscess controlled in fluoroscopy or computer tomography is a method introduced in the past three decades and is an effective method of treatment in some cases. This method is limited by an unfavourable location of the abscess concerning vital anatomical structures, which may make a safe application of the drainage impossible. Serious complications of using this method are: pneumothorax with bronchial fistula, pleural empyema, bleeding, sudden circulatory arrest [7]. This method is contraindicated in patients with hemostasis disorders [8].

### Endoscopic abscess drainage

This is a new method of treatment of the abscesses connecting with the bronchus. The procedure involves entering the bronchial tree with the fiberoptic bronchoscope and placing its end as close to the abscess cavity as possible. Next, the guide wire, controlled by fluoroscopy, is passed through the operating channel into the abscess cavity. After making sure that the guide wire is placed correctly, the catheter (7F, 90 cm long) is fed over the guide wire (*pigtail catheter – Cordis; Miami, FL*). The position of the catheter can be evaluated by application of the non-barium contrast medium (Isovist-300) into the abscess cavity. The end of the catheter is led out through the nostril. This method allows evacuation of the fluid from the abscess and rinsing it with the antibiotic or antimycotic agent

solution (Amfotericin B). The catheter is placed for 3 to 21 days. This technique allows gradual emptying of the abscess, its sterilization and obliteration [1].

### Surgical treatment of the lung abscesses

The resection of lung tissue with the abscess is a final method of treatment, which often cannot be performed due to the risk of severe septic complications and poor patient's general condition. Surgical treatment is recommended when all methods of conservative treatment or less invasive techniques proved ineffective or when complications requiring surgical intervention occur. Indications to surgical treatment are abscesses leading to bleeding from the bronchial tree, development of pleural empyema, bronchial fistula, foreign object that cannot be removed, extensive damage of the lung tissue and suspicion of neoplastic aetiology. Removing the part of the lung tissue with the abscess allows recovery in 90% cases, however, it should be mentioned that the postoperative period is burdened with a high mortality rate up to 11-28%.

The kind of resection of the lung tissue depends on the location and dimensions of the abscess and patient's general condition. In case of smaller peripheral abscesses, unanatomical resection (wedge, marginal resection) of the lung tissue can be performed using linear staplers type TA and GIA. Large abscesses, abscesses located deeply into the lung tissue or multiple abscesses are indications to more extensive anatomical resections. The most frequent procedure is the resection of the lung lobe (lobectomy) or two lobes of the right lung (bilobectomy). In case of abscesses, causing a wide damage of the lung tissue it is sometimes necessary to perform pneumonectomy. Rarely topical conditions enable semisegmentectomy or bisegmentectomy. In case of some small peripheral abscesses or in limited pleural empyema it is possible to apply the VATS technique [9].

### Anaesthesiological problems

An anaesthesiologist takes care of the patient with a lung abscess at two stages of treatment: first – in the operating theatre, second – in the intensive care unit. The patient's anaesthesia, concerning his poor general condition, should influence the activity of his organs the least possible. Oral premedication with benzodiazepines (Midazolamum) is a preferred method. Another recommended technique is a balanced anaesthesia (connected, combined). It is the conduction anaesthesia (paravertebral or epidural anaesthesia in the thoracic segment of the spine) combined with the general anaesthesia. Conduction anaesthetics (bupivacaine, ropivacaine) may be applied into the epidural space with or without opioids (Fentanyl-Janssen, Morphinum-Spinal). In general anaesthesia it is recommended to use a respiratory mixture containing oxygen, air and halogenated

anaesthetic (sevoflurane, isoflurane, desflurane). In this kind of procedure, it is necessary to exclude the operated lung from ventilation so the patients should be intubated with bicanalicular tubes. The patient's condition and the influence of applied techniques should be properly monitored. A routine procedure involves evaluation of the heart rate, blood pressure with a non-invasive method (NiBP), ECG, body temperature and ventilation parameters as well as the composition of the respiratory mixture. In patients estimated at  $\geq$  stage III of physical state ASA (American Association of Anaesthesiologists Scale) it is recommended to evaluate blood pressure with an invasive technique (BP) and consider hemodynamic monitoring with a Swan-Ganz catheter [10].

In the postoperative period, it is vital to apply proper analgesic treatment. Pain is estimated in VAS (visual analogue scale) or/and PHHPS (Prince Henry Hospital pain scale). Usage of conduction methods of anaesthesia, thanks to effective pain killing makes expectoration easier and improves patient's comfort. By speeding up the peristalsis it enables early (after a few hours) enteral nutrition and drug application. Analgesic drugs MUST be applied in a specified period of time, before the pain occurs. In some cases, there is a necessity of applying respirotherapy. It is then recommended for the intubation tubes to be made of biocompatible materials (silicone/polyurethane) and for the pressure in the cuff of the intubation tube to be monitored (prevention of mucous ischemia). Atelectasis on one side is an indication to applying ventilation with positive end expiratory pressure (PEEP) and combining standard ventilation with quick one (e.g. jet ventilation). In this technique, a special catheter (connected to a jet respirator) is passed through the intubation tube and placed in the main bronchus of the atelectatic lung. For sedation of these patients, it is recommended to use a constant intravenous infusion of Midazolam combined with e.g. morphine. An appropriate antibiotic therapy is vital and is established in cooperation with the Bacteriological Laboratory. Some patients require constant vascular access. Cannulation of the subclavian vein and usage of the catheter with antibacterial cover (Vantex/ ArrowGuardBlue) is then recommended [11].

### Material and methods

Over 10 years (January 1995 – December 2004) there were 89 patients with lung abscesses admitted to the clinic. Most of them were men – 62 (69.7%), women – 27 (30.3%). They were aged between 21 and 86 years old (approximately 49.4 years old). All of them underwent conservative treatment in the pulmonologic ward, internal medicine ward, intensive care unit, neurological and laryngological wards, where they were treated with antibiotics for 3 to 62 days. The cause of referral of these patients to

**Table I.** Causes of the lung abscess in 89 patients

No.	The cause of abscess	Number	Percentage
1	Pneumonia	27	30.3%
2	Choking	15	16.8%
3	Aspiration of a foreign object	9	10.1%
4	Injury	7	7.9%
5	Tuberculosis	5	5.6%
6	Abscess in the neoplastic process	4	4.5%
7	Mycelium	3	3.4%
8	Unknown	19	21.3%

**Table II.** Bacterial flora in the material from the lung abscesses

No.	Bacterial strain	Number	Percentage
1	<i>Streptococcus pneumoniae</i>	13	21.3%
2	<i>Staphylococcus aureus</i>	11	18.1%
3	Mixed flora	10	16.4%
4	<i>Pseudomonas aeruginosa</i>	7	11.5%
5	<i>Klebsiella pneumoniae</i>	5	8.2%
6	<i>Bacteroides fragilis</i>	4	6.5%
7	<i>Aspergillus fumigatus</i>	3	4.9%
8	<i>Fusobacterium</i>	3	4.9%
9	<i>Proteus mirabilis</i>	2	3.3%
10	<i>Escherichia coli</i>	2	3.3%
11	<i>Haemophilus influenzae</i>	1	1.6%
	<b>Total</b>	<b>61</b>	<b>100%</b>

surgical treatment was ineffective conservative treatment or development of complications of the lung abscess. The most important causes of development of the lung abscess were pneumonia, choking, aspiration and injuries (Table I). Singular abscess was diagnosed in 71 patients (79.8%). Multiple abscesses were diagnosed in 18 cases (20.2%), 16 of these were located in one lung and two in both lungs. Double abscesses were the most frequent among multiple abscesses (15 cases), triple in two cases. In one case, we noticed four abscesses in one patient – 3 in the right lung and one in the left one. Taking multiple abscesses into consideration, the general amount of abscesses was 111.

In 61 patients (68.5%) we were able to gather the material for bacteriological evaluation, which enabled us to estimate bacterial flora from the abscesses (Table II).

The dimensions of the abscesses were between 1.5 and 10.2 cm (approximately 4.1 cm). As for the location of the abscesses, they were placed in the following way: a) right lung: lower lobe – 44 (40%), medial – 9 (8.1%), upper – 17 (15.3%), b) left lung: lower lobe – 29 (26.1%), upper lobe – 12 (10.5%).

**Table III.** Surgical methods of treatment of patients with lung abscesses

No.	Procedure	Number
1	Transcutaneous drainage of the abscess	9
2	Pleural drainage + antibiotic therapy	6
2	Repeated bronchoaspirations + antibiotic therapy	5
3	Wedge or marginal resection	35
4	Segmentectomy	7
5	Lobectomy	18
6	Bilobectomy	3
7	Pulmonectomy	4
8	Cavernostomy	2

**Table IV.** Postoperative complications in patients with a lung abscess

Light complications	Number
1 Lung atelectasis	11
2 Pleural exudate	9
3 Infection of the thoracotomy wound	8
4 Long lasting air shunt	7
<b>Total</b>	<b>35</b>
Serious complications	Number
5 Pleural empyema	6
6 Circulatory insufficiency	5
7 Septic shock	5
8 Recurrence of the abscess	4
9 Bleeding after thoracotomy	3
10 Phlegmon of the thorax	2
11 Septic encephalitis	2
<b>Total</b>	<b>26</b>

Twelve (13.5%) of our patients with the lung abscess had pleural exudates, 17 (19.1%) limited or diffuse empyema, 11 (12.3%) had pneumothorax caused by perforation of the abscess to the pleural cavity or iatrogenic causes (puncture of the abscess, incompetent application of drainage), 5 (5.6%) patients had bleeding to the respiratory tract and in 3 cases there was a malignant neoplasm (3.4%).

## Results

Before making the decision about the kind of procedure for every patient, they had classical x-ray images, computer tomography and fiberoptic bronchoscopy performed. After taking into consideration all data concerning the dimensions of the abscess, its location, communication with the bronchus, the state of both lungs, complications present, general patient's condition and ventilation

parameters we chose the best method of treatment. Surgical resection of the lung tissue was necessary in 67 cases, cavernostomy in 2; in the rest of cases, we applied surgical methods without thoracotomy. Among all surgical procedures the most frequent was unanatomical resection of the lung tissue applied in 35 cases (including stapler wedge resection – 23, marginal resection – 12). Small peripheral abscesses were an indication to this method. In some cases when we diagnosed restricted pleural empyema, exudates with fibrin or cavities the procedure was completed with decortication or debridement. Anatomical resections of the lung tissue were performed in 32 cases. Among this group, resection of one lobe was the most frequent (18 patients). The basic indication to lobectomy was an abscess of a large diameter or smaller one but placed deep in the lung tissue causing bleeding to the bronchial tree as well as the abscess in the course of lung cancer. Seven patients had larger procedures performed: 3 bilobectomies and 4 pulmonectomies. They were necessary in case of large abscesses, which involved the lung area larger than one lobe or in case of multiple abscesses. In 7 cases of favourably located abscesses of smaller dimensions we managed to perform anatomical segmentectomies (3 semisegmentectomies and 4 bisegmentectomies). In two patients with chronic lung abscesses and coexisting empyema, in whom the lung did not expand after the drainage, we applied cavernostomy with fenestration of the thoracic wall after resection of two ribs and then we continued outpatient treatment involving application of setons soaked in an antiseptic drug into the pleural cavity. After sterilization of the pleural cavity and healing by granulation, we closed the stomy in the thoracic wall using thoracoplasty.

In the last 20 cases, we performed other procedures. In 5 patients, where the constriction of the bronchus was the cause of the abscess, bronchoaspirations (repeated twice a day) and antibiotic therapy based on the antibiograms proved successful. In 5 patients we achieved good results after targeted antibiotic therapy and pleural drainage. There were cases of peripheral abscesses with pleural exudates in the acute phase (up to 3 weeks from the beginning of the disease) where the lung tissue was not destroyed.

In 9 patients in a poor general condition, whose state prevented us from performing resection of the lung tissue, we applied transcutaneous drainage of the abscess cavity (Table III).

In some patients who underwent resection it was necessary to perform additional procedures such as decortication – 17 patients, irrigation drainage of the pleural cavity – 9 patients, chemical pleurodesis – 32 patients.

Positive treatment results such as: expansion of the lung, regression of the septic process and the ability to discharge the patient were obtained in 72 cases

(80.9%). 26 patients developed serious complications 7 (7.9%) of which died in the early postoperative period (up to 30 days after the operation).

Most complications were dealt with using conservative treatment in the intensive care unit with cooperation of a cardiologist, pulmonologist, neurologist and infectious diseases specialist. Rethoracotomy was necessary in 10 cases (bleeding, recurrence of the abscess, pleural empyema) three of which required another (second) rethoracotomy. In case of pleural exudates or empyema after thoracotomy they were cured by drainage of the pleural cavity (Table IV).

The time of treatment of the patients with a lung abscess was between 4 and 38 days (approximately 12.3 days).

## Discussion

High effectiveness of modern antibiotic therapy enables conservative treatment of most patients with a lung abscess. In the past decade a significant growth in the number of resistant pathogens, which release enzymes inactivating even the most sophisticated antibacterial agents, can be observed, which is the cause of failure in treatment of some patients. Invasive methods of treatment like: transcutaneous drainage and resection of the lung tissue are reserved for a limited group of patients (approximately 10-15%), who develop serious complications requiring surgical treatment regardless of the abscess such as bleeding, pneumothorax or pleural empyema. An abscess coexisting with the cancer, tuberculosis or mycetoma is also an indication to surgical treatment as well as the abscess not responding to conservative methods and leading to extensive damage of the lung tissue. A long lasting conservative treatment of patients in non-surgical wards ended in failure leads to the situation in which patients directed to surgical treatment are in a very poor general condition: cachectic, in a septic state with immune failure, with low breathing reserve and accompanying organ failure. In such cases, qualification to surgical treatment requires consideration. If less invasive methods were not fully used earlier, after necessary examinations and patient's evaluation, it is recommended to perform endoscopic restoration of bronchus patency, drainage of the pleural cavity or puncture of the abscess through the thoracic wall. These procedures are completed by a targeted antibiotic therapy, dietetic treatment, compensating the loss of electrolytes and proteins and application of immunoglobulins in order to improve the function of the immune system. In some cases, these activities are effective and enable the patients' recovery. The other patients, who did not reveal improvement, require thoracotomy with resection of the lung tissue. The range of the planned resection should be adjusted individually to the patient based on the x-ray and CT images and endoscopy. The factor

determining the operating tactics is an intraoperative image, particularly the location of the abscess, its dimensions, the condition of the lung and coexisting pathologies. Small favourably located peripheral abscesses may be removed by wedge resection of the lung tissue using two or more linear staplers. A simple marginal resection is rarely effective due to spherical shape of the abscess, significant thickness of the lung tissue encapsulating it, difficulties in precise estimating abscess borders and evaluation of the communication with the bronchus. In larger abscesses, it is necessary to perform anatomical resection. The most frequent is lobectomy or bilobectomy and sometimes resection of one or more lung segments. If the abscess causes extensive damage of the lung tissue or there are multiple abscesses, it may be an indication to resection of the whole lung. In some cases beside the lung resection, there are other additional procedures necessary such as debridement of the pleural cavity, pleurectomy, decortication, fenestration of the pericardium in a coexisting pericardial empyema, mediastinotomy, application of irrigation drainage in the pleural cavity and chemical pleurodesis.

It is significant that anatomical resections of the lung tissue with an abscess are technically difficult due to inflammatory processes, adhesions, obliteration of the interlobular fissure, blurring of the anatomical borders in the pulmonary hilus. There are especially high requirements to the surgeon in case of the lung abscess coexisting with the pleural empyema. In this situation, in the first stage of the operation it is necessary to perform decortication, which usually is connected with significant bleeding and the air shunt from the surface of the lung decorticated from the empyema capsule. It creates difficult conditions for safe preparation of the vessels and bronchus necessary for anatomical resection. We observed that in case of abscesses coexisting with empyema, beside decortication and resection of the lung tissue, application of the irrigation drainage for 3-5 days had a positive effect and reduced the risk of recurrence of the empyema. If those patients had to have lobectomy or bilobectomy performed, the air shunt caused by difficulties in expansion of the rest of the lung lasted much longer in the postoperative period. In some cases, when patients developed respiratory insufficiency and a little susceptibility of the lung to expansion, in an early postoperative period we applied ventilation with positive end expiratory pressure or jet ventilation of a high frequency. A significant element of the postoperative treatment was everyday cleaning of the bronchial tree from the remaining exudates with bronchoaspiration. Two patients developed a bronchial fistula in the postoperative period, the lung did not manage to expand, in this case rethoracotomy, closing of the fistula, and thoracoplasty was necessary.

The method of transcutaneous drainage was applied in nine cases. Its outcome must be considered ineffective. Three of those patients developed pneumothorax with empyema, which qualified them to surgical treatment (thoracotomy). One of them had sudden circulatory arrest and died during application of the drainage. As our slight experience shows, this method should be limited to selected cases (poor general condition making thoracotomy impossible, large abscess not communicating with the bronchus, adhesion of the lung to thorax).

## Conclusions

Surgical treatment of abscesses requires an individual approach to every patient regarding his general condition, aetiology, dimensions and location of the abscess, presence of coexisting diseases and predictable postoperative outcome. In some cases less invasive methods combined with intensive medical treatment in the intensive care unit with a constant thoracosurgery surveillance is effective. Thoracotomy with resection of the lung tissue with the abscess makes the recovery possible; however, intensive postoperative treatment is a determinant factor. Poor general condition of patients and the risk of severe complications make the postoperative period dangerous and lead to death in almost 10-20% cases.

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