Surgical considerations in the therapy of pleural empyema

Problemy chirurgicznego leczenia ropniaka opłucnej

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Abstract

Introduction: The therapy of pleural empyema is the most challenging issue in surgery due to long-term hospitalization, high costs and frequent complications as well as the high mortality rate exceeding 20%.

Aims: The study aimed to evaluate early results of pleural empyema therapy with respect to therapeutic modality, pleural empyema phase, aetiology, image study patterns, general patient state and coexisting diseases.

Material and Methods: The study involved the retrospective review of 51 patient medical records with the diagnosis of pleural empyema within two years.

Results: The study enrolled 42 male and 9 female patients. The serous, fibropurulent and organization stage of pleural empyema were 19.6%, 70.6% and 9.8%, respectively. With regard to aetiology, the majority were parapneumonic empyemas 66.7%, then iatrogenic 12.7%, post-traumatic 9.8%, and the remaining 2%. The bacterial cultures produced positive results in 32 patients. The most common were aerobic pathogens: *Klebsiella pneumoniae* (12.5%), *Staphylococcus aureus* (9.4%) and *Pseudomonas aeruginosa* in addition to anaerobic *Bacteroides fragilis* (6.2%). In 9 patients (28.1%) mixed bacterial pathogens were found. The majority of patients were in a poor general state and their immune system was impaired due to the underlying condition.

Conclusions: The therapy of pleural empyema requires a differential approach with regard to: general state of patient, dimensions and empyema location, disease duration, coexisting lung pathology and surgical experience. Superior results are achieved with early stages of pleural empyema using antibiotic therapy, pleural drainage along or with the administration of fibrinolytics or videothoracoscopy. Empyemas in the late, fibropurulent or organization stage usually require thoracotomy with decortication. Serious general condition, coexisting con-

Streszczenie

Wstęp: Leczenie ropniaka opłucnej pozostaje jednym z najtrudniejszych wyzwań w chirurgii ze względu na długi czas hospitalizacji, wysokie koszty, częste powikłania oraz wysoką śmiertelność przekraczającą 20%.

Cel: Ocena wczesnych wyników leczenia ropniaka opłucnej z uwzględnieniem zastosowanej metody leczenia, fazy ropniaka, etiologii, obrazu ropniaka w badaniach radiologicznych, stanu ogólnego pacjenta oraz chorób współistniejących.

Materiał i metody: Retrospektywna ocena dokumentacji medycznej 51 chorych (42 mężczyzn oraz 9 kobiet) leczonych przez okres dwóch lat z rozpoznaniem ropniaka opłucnej.

Wyniki: Ropniaki w fazie surowiczej stanowiły 19,6%, włóknikowo-ropnej 70,6%, w fazie organizacji 9,8%. Pod względem etiologii dominowały ropniaki parapneumoniczne – 66,7%, następnie ropniak jatrogenny – 12,7%, pourazowy – 9,8 %, inne – 2%. W posiewach bakteriologicznych główne patogeny zidentyfikowano u 32 chorych. Najczęściej występowały tlenowce: *Klebsiella pneumoniae* (12,5%), *Staphylococcus aureus* (9,4%) oraz *Pseudomonas aeruginosa*, wśród beztlenowców *Bacteroides fragilis* (6,2%). U 9 chorych (28,1%) wykazano obecność mieszanej flory bakteryjnej. Większość pacjentów prezentowała złą kondycję ogólną i była obciążona chorobami prowadzącymi do upośledzenia sprawności układu immunologicznego.

Wnioski: Leczenie ropniaka opłucnej wymaga zróżnicowanego podejścia uwzględniającego: stan ogólny pacjenta, rozmiary i lokalizację ropniaka, czas trwania choroby, współistniejące patologie w płucu i jego sąsiedztwie oraz doświadczenie chirurga. Najlepsze rezultaty daje leczenie we wczesnej fazie ropniaka z zastosowaniem: antybiotykoterapii, drenażu opłucnej lub drenażu z podawaniem fibrynolityków, wideotorakoskopii. Ropniaki w późnej fazie włóknikowo-ropnej i fazie organizacji wymagają zwykle torakotomii z dekortykacją. Zły stan ogólny, współistnie-

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ditions and surgical complications are associated with a high percentage of fatal final outcomes.
Key words: pleural empyema, parapneumonic effusion, pleural empyema therapy, bronchial fistula.

jące choroby oraz powikłania leczenia chirurgicznego związane są z wysokim odsetkiem niepowodzeń i śmiertelności.
Słowa kluczowe: ropniak opłucnej, wysięk parapneumoniczny, leczenie ropniaka opłucnej, przetoka oskrzelowa.

Introduction

Pleural empyema is a rapid inflammatory process related to infection of the sterile pleural cavity affected by various microorganisms (bacteria, fungi, some protozoa). The most frequent aetiology (about 40-60%) is lung infectious diseases, particularly the outcome of para- or postpneumonic exudate [1-5]. Iatrogenic infections after surgical interventions take second place in frequency of empyema causes (about 30%) [6]; injuries of the thorax and mediastinum should also be mentioned (1.6-4.2%) [7, 8]. The pleural cavity may be rarely infected through blood-borne infection or lymphatic passage from a different infectious focus (liver abscess) or from surroundings (subphrenic abscess, mediastinitis). Various diseases and states leading to immunosuppression, such as diabetes mellitus, neoplastic disease, chronic alcoholic disease, malnutrition, drug addiction, and immunosuppressive drug treatment, are associated with pleural empyema evolution including leucopenia, irradiation-radiotherapy with bone marrow failure, chemotherapy, HIV infection, and advanced age [9-11]. Three stages of pleural empyema evolution are typically discerned [12-14]. It begins with the serous phase (stage I). It is caused by higher permeability of capillary vessels of pleura in response to invading microbes. Accumulating exudate has low density and the lung is mobile. Antibiotic therapy and closed pleural drainage are the basic treatment in this stage. In the next stage (fibrinopurulent) the pus accumulates in the pleural cavity, and deposits of produced fibrin cover the surface of the lungs and parietal pleura. This results in formation of numerous, well limited fluid cisterns. In such circumstances, lung permeability to expand is limited and closed drainage is usually ineffective. Without surgical intervention empyema evolves to the third stage called the organization phase. It is characterized by migration of fibroblasts from the pleura and deposits of collagen fibres forming a thick crust encircling the pus cistern, continuous with adhesions of the parietal pleura and the lung. It results in fixation and aggravating lung restriction, limited diaphragm and chest wall mobility with contracted intercostal spaces. Evacuation of purulent fluid from the pleura and releasing the lung fixed under the thick fibrous capsule of empyema can be performed only during thoracotomy. The treatment of a pleural empyema, despite progress in modern medicine, is still a substantial surgical challenge because of the long time of hospitalization, high expenses and disappointing treatment results. A risk of serious complications occurs in the course of the disease, and prognosis is uncertain. It is estimated that 40% of patients treated for pleural empyema require surgical intervention. General mortality is estimated at the level of about 15%. The fatality in patients with a history of serious diseases, immunodeficiency and at advanced age reaches 25%-75% [8, 15].

Aims

A retrospective analysis of medical records of 51 patients treated during 2 years for pleural empyema was performed. General condition, coexisting diseases, reported ailments, RTG and CT image of empyema were analyzed. Molnar's classification (Table I) was used to determine the aetiology of empyema [16]. The pathological agent was identified based on bacteriological culture in the case of some patients. The analysis of early effects of treatment was performed, considering the stage of empyema, coexisting pulmonary lesions and/or lesions in adjacent organs, and general state of the patient.

Materials and Methods

During 2 years (2006-2007), 51 patients with a diagnosis of pleural empyema were treated. The diagnosis of empyema was established after complying with at least one of four requirements: 1) purulent secretion in pleural cavity during thoracocentesis, pleural drainage, videothoracoscopy, thoracotomy; 2) isolation of bacterial strains in bacteriological cultures; 3) complying with positive biochemical criteria defined by Light in a sample of pleural effusion (pH < 7.2, glucose level in specimen < 400 mg/l, LDH > 1000 IU/ml, protein level > 3 g/ml and WBC > 15000/mm^3 [17]; 4) positive correlation between clinical and radiological image of empyema. The study included 42 males, aged 63.8 (± 29-83 years) and 9 female aged 65.5 (± 31-87 years). Empyemas were localized in: the right pleural cavity in 25 patients (49%), the left pleural cavity in 24 patients (47%), bilateral empyemas in 2 patients (4%). All patients formed a heterogeneous group considering aetiology, stage of evolution and coexisting diseases. Most patients were in a poor general condition caused by septic state and coexisting diseases.

Results

Aetiology

The most frequent aetiology was para- and postpneumonic; it was diagnosed in 34 patients (66.7%). The second cause of empyemas, iatrogenic infections, was identified in

Tab. I. Aetiology of pleural empyema

Aetiology of pleural empyema	
Primary para/postpneumonic **empyema**	
Secondary **empyema after lung resection**	
	without bronchial fistula
	with bronchial fistula
Secondary **empyema** after other surgical injuries	
Secondary **empyema** after non-medical injuries	

11 patients (21.6%). Past injuries of the thorax caused empyemas in a further 5 patients (9.8%). In 1 case (2.9%) the aetiology was defined as 'other'. In that case the empyema developed in a patient with Hodgkin's disease. Aetiology of the empyemas in the material is presented in Table II.

In a group of 34 patients with para- or postpneumonic empyemas initial causes were established as (Table III): pneumonia – 18 cases (52.9%), lung abscess – 5 (14.7%), pneumothorax – 3 (8.8%), pulmonary tuberculosis – 3 (8.8%), pulmonary carcinoma – 2 (5.9 %), metastatic carcinomas in lungs (rectal carcinoma, bladder cancer) – 2 cases (5.9%), pleural epithelioma – 1 (2%). Iatrogenic empyemas, diagnosed in 11 patients, were complications after surgical procedures. Four cases were diagnosed after pneumonectomy (including 2 with bronchial fistula), in 3 patients with prolonged pleural drainage because of pneumothorax (air shunt from 7 to 12 days). Repeated thoracocentesis in patients with hydrothorax resulted in 2 empyemas. In one case the empyema was a result of prolonged air shunt after lobectomy. In the last case a pleural cavity was infected after VATS procedure with talc pleurodesis in a patient with hydrothorax caused by circulatory failure.

Stages of evolution of pleural empyema

Among patients treated for empyema as many as 36 cases were in the fibropurulent stage (70.6%) (Table IV). Serous empyemas were diagnosed in 10 patients (19.6%). A less numerous group was that of empyemas in the organization stage that occurred in 5 patients (9.8%). It should be emphasized that 42 of the examined patients (82%) were previously inefficiently treated for empyema in non-interventional wards with conservative methods reduced to intravenous antibiotic therapy and pleural thoracocentesis.

Tab. II. Aetiology of pleural empyema in the study cases (51)

Empyema aetiology	Cases	%
Primary empyema para/postpneumonic	34	66.7
Secondary empyema after other surgical injuries	6	11.7
Secondary empyema after lung resection without bronchial fistula – 3 with bronchial fistula – 2	5	9.8
Secondary traumatic empyema	5	9.8
Other	1	2

Tab. III. Causes of para- and postpneumonic empyema

No	Initial cause	Number	%	Comment
1.	pneumonia	18	52.9	
2.	empyema	5	14.7	
3.	pneumothorax	3	8.8	
4.	tuberculosis	3	8.8	
5.	primary lung cancer	2	5.9	Ca micro Ca plano
6.	lung metastases	2	5.9	Ca recti Ca uteri
7.	malignant mesothelioma	1	2.9	
	all:	34		

Tab. IV. Stages of pleural empyema evolution

	Serous	Fibrinopurulent	Chronic
Number	10	36	5
%	19.6	70.6	9.8

Microbiology

The pathological constituents of empyemas were determined in 32 cases (62.7%).

The cultures were prepared from samples obtained during thoracocentesis, pleural drainage, videothoracoscopy or thoracotomy (Table VI). No substantial prevalence of infection with a certain type of bacteria was observed. The most frequently obtained microbes were aerobic bacteria: Gram negative bacilli: *Klebsiella pneumoniae* (12.5%) and *Pseudomonas aeruginosa* (9.4%) and Gram negative *Staphylococcus aureus* (9.4%). Among anaerobic bacteria the most frequent was Gram negative *Bacteroides fragilis* (6.2%). In 9 patients (28.1%) mixed bacterial flora was demonstrated.

Tab. V. Microbiological analysis of pleural empyema

No	Pathogen		Cases	%
1.	*Klebsiella pneumoniae*		4	12.5
2.	*Staphylococcus aureus*		3	9.4
3.	*Pseudomonas aeruginosa*		3	9.4
4.	*Pneumococcus pneumoniae*		2	6.2
5.	*Bacteroides fragilis*		2	6.2
6.	*Acinetobacter baumannii*		2	6.2
7.	*Haemophilus influenzae*		1	3.1
8.	*Enterobacteriaceae*		1	3.1
9.	*Escherichia coli*		1	3.1
10.	*Serratia marcescens*		1	3.1
11.	*Streptococcus pneumoniae*		1	3.1
12.	*Moraxella catharalis*		1	3.1
13.	*Staphylococcus epidermidis*		1	3.1
	Mixed flora			
1.	*Klebsiella pneumoniae*	*Haemophilus influenzae*	2	6.2
2.	*Klebsiella pneumoniae*	*Bacillus fragilis*	1	3.1
3.	*Staphylococcus ureus*	*Pseudomonas aeruginosa*	2	6.2
4.	*Pseudomonas aeruginosa*	*Serratia marcescens*	1	3.1
5.	*Pneumococcus pneumoniae*	*Acinetobacter baumannii*	1	3.1
6.	*Acinetobacter baumannii*	*Staphylococcus epidermidis*	1	3.1
7.	*Acinetobacter baumannii*	*Serratia marcescens*	1	3.1
	all:		32	

Tab. VI. Coexisting diseases in patients with pleural empyema

No	Coexisting disease	Cases	%
1.	Chronic heart failure	19	29.4
2.	Chronic respiratory failure	16	21.6
3.	Diabetes	11	15.7
4.	Emphysema	7	13.7
5.	Prior surgery (excluding chest surgery)	5	9.8
6.	Chemo/radiotherapy completed	5	9.8
7.	Alcohol abuse/addiction	4	7.8
8.	Cancer with metastases	3	5.9
9.	Recent myocardial infarction	2	3.9
10.	Leukaemia	2	3.9
11.	Chronic renal failure, dialysis	2	3.9
12.	Tetraplegia	1	1.96
13.	Oesophageal cancer	1	1.96
14.	Stroke	1	1.96
15.	Anorexia	1	1.96
16.	Extreme scoliosis	1	1.96
17.	Polyarthrosis	1	1.96

Clinical picture

Commonly reported ailments in the course of empyema were: thoracic pain (86.3%), high temperature (76.5%), cough (68.6%), weight loss (62.7%), dyspnoea (58.8%), excessive sweating (52.9%), loss of appetite (47%), tachycardia (37.2%), short breath (33.3%), purulent sputum expectoration (31.4%), hypotension – RR < 90 mm Hg (29.4%), abdominal pain (11.7%). In laboratory investigations, the most vital deviations were: thrombocytosis (62.7%), hypoalbuminaemia (66.7%), leukocytosis over 15 000 (37.5%) and anaemia (23.5%).

Coexisting diseases

Serious coexisting diseases leading to impairment of the immune system or triggering pleural infections were diagnosed in most patients treated for pleural empyema (Table VI). The most common were: circulatory failure (37.3%), respiratory failure (31.4%), diabetes mellitus (21.6%), emphysema (13.7%), past extensive surgeries not related to thoracic surgery (9.8%), state after chemotherapy or radiotherapy in neoplastic disease (9.8%), chronic alcoholism (7.8%), disseminated neoplastic disease (5.9%) and others. More than 2 risk factors for a pleural empyema coexisted in some patients. Furthermore, as many as 82% of patients were previously treated in different wards for mentioned diseases: 21 in the pulmonary department, 8 in the intensive care unit, 6 in the internal diseases department, 5 in the department of general surgery and 2 in the neurosurgical department. This increased the risk of hospital infections.

Therapeutic methods

Intravenous antibiotic therapy was a routine therapy in all patients regardless of previously performed thoracosurgical procedures. A combination of two or three antibiotics was used in most cases. It was mainly metronidazole conjugated with third generation cephalosporin, less frequently with methicillin, ciprofloxacin, imipenem, modified according to the results of a bacteriological culture.

Pleural drainage

An elementary indication to perform pleural drainage was an empyema in the serous stage, where evacuation of infected liquid enabled expansion of the lung. The drainage was continued in the next stages of an empyema if the general state of the patient made general anaesthesia impossible. This technique was used as a preliminary therapy before introduction of different thoracosurgical procedures. Six patients were treated with classic active drainage of a serous stage empyema. An analysis of the radiological imaging (RTG, CT) enabled appointing of the drain insertion place. In the case of well-circumscribed cisterns the procedure was performed directly under ultrasonographic control. In one case talc pleurodesis was performed apart from drainage. This procedure was performed in a patient with a bilateral empyema after past chemo- and radiotherapy because of *ca. microcellulare*. In all patients pleural cavities were evacuated of liquid content and the lungs expanded. The duration of treatment with drainage varied from 3 to 9 days (average 3.7 days). Despite effective drainage, 2 patients from the examined group died of poor general condition caused by serious coexisting diseases (mentioned *ca. microcellulare* with bilateral empyema and a patient with disseminated neoplastic disease and diabetes). We also used the technique of drainage in the treatment of 14 patients with fibropurulent stage empyema. In order to remove fibrin effectively, fibrinolytics were administered intrapleurally during drainage in 8 patients. 250 000 IU of streptokinase in 100 ml of 0.9% NaCl were administered intrapleurally for 4-6 hours for the next 3 days. In 6 other patients irrigation drainage was performed. It requires insertion of two drains into the pleural cavities. Through the upper drain with smaller diameter (20F) placed anteriorly in the 2nd intercostal space, 200 ml of 0.9% NaCl solution was administered during 1 hour. The lower drain with a big diameter (32-36 F) inserted through the 7^{th} to 9^{th} intercostal space and connected with continuous suction enabled emptying of the pleural cavity. Solution of 0.9% NaCl was infused three times a day for 4 to 7 days. The effects of the stage II empyema treatment with drainage were assessed positively. The evacuation of purulent content and fibrin as well as lung expansion were obtained. One of the patients treated with irrigation drainage died. It was a patient after amputation of the left lower limb because of necrosis in the course of *arteriosclerosis obliterans*, with a history of diabetes mellitus and tuberculosis. The direct cause of death was atrial fibrillation with progressive cardiorespiratory insufficiency.

Videothoracoscopy procedures

Patients in good general condition with single, circumscribed fluid cisterns imaged on CT were qualified for tre-

atment with videothoracoscopy. Classic videothoracoscopy was performed with access of 3 trocars or VATS (*video assisted thoracic surgery*) with the approach from minithoracotomy and widening of the intercostal spaces. After introduction of the camera and the equipment into the pleural cavity the pleural adhesions formed of fibrin were separated, cut, irrigated and lavaged from fluid consistence with fibrin. This kind of procedure was performed in 6 patients. The evacuation of purulent material from pleural cavities and lung expansion were obtained in 5 out of 6 patients with stage II empyema. One patient with chronic respiratory insufficiency, serous stage empyema and syndromes of slowly aggravating cardiac tamponade was classified for videothoracoscopy. Apart from decortication also fenestration of the pericardium was done. It resulted in regression of symptoms of cardiac tamponade. Three days after drainage the patient was passed to the cardiology ward for further treatment of the underlying disease.

Thoracotomy

The basic indications for treatment with a surgical approach through thoracotomy were cases of chronic empyemas in the organization stage and complicated empyemas regardless of stage with coexisting pathologies of the lung or surrounding organs (tumour, abscess, persistent air leak, thoracic wall inflammation, bronchial fistula, oesophageal perforation). Thoracotomy was necessary in 3 patients with serous stage empyema because of pathological changes in the lung. Non-anatomical lung resection with good results was performed in 2 cases: because of *adenocarcinoma* type tumour after sigmoidectomy and in a patient with myeloid leukaemia and bronchiectasis. In the third patient a diagnosis of simultaneous pleural empyema, lung abscess and oesophageal cancer was established. The oesophagus was resected during thoracoscopy using the Ivory-Lewis method and wedge resection of the lung with abscess was performed. The patient died because of cardio-respiratory failure in the course of postoperative care. Access through a thoracotomy was used in the treatment of 12 patients with a fibropurulent stage empyema. In this group, lung decortication was performed in 8 patients, successfully in all cases. Apart from decortication, also pneumonectomy was necessary in 4 other patients. Multiple lung abscesses were indications for lung resection in 3 patients; in one case it was indicated because of gigantic emphysematous bullae. After pneumonectomy, 2 patients died in the postoperative course. In 5 patients a chronic empyema in an organization stage was an indication for thoracotomy. In 2 patients only decortication was performed during the procedure. In 1 patient, apart from decortication, also resection of the marginal part of the lung was necessary because it became damaged during preparation. A decision of additional thoracoplasty was made in the next patient after decortication. It included excision of 3 ribs because of small volume of unbound lung and intraoperative air leak. In the last case, after the decortication, a decision of pneumonectomy was made because of vast lung abscess. Two of the described patients died during the early postoperative period.

Thoracotomy in treatment of complications

Performing thoracotomy in the treatment of complications was necessary in 5 out of all patients treated for pleural empyema. The treatment of empyemas with drainage resulted in complications most frequently. This refers to 2 patients with traumatic empyemas treated with protracted drainage in different health centres. The first one required thoracotomy because of persistent air leak and no lung expansion. The patient was operated on twice: the marginal part of the lung was resected primarily and then, because of air leak and abscess, decortication and dressing of the fistula was needed. Despite intensive treatment, the patient died because of multiorgan insufficiency. The other patient after thoracic injury with persistent air leak, after ineffective drainage of an organized pleural haematoma, was primarily qualified for videoscopy, in which also haematoma evacuation and chemical pleurodesis were performed. After 11 hours thoracotomy with decortication was necessary due to prolonged air leak and abscess. The patient was cured. In the third patient, an abscess that developed after inefficient pneumothorax treatment initiated in a different medical centre was an indication for thoracotomy. Because of developing complications, as many as 3 procedures were performed in this patient. During the first thoracotomy, the lung was decorticated. Prolonged air leak and poor lung expansion were indications for a second thoracotomy. The reason for a third thoracotomy was a pleural empyema in the emphysematous chamber. Decortication and thoracoplasty with resection of 3 ribs was performed. The patient died in the course of serious cardio-respiratory insufficiency. Thoracotomy was also necessary in the treatment of two patients with empyema of the right pleural cavity caused by bronchial fistula after pneumonectomy. This complication occurred in 3.3% of patients after pneumonectomy in the mentioned period (61 cases). The first case was related to an early bronchial fistula that was diagnosed 5 days after the procedure. Irrigation drainage was involved at first. Then the fistula was provided with manual stitches during thoracotomy. Fenestration using Clagett's method was necessary because of recurrence of the fistula. After 14 weeks the bronchial fistula closed. After the next 4 days the thoracotomy was removed. The second case referred to a late bronchial fistula that appeared within 6 days after a pneumonectomy performed because of a non-microcellular carcinoma. The bronchial fistula was closed effectively using the method of myoplasty and covering it with a pedunculated fold of the major pectoral muscle.

Discussion

Pleural empyema is one of the oldest disease entities known to mankind. Its treatment is difficult and associated with a high death rate estimated at over 20% [18] despite

the progress of modern medicine. The main treatment of pleural empyema, known since Hippocrates' times, is effective pleural drainage. Its aim is evacuation of the purulent content, controlling the infection, and restoration of normal lung function [3]. The most important and still valid guidelines of pleural empyema treatment were presented by Mayo and associates in 1982: (1) saving life, (2) empyema elimination, (3) expansion of the bound lung, (4) restoration of physiological mobility of the thoracic wall and the diaphragm, (5) restitution of normal respiratory function, (6) avoiding complications and a chronic state as an outcome, (7) reduction of hospitalization time [19]. The choice of treatment strategy depends on three main factors: pleural empyema size, type of pleural exudation and the general condition of the patient [20, 21]. According to the American College of Chest Physicians, poor prognosis is associated with some radiological determinants: exudate filling over 50% of the pleural cavity volume, divided into cisterns, with parietal pachypleura [22].

The optimal method of pleural empyema treatment, especially late cases, is still controversial. It is certain that the basis of early pleural empyema treatment is intravenous antibiotic therapy in combination with procedures enabling evacuation of the infected fluid from the pleural cavity; thoracocentesis, insertion of an image guided catheter or active pleural drainage. Lately, intrapleurally administered fibrinolytic drugs and minimally invasive surgical techniques such as VATS (video assisted thoracoscopic surgery) were successfully introduced into practice in the treatment of early fibropurulent stage empyema. These methods result in reduced invasiveness and hospitalization time compared to thoracotomy [23, 24]. Simultaneously, in the case of incorrect qualification, it may result in failure in even 40% of cases and the necessity of thoracotomy during the procedure (conversion) or in the post-surgery period because of a persistent abscess or air leak complications [25-28]. Thoracotomy with decortication is a standard procedure in the treatment of late pleural empyema. In the case of accessory indications it is followed by lung resection and open drainage with resection of the ribs (fenestration). The surgical treatment of late empyemas is related to a high risk of failure because of a poor general state and development of general and local complications.

In the current study, 10 patients treated for empyema died. The general death rate reached 19.6% and is close to the rates reported in the literature. The fatality analysis depending on the method of treatment revealed 3 deaths in a group of 20 patients treated with drainage only (15% mortality). The cause of fatal final outcome in all cases was the serious general state emerging from coexisting diseases: neoplastic disease, diabetes, circulatory insufficiency and past surgeries. No complications caused directly by drainage were observed. The death rate in patients treated with drainage and irrigation of a pleural cavity in the early stages of empyema may reach even 10-15% [29, 30]. In the group of 6 patients treated with videothoracoscopy techniques no deaths were noted and the treatment resulted in pleural cavity evacuation and lung expansion. This was a result of meticulous qualification for this procedure. All patients, including the case of empyema with coexisting *hydropericardium*, were in good general condition. Among 25 patients treated with surgery from thoracotomy access with decortication and with or without lung resection (including 5 cases of reparation after previous thoracic surgeries), 7 died (28% mortality). In this group the main cause of death was also serious general state caused by coexisting diseases. It should be mentioned that decortication is a technically difficult procedure, usually performed in malnourished and wasted patients with other diseases, which corresponds with high mortality ranging from 1.3% up to 13% [31-35]. One of the most problematic concerns in thoracosurgery is the treatment of patients with empyema and a bronchial fistula after pneumonectomy. This complication is connected with the highest death rate in thoracosurgery, estimated at 30-50% [36, 37]. Empyemas after pneumonectomy are related to a bronchial fistula in almost 78-80% of cases, whereas the cause of empyemas after lobectomy is prolonged air leak from pulmonary parenchyma [38]. Patients with a bronchial fistula need immediate surgical treatment because of a low breathing reserve, septic state, risk of purulent leakage in the bronchial tree and development of multiple empyemas in one lung. Effective bronchial stump stitching is rare in the case of an early fistula. A local inflammatory state, ischaemia and stump fragility complicate attempts of manual or stapler suturing. The edges of the bronchus tear again. The techniques of removing and covering the fistula with a pedicle flap of the thoracic muscles (myoplasty) or a greater omentum (omentoplasty) with reducing thoracic volume (thoracoplasty) often result in failure. The simplest solution in the case of a late bronchial fistula with a diameter from 1 mm to 3 mm is prolonged drain presence. If the fistula has bigger size, drainage is recommended as the first procedure to save life. Then fenestration using Clagett's method is performed [39]. On the one hand, this procedure gives the possibility of curing the fistula. On the other hand, it results in the long-term necessity of managing with thoracotomy, which causes significant psychological discomfort and obligations hard to comply with in everyday life (changing bandages, wound dressing). The patients are at risk of serious complications that are often fatal. Attempts of managing with a bronchial fistula in the non-infected mediastinal area with access through sternostomy or mediastinoscopy and stapler stitching of the bronchus are known from the literature but are also technically difficult and risky. This is probably the reason why this technique is still not a common thoracosurgical procedure [40, 41].

Conclusions

Pleural empyema requires a differential approach at various stages in addition to specific considerations of general state of the individual patient, localization and dimension of the empyema in image studies, the duration of the disease, coexisting lung diseases and the experience of the

surgeon. The optimal results are achieved in the case of early stages of empyema: serous and fibrinopurulent stage. At this stage it can often be managed with antibiotics and drainage, intrapleural fibrinolytics or limited invasive thoracoscopy. Treatment of empyema in advanced purulent, fibrin and organization stages requires qualification for thoracotomy with decortication. Empyema surgery is associated with high risk of complications and mortality in numerous patients due to complications after decortication with lung damage, respiratory failure, persistent air leak, sepsis and coexisting conditions.

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