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## THE PROBLEM OF THE SURGICAL TREATMENT OF NON-SPECIFIC CHRONIC PLEURAL EMPYEMA: LITERATURE REVIEW

**Summary.** Despite the rapid development of thoracic surgery, the problem of the surgical treatment of non-specific chronic pleural empyema remains relevant. The variability of the proposed treatment methods: puncture and drainage interventions aimed at pleural cavity sanitation, minimally invasive videothoroscopic surgeries and traditional lung decortication, dictates the need for case-by-case surgical tactics and determining the stages and duration of the above methods. Treatment outcomes are significantly worsened by the presence of bronchial fistulas, which either cause the development of chronic pleural empyema or develop as a result of its presence and late treatment. Some answers to these key questions are provided in this paper, which aims to identify them in the Ukrainian and foreign literature.

**Key words:** *non-specific chronic pleural empyema, bronchial fistula, surgical treatment.*

**Problem status, structure and proportion of non-specific chronic pleural empyema.** Despite the significant progress of thoracic surgery, non-specific chronic pleural empyema remains a complex and severe condition. Acute pleural empyema becomes chronic in 11-40 % of patients [1].

Surgical treatment of the latter involves frequent complications – 9.8 %-28.5 % [2, 3].

A steady increase in the number of purulent lung and pleura diseases also contributes to the development of chronic pleural empyema. The increased incidence of pneumonia is accompanied by the development of pleural empyema in 4 % - 50 % of cases [4].

In many cases, pleural empyema is associated with closed chest injuries – 2.9-5.2 %, and injuries caused by cold and firearms – 1.7-5.4 % and 21.7 %, respectively [5].

The problem of pleural empyema development also affects patients after surgeries for purulent-destructive pulmonary diseases with an incidence of 4.8 % to 39 % [6].

Also, the rising number of lung and pleural surgeries for cancer pathology also led to an increase in the incidence of pleural empyema in the post-operative period – 2-31 %. Pleural empyema occurs in 0.5-4 % of cases following lung resection and in 1.9–5.3 % of cases after pneumonectomy [7, 8, 9].

Conservative treatment of pleural empyema remains ineffective. According to the literature, acute pleural empyema becomes chronic in 33 % of cases. Usually, it affects working-age individuals. It is associated with late diagnostics, delayed hospitalization to specialized departments and inadequate ambulatory therapy [10].

Subsequently, 13.3–45.5 % of patients require decortication and lung resection due to ineffective conservative therapy [11].

An even greater problem is complications after surgical interventions at the backdrop of the purulent inflammatory process in the pleural cavity, which occur in 25.7 % of patients with a mortality rate of up to 12 %. The mortality rate after surgeries for pleural empyema with lung destruction is 62.2 % [12].

**Aetiopathogenesis of non-specific chronic pleural empyema.** Pleural empyema is an accumulation of pus or fluid with biological signs of infection in the pleural cavity with the involvement of the parietal and visceral pleura in the inflammatory process and secondary compression of lung tissue. The generally accepted classification includes three stages of pleural empyema – exudative (Stage I), fibrinopurulent (Stage II), and organisation stage (Stage III). The disease progression lasts from 3 to 6 weeks [13].

At the exudative stage, the accumulation of serous effusion is caused by the inflammation of pleural leaves. During the exudative stage, bacteriological examination is negative and the patients do not require any additional surgeries. The infection of pleural effusion occurs during the fibrinopurulent stage, usually hematogenously or lymphogenously. 3–4 weeks later, the fibrinopurulent stage turns into the organisation stage, i.e. chronic pleural empyema. The organisation stage is characterised by the formation of pleural indurations, which collapse the lung and cause fibrinous changes. Patients develop signs of respiratory failure due to the formation of a dense capsule because collagen fibres mature and fibroblasts proliferate in granulations [14].

The pyogenic membrane quickly produces pus and a pyogenic layer appears on the pleura. Visceral and parietal pleural leaves grow tightly together forming an encapsulated cavity with purulent contents [6].

Other authors characterise chronic pleural empyema as an intermittent disease lasting more than 12 weeks, with persistent purulent-destructive morphological changes of the parietal and visceral pleura [15].

Chronic pleural empyema is characterised by alternating exacerbation and resolution phases, during which proliferative processes are intensified and diffuse cellular infiltrates are formed, which further enhances the formation of fibrosis in the residual pleural cavity. Three layers are differentiated in the morphological structure of chronic pleural empyema biopsy materials: pyogenic, cicatricial and formed by pleural layers. It occurs due to the cicatricial granulation tissue growing during the excessive tissue generation [15, 16].

The thickness of pleural indurations can reach 2–3 cm, with fibrinous layers and pus. The severity of the adhesive (commissure) process dictates the need for individualised therapeutic tactics, as in the case of pronounced pleural layers it is reasonable to perform only open traumatic surgeries involving lung decortication with the removal of residual empyema cavity. Individual predisposition to adhesiogenesis should be taken into consideration when choosing the therapeutic tactics for patients with chronic pleural empyema [16, 17, 18].

**Diagnostics of non-specific chronic pleural empyema.** Pleural empyema diagnostics methods include X-ray examination, bronchoscopy, bronchography, and multi-slice computer tomography [19].

Pneumothorax, bronchial fistula, residual pleural cavity, subcutaneous emphysema, and displacement of the mediastinum towards the healthy side can be diagnosed using X-ray examination [20].

In addition to X-ray methods, one of the tactically important steps is bronchoscopic examination. The latter can help detect the failure of bronchial stump suture line, diagnose ulcerous endobronchitis, perform biopsy, obtain material from the tracheobronchial tree for microbiological examination and assess the size of the bronchial fistula and the length of the bronchial stump in the post-operative period [21].

Bronchographic examination is one of the bronchial fistula imaging techniques that can determine its precise localization, dimensions and connection with other organ structures [22, 23, 24].

Currently, the most informative diagnostic technique remains multi-slice computer tomography. MSCT uses non-invasive technique to perform differential diagnostics between controversial X-ray and bronchoscopic data for various lung pathology. The technique can assess the dimensions of the residual pleural cavity, the degree of parietal and vis-

ceral pleura thickening, and the condition of lungs and other thoracic organs. According to the literature, the diagnostic precision of bronchial fistulae and pleural empyema is 91 % [25, 26].

**Surgical treatment of non-specific chronic pleural empyema.** The treatment tactics for chronic pleural empyema remains one of the most relevant and disputable issues of modern thoracic surgery. Conservative therapy is not always effective as pleural indurations collapse the lung and prevent the lung from unfolding without surgical intervention. It is believed that lung decortication leads to quick lung unfolding and obliteration of the residual pleural cavity [16, 17].

The literature currently discusses the issue of indications and contraindications to the drainage and sanitation of pleural cavity as pre-operative preparation for the removal of the residual cavity in one block and resolution of the problem of using pleural cavity drainage as a single stage of surgical treatment, especially in patients with severe somatic pathology and high operative risk [18, 27, 28].

A number of authors find conservative and surgical treatment to be competing [29].

Some authors think that, on the contrary, pleural cavity drainage at initial treatment stages significantly worsens treatment outcomes and leads to complications causing to increased mortality rates. They prefer puncture methods thinking that it maximizes treatment efficacy [30].

Taking this into consideration, it can be stated that there is no single tactics for the treatment of chronic pleural empyema. This calls for the measures aimed at increasing the effectiveness of minimally invasive methods of chronic pleural empyema treatment and individualisation of conservative treatment.

One way to achieve obliteration of the residual pleural cavity is to adopt minimally invasive interventions aimed involving drainage and sanitation of the empyema cavity. The effectiveness of these methods has been highlighted in numerous studies [31].

However, the use of minimally invasive interventions involving drainage and sanitation of the pleural cavity requires further clarifications regarding indications and contraindications, terms of performance and possibilities of integrated use of minimally invasive videothoroscopic surgeries that use proteolytic enzymes in order to remove pleural indurations. Topical therapy of pleural empyemas increases the effectiveness of conservative treatment and prevents the development of cicatricial changes in the pleural cavity. However, the bactericidal action of antiseptic solutions is not enough to fight against the combined, ever changing microflora [32].

On the one hand, videothoroscopic surgeries enable sanitation and separation of individual empyema cavities and help quickly unfold lungs and



clean the pleural cavity, this minimizing major surgical injuries [33, 34].

The literature indicates that it is possible to perform videothoroscopic sanitation and partial decortication in patients with chronic pleural empyema in 42-56 % of cases [18].

On the other hand, despite the development of minimally invasive surgeries there is a risk of pleurogenic lung cirrhosis progression in the post-operative period [16].

Some authors believe that the use of minimally invasive videothoroscopic surgeries is reasonable after prior laboratory and instrumental examination, including X-ray and multi-slice computer tomography of thoracic organs. 96.9 % of patients recovered following thoracoscopic interventions. Treatment failure occurred in 2.6 % of patients and was usually due to progressive destructive processes in the lungs [16].

Up to now, there is no precise algorithm for the treatment of non-specific chronic pleural empyema taking into account the use of videothoroscopic interventions, their terms are not defined, and its use for gangrenous lung damage is not described [35].

A surgery can be performed using modern high-frequency electrocoagulation techniques in the bipolar mode, which help perform pleurolysis and achieve homeostasis [36].

Despite the localised action of bipolar tools, the adverse effect of the current spreads to the adjacent organ structures within 5-8 mm. It is optimal to stop the coagulation process when it is completed between the tool branches, when the influence on the adjacent region is minimal. High-frequency current is switched off manually under visual control of the organ structures and tissues: smoking, deformation, contraction of tissue structures. The current is switched off automatically when the dehydration and drying (coagulation) have already taken place (the tissue resistance increases 3-5-fold — from 300–500 ohms to 900–2500 ohms), but there are not visual changes of the adjacent tissues [37].

Another disputable issue is determining the terms when acute pleural empyema becomes chronic and further determining the extent and terms of operative treatment. Nowadays, it is believed that leaving pleural indurations does not result in the recurrence of the empyema process and progression of pleurogenic lung cirrhosis. There is evidence in the literature that adequate sanitation of the pleural cavity may contribute to the resorption of pleural indurations [38, 39, 40, 41, 42, 43].

It is assumed that when chronic pleural empyema lasts longer than 2-3 months, it is reasonable to perform lung decortication with pleurectomy, mainly using minimally invasive videothoroscopic surgical interventions. However, videothoroscopic interventions have a number of contraindications

and in some cases require approach conversion with further thoracotomy decortication [4, 31, 44, 45].

Unfortunately, lung decortication remains a very traumatic surgery. It is not always that patients, especially those with a high operative risk and severe comorbidities, can survive it. When removing the empyema cavity, it often becomes depressurized with inevitable infection of the operative field with pus [4].

The presence of bronchial fistulae, the volume of the residual purulent cavity, the duration of the pleural empyema, and co-morbidities significantly influence the treatment outcome prognosis [46].

Bronchial fistulae are the most frequent source of maintaining chronic inflammation and persistent residual pleural cavity. Purulent intoxication makes the course of the disease more complicated and prevents from performing open surgeries without prior stabilisation of the patients' condition [47, 48].

Another issue that concerns thoracic surgeons regarding pleural empyema treatment is thoracoplasty. Should it be complete bone excision or resection of ribs aiming to reduce the volume of the residual cavity, or its obliteration in pleural empyema, or its complete removal in the presence of a bronchial fistula? There is no single surgical doctrine concerning these traumatic, incapacitating surgeries [48, 49].

Lung resection and pneumonectomy cause a high risk of post-operative pleural empyema development. The principle of its treatment after such surgical interventions involves moving the chest wall closer to the lung or mediastinum. An integrated approach including one-stage transpleural surgeries on bronchial stumps and thoracoplasty helps resolve both issues if the latter is corrected in stages. At the same time, these so-called simultaneous surgeries can be performed only in stable patients, which is not always possible because purulent intoxication contributes to the unsatisfactory condition, which significantly increases operative risks and adversely affects the condition in the post-operative period. Some authors believe that thoracoplasty is an outdated surgery and advise against it [49, 50].

Another factor of pleural empyema development after thoracic surgeries, which is not related to the unavailability of the main bronchial stump, is infection of the pleural cavity and post-operative shock [51].

**Sanitation of the pleural cavity in non-specific chronic pleural empyema using traditional and minimally invasive surgical methods.** Puncture, drainage and videothoroscopic interventions remain the most wide-spread ways to sanitize the pleural cavity in chronic pleural empyema. However, despite the extensive background of these interventions, there are many unresolved issues concerning indications and contraindications to them [52, 53, 54].

Pleural cavity drainage with sanitation and obliteration is usually administered for the treatment of

chronic pleural empyema, as well as antibacterial therapy taking into account the sensitivity to the etiopathogenetic microbial causative agent [55, 56].

The use of videothoroscopic pleural cavity sanitation techniques is aimed at removing pus masses and fibrin septa [57].

Early studies demonstrate ineffectiveness of videothoracoscopy in patients with non-specific chronic pleural empyema and report lack of positive outcomes regarding the restoration of damaged lungs in 30 % of patients within 6 months after treatment [58].

Scientific papers published in the 21<sup>st</sup> century show larger experience of using minimally invasive videothoroscopic surgeries, report that more than 40 % of patients did not require approach conversion during the videothoroscopic sanitation of the pleural cavity, and even demonstrate a 54-93 % effectiveness in patients with pleural empyema at the organisation stage [59, 60, 61].

Foreign authors also report a significant decrease in the mortality rate when using videothoroscopic sanitation as compared to lung decortication [62].

The literature also demonstrates maximum effectiveness of videothoroscopic interventions for an empyema process that has lasted not more than 1-2 months. It is considered that during this period the lung is not yet involved in the cicatricial-deformative process in the pleural cavity [63, 64, 65].

Other authors report the effectiveness of videothoroscopic sanitation only for pleural empyema that has lasted for 2-3 weeks [59, 66, 67].

Videothoroscopic sanitation has a number of advantages and disadvantages, and, according to other literature sources, it is ineffective in 10-15 % of patients [68].

There is also data supporting the effectiveness of videothoroscopic sanitation for chronic pleural empyema in 77-85 % of patients [4].

The British Thoracic Society for the treatment of pleural empyema considers that there are no objective criteria for choosing between the traditional or minimally invasive sanitation of the pleural cavity that would determine precise terms of these interventions after the onset of the disease. It means that the decision about the surgery is made based on the doctor's subjective opinion. There are still a number of indications to the surgical treatment of chronic pleural empyema, such as SIRS symptoms and constant inflow of exudate from the pleural cavity for 7 days [69].

Contraindications to videothoroscopic interventions include: severe cardiopulmonary comorbidity, including potential unilateral artificial lung ventilation, progressive lung destruction, pleural cavity obliteration, narrow intercostal space, low volume of the residual pleural cavity, large bronchial fistulae, pleural empyema lasting for more than 1.5 months, pronounced adhesive process in the pleu-

ral cavity with a high risk of thoracic organ damage [60].

Other authors believe that videothoroscopic interventions should only be performed for acute pleural empyema, not later than 1-2 weeks after the onset of the disease [67].

Videothoroscopic interventions are also chosen for pleural cavity sanitation in multiple encapsulated purulent cavities. They are also effective for total and advanced pleural empyema lasting for up to 2 months after the onset of the disease [66].

There are only few studies about videothoroscopic decortication reporting the occurrence of post-operative complications in 23.8 % of cases [69].

It is believed that persistent sclerotic changes occur in the pleura after 90 days of chronic pleural empyema, so it is unreasonable to perform videothoroscopic lung decortication after that time [60].

At the same time, there are no precise terms of the development of cicatricial changes in the pleura that would indicate their severity; therefore, there is no single surgical doctrine for the use of videothoroscopic lung decortication. The severity of pleural adhesion should not be assessed based on the disease duration, but rather based on the dynamics of the clinical and X-ray findings at all treatment stages of non-specific chronic pleural empyema [62, 65].

**Radical surgical treatment of patients with non-specific chronic pleural empyema.** The Fowler-Delorm operation for lung decortication involves releasing a collapsed lung in chronic pleural empyema. It is due to the reduced pulmonary function, perfusion values and gas exchange owing to decreased lung volume. Decortication contributes to the restoration of vital lung capacity, forced expiratory volume per second, lung perfusion and partial oxygen pressure in the arterial blood. The development of restrictive pulmonary impairment can only be prevented by early lung decortication [70, 71].

Many authors believe that performing minimally invasive interventions and lung decortication is unreasonable for chronic pleural empyema and suggest performing only traumatic radical surgeries, such as thoracostomy with subsequent thoracoplasty [72, 73].

It is believed that thoracostomy is reasonable when lung decortication cannot be performed, which contributes to full sanitation of the residual pleural cavity. Thoracostomy can be temporary or permanent. Temporary thoracostomy is performed as phase treatment. Permanent thoracostomy is usually performed in patients with a high operative risk and severe co-morbidity when the walls of the residual pleural cavity are calcified [74].

Thoracostomy is complemented with the relocation of muscular or epiploic flaps on the vascular pedicle, rib resection and pleural cavity drainage, or thoracoplasty [75].

Open thoracostomy with cutting out the cutaneous-subcutaneous-fascial flap (Clagett modification



of the Eloesser flap) is performed in patients with a high operative risk and severe co-morbidity. However, traditional thoracostomy has advantages owing to its better post-operative results [76, 77, 78, 79].

The data of clinical trials indicate a 5 % mortality rate in patients with chronic pleural empyema undergoing extended thoracostomy [80].

**Etiopathogenetic antibacterial therapy in patients with non-specific chronic pleural empyema.** Timely detection of the etiological factor of chronic pleural empyema and adequate antibacterial therapy taking into account microbial sensitivity is one of the tactical steps in fighting this severe thoracic pathology. The potential of topical use of antibacterial drugs in combination with immunomodulators combined with antiseptic solutions for the sanitation of purulent destructive pleural cavities is understudied [81, 82, 83].

The choice of antibacterial drugs is another problem. Although it is possible in most cases to decide on antibacterial therapy based on the microbiological tests of the pleural cavity contents, it is not always possible to adequately estimate its optimum duration and targeted combination of drugs at different stages of in-patient treatment [68, 84].

Empirical antibacterial therapy is usually aimed at treating pleural empyema as a complication of community-acquired pneumonia, but it is not taken into account that before being admitted to specialized thoracic department patients are treated at different clinics and have a high risk of getting infected with hospital strains of pathogenic microflora [85, 86].

The etiological causative agent of pleural empyema is usually *Staphylococcus aureus*. However, there is extensive data about the domination of different types of pathogenic agents in case of pyothorax [87, 88].

An increase in polyresistant microbial strains is observed during microbiological tests of pathogenic agents [89].

According to many authors, particular attention must be paid to microbiological monitoring of nosocomial infections [89].

Depending on the sensitivity of the causative agent, oxacillin, vancomycin, cefazolin, and linezolid are widely used. When purulent exudate is sterile, a combination of antibacterial drugs is used consisting of anaerobic and aerobic gram-negative enterobacteria – inhibitor-protected penicillins and second- to fourth-generation cephalosporines, cefoperazone/sulbactam, fluoroquinolones with metronidazole, lincosamides with second- or third-generation aminoglycosides. In cases when it is impossible to determine the causative agent and the microbiological results are negative, the contents of the pleural cavity should be considered sterile [90, 91].

**Conclusion.** Non-specific chronic pleural empyema treatment failures urge surgeons from the entire world to search for new and to improve the existing methods of treating this severe pathology. On the one hand, there arises an issue of timely treatment of acute empyema before it becomes chronic. On the other hand, when the chronic process is established, there is no single answer to the question whether to choose single-stage treatment, i.e. lung decortication with intraoperative sanitation of the residual pleural cavity, or to perform adequate pre-operative sanitation using the existing traditional and minimally invasive methods or their combination, then followed by a radical surgery. The problem of the surgical treatment of non-specific chronic pleural empyema requires the development of a new, state-of-the-art surgical treatment tactics.

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ПРОБЛЕМА ХІРУРГІЧНОГО  
ЛІКУВАННЯ  
НЕСПЕЦИФІЧНОЇ  
ХРОНІЧНОЇ ЕМПІЄМИ  
ПЛЕВРИ: ОГЛЯД  
ЛІТЕРАТУРИ

*А. Л. Сочнева*

**Реферат.** Незважаючи на стрімкий розвиток торакальної хірургії, проблема хірургічного лікування неспецифічної хронічної емпієми плеври залишається актуальною. Варіабельність запропонованих методів лікування, пункційні та дренажні втручання направлені на санацію плевральної порожнини, мінінвзивні відеоторакоскопічні оперативні втручання та традиційна декортикація легені, диктує необхідність індивідуалізації хірургічної тактики та визначення етапності і тривалості використання вищеперерахованих способів. Значно погіршує результати лікування наявність бронхіальних норниць, які стають або причиною розвитку хронічної емпієми плеври або ж формуються у результаті її наявності та несвоечасного лікування. Деякі відповіді на ці вузлові питання наведено у цій науковій роботі спрямованій на їх пошук у вітчизняних та іноземних літературних джерелах.

**Ключові слова:** *неспецифічна хронічна емпієма плеври, бронхіальна нориця, хірургічне лікування.*