Determination of anatomical locations and pathomorphological features of pleural empyema with acquired bronchial fistulas to the stage of purulent inflammation requires strict systematization and individualization of the terms of conservative and surgical treatment, as well as the nature and volume [14]. The clinical picture of reactive infectious pleural TB empyema, usually with fluid

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in the pleural cavity, often coincides with the manifestations of pneumothorax and is revealed during radiological examination [4]. The exudate of TB empyema is often serous in nature with little protein [7]. The degree of pleural thickening indicates the specificity of tuberculosis (TB) infection [8]. Special morphological studies allow the diagnosis of Mictobacterium tuberculosis (MBT) in exudation [3]. Video-thoracoscopy (VTS) reveals fibrin loss, sometimes tuberculous granules, and caseous ulcers appear on the surface of the pleura [5]. Minor pleural lesions by MBT, absence of pleuro-bronchial fistula, with massive antibiotics therapy (fluoroquinolones, aminoglycosides — indirectly affect the MBT), usually end with resorption of exudation and pleural obliteration [2]. However, the activity of the tuberculous process in the pleura remains high, and the process often recurs, leading to TB empyema and a of pleural suppuration [13]. It is the suppuration of the mixed flora, including Streptococcus pneumonia, Staphylococcus aureus, Pseudomonas aeruginosa, Acinetobacter baumannii (and other persistent in-hospital strains), along with MBT, necessitating further study of superinfection in TB suppuration [9]. Local changes in the pleura of pleura TB empyema are characterized by the breakthrough of large caverns in the pleural cavity, the collapse of granulations, caseous-necrotic ulcers and septicopyemic eruptions on the skin [6]. This confirms the relevance of the research topic and the need for further development of high-tech diagnostic and surgical techniques [1].

**Objective** — to improve the surgical treatment of pleural tuberculosis empyema through minimally invasive diagnostics and video-assisted thoracic resections.

**Materials and methods**

This study was conducted in the Tuberculosis and Surgical Department of the Ternopil Regional TB Dispensary. To address the defined objectives, we analyzed the medical records of 685 patients with tuberculous pleural empyema treated between 2005 and 2019. The calculation of the required sample size was performed in accordance with the recommendations for good clinical practice.

The preliminary selection of patients was carried out taking into account the requirements of the clinical trial. This process was based on the following criteria: informed consent of patients’ rights to surgery; compliance with medical ethics, approvals of the bioethics commission, literature analysis and personal experience. The diagnostic possibilities of VTS in patients with complications of pleural TB empyema, studied retrospectively, were analyzed. The criteria for inclusion of subjects in the study were as follows: aged from 20 to 80 years; both sexes; clinical and radiological confirmation of tuberculous changes in the lungs with pleural TB empyema in patients of 1–4 clinical categories of TB; clinical category 5.1 residual changes of the earlier tuberculosis (RCT); stage 0–II of pulmonary insufficiency. The effectiveness of long-term outcomes was evaluated based on criteria for clinical cure, progression of TB and suppuration in the pleura (average life expectancy, percentage of local recurrences of purulent process), formation of chronic TB, death from TB and complications.

All types of statistical processing were performed using the standard package Statistica, version 6.1 (serial number AGAR 909 R455721FA). Statistical characteristics are presented as follows: the number of observations (n), arithmetic mean (M), standard error of the mean (m), median (Me) and relative values (%).

The operated patients were divided into two groups: Group 1, consisting of 351 (51.25 %) patients, underwent operations using minimally invasive technologies (VTS, video-assisted surgical resections (VATS)), and this constituted the main group; Group 2, comprising 334 (48.75 %) patients, underwent open wide thoracotomy, forming the comparison group. Of the 351 patients in the main group, 301 had acute of pleural TB empyema and 50 had chronic pleural TB empyema. Among the patients in the comparison group, acute pleural TB empyema was observed in 284 patients, and chronic TB empyema in 50. According to our data, only VTS is a highly informative method for detecting tuberculous pleural empyema in the 1st, 2nd and 3rd stages of its development, as shown in Table 1.

These data confirm that most patients are diagnosed with acute of pleural TB-empyema in stage I–II of the disease. As a result of errors in treatment,

<table>
<thead>
<tr>
<th>Indicator of tuberculosis process</th>
<th>Group 1 (n = 351)</th>
<th>Group 2 (n = 334)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abs.</td>
<td>%</td>
</tr>
<tr>
<td>Acute TB empyema (stage I–II)</td>
<td>301</td>
<td>85.7 ± 1.3</td>
</tr>
<tr>
<td>Chronic TB empyema (stage III)</td>
<td>50</td>
<td>14.2 ± 0.3</td>
</tr>
</tbody>
</table>

Note. *Significant difference between groups (p < 0.05).
this process turns into a periodically progressive chronic course stage III.

The distribution of patients by sex in both study groups is shown in Table 2.

The majority of patients with pleural TB empyema were men, accounting for 264 (75.2 %) and 254 (76.1 %) in the comparison groups, while women accounted for 87 (23.9 %) and 80 (24.7 %) of cases, respectively. The analysis of age groups showed that in our studies, the age of patients ranged from 18 to 80 years. The number of patients of working age, up to 60 years, was 80.9 % in the main group and 81.8 % in the comparison group. The maximum number of patients in both groups was in the age category of 31—70 years. The tendency to increase in elderly patients requires further study, taking into account age peculiarities and existing comorbidities.

Results

The development of pleural TB empyema occurs with its caseous lesions due to the perforation of subpleurally located foci, tuberculosis or caverns. MBT penetrate the pleura through lymphogenous, hematogenous or contact way with tuberculosis of the inferior lymph nodes or through reactivation of old pulmonary foci that cause hematogenous dissemination from primary encapsulated Gon focus in tuberculosis. The distribution of patients in both groups, depending on the specific form, is presented in Table 3.

In most cases of pleural TB empyema (57.8 %), there was a secondary empyema in pulmonary TB; in 21.6 % of cases, the empyema developed independently in tuberculous pleurisy. Bronchial fistulas were diagnosed in 11.7 % of cases of pleural TB empyema. In patients with acute of pleural TB empyema, the duration the disease was not more than 1—2 months.

Stage I pleural TB-empyema was characterized by granulomatous inflammation, which spread to the lattice-like structure of the elastic-collagen layer of the pleura and had a characteristic dilation of blood vessels with edema.

Inhibition of effusion absorption during exudation accumulation is associated with the compression of the lymphatic vessels of the parietal pleura, leading to impaired lymphatic transport function. Closure of the ducts and hatches between the mesothelial cells of the pleura results in the dropout of fibrin, causing impaired lung excursion and diaphragmatic function, which plays the role of a pump. Fibrinous layers begin to be organized by connective tissue, leading to the formation of zonal pachypleuritis, sutures and fissures that partially or completely obliterate the costal diaphragmatic sinuses and a free pleural cavity, as schematically shown in Fig. 1.

Stage II of pleural TB empyema begins when the exudate in the pleura became purulent. During this period, the inflammatory processes develop in the

| Table 2. Distribution of patients by sex of pleural TB-empyema (M ± m) |
|--------------------------|--------------------------|--------------------------|
| Sex                      | Group 1 (n = 351)        | Group 2 (n = 334)        |
|                         | Abs. | %            | Abs. | %            |
| Men                      | 264  | 75.2 ± 1.3  | 254  | 76.1 ± 1.7*  |
| Women                    | 87   | 24.7 ± 0.3  | 80   | 23.9 ± 2.2*  |

Note. * Significant difference between groups (p < 0.05).

Table 3. Etiological forms of pleural TB empyema (M ± m)

<table>
<thead>
<tr>
<th>Indicator of tuberculosis process</th>
<th>Group 1 (n = 351)</th>
<th>Group 2 (n = 334)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abs.</td>
<td>%</td>
</tr>
<tr>
<td>Empyema in pulmonary tuberculosis</td>
<td>203</td>
<td>57.8 ± 1.3</td>
</tr>
<tr>
<td>Fibrinous pleurisy</td>
<td>76</td>
<td>21.6 ± 2.5</td>
</tr>
<tr>
<td>Mixed</td>
<td>44</td>
<td>12.5 ± 0.3</td>
</tr>
<tr>
<td>Post-operative</td>
<td>28</td>
<td>7.9 ± 1.7</td>
</tr>
<tr>
<td>Bronchial fistulas</td>
<td>41</td>
<td>11.6 ± 2.3</td>
</tr>
</tbody>
</table>

Note. * Significant difference between groups (p < 0.05).
vascular elastic-collagenous layer of the pleura: collagen fibers are stratified by a protein fluid that is rich in fibrin. In this stage, the surface and even the deep elastic layer are often disrupted. The inflammatory process at this stage is strictly limited to the pleural layer and does not extend to the lung tissue, as is shown in Fig. 2.

The stage of fibrinous-purulent inflammation always indicates the maximum degree of inflammatory response and depends on the preservation or termination of the causative agent. Therefore, in the study of the clinical stage of empyema, the decisive factor in the transition from the second stage to the third (reparative stage) is not the time factor, but a state of the main focus of infection.

Stage III of TB suppuration is essentially not a reaction of inflammation; it is only a consequence of infection. Usually, the intensity of the regenerative reactions is proportional to the degree of pre-existing tissue destruction and the appearance of the so-called «dead» substance in the pleural cavity.

Initially, the granulation tissue has the appearance of a thin layer of round glomerular cells, which are positioned between the boundary layer of fibrinous-purulent layers and the preserved layers of the pleura. Then, the collagen fibers begin to gather in granulations. The forming granulation tissue creates a pyogenic membrane that produces suppuration on one side and separates it from adjacent tissues on the other, as shown in Fig. 3.

Depending on the stage of the inflammatory process, it is morphologically possible to distinguish a more subacute course of pleural TB empyema, which alternates with periods of exacerbation and attenuation. There is no clear criterion for the transition from acute empyema to chronic one. The course of an acute TB empyema usually lasts 1 — 3 months, but this period can be prolonged or shortened. Actually, it is not the timing of inflammation that causes the transition from acute pleural TB empyema to chronic, but the condition of its walls. If alternative inflammatory processes predominate in the inflammatory zone, then even with long-term course of pleural TB empyema, the disease should be considered as acute, as shown in Fig. 4.

In practice, pleuro-pulmonary fistulas are more common, while pleuro-thoracic ones are rare. It should be noted that we observed 2 mechanisms of pleuro-bronchial fistula formation: 1) the rupture of a parietal tuberculous lesion or cavern from the lung to the pleura; 2) caseous necrosis of a tubercle on the pleura in the lung. As a result of the rupture of the tubercle, a narrow gap is formed between the pleura, alveolar passages and small bronchi. With deep caseous necrosis and extensive pleural involvement, wider fistulas are formed between the pleura and the larger bronchi. The largest fistulas are formed when the cavern opens into the pleural cavity, transforming the drainage of the bronchial cavern into an actual bronchial fistula. Very often, causal masses of the cavern close the mouth of the fistula, but when caseous necrosis undergoes lysis, the fistulas continue to function. In the tissues of the fistulous passages, there are almost always specific Tuberculous elements in the form of epithelioid-
cell granulomas. These granulomas are always inflammatory; only mechanical surgical removal contributes to the process of scarring and healing. In the diagnosis of pleural TB empyema, video VTS played a paramount role in the timely identification of the etiology of pleural suppuration. In patients with a pleural TB empyema, only 51.2% of cases were diagnosed in time for minimally invasive thoraco-surgical treatment (VTS, VATS). Analyzing data from various authors regarding the morphological features of pleural TB empyema, it was found that specific suppuration tends to have a more acute nature compared to general suppuration in pleural TB. In 57.8% of cases, there was the appearance of secondary TB empyema in pulmonary tuberculosis, in 21.6% of cases, empyema developed independently in tuberculous pleurisy. Bronchial fistulas were diagnosed in 11.7% of cases of pleural TB empyema.

**Discussion**

Recent studies have frequently referred to atypical tuberculous pleurisy as a distinct pleural inflammation associated with intra-pleural suppuration [10]. The accumulation of purulent exudate over an extended period is often diagnosed too late, following courses of non-specific disease treatment and haphazard administration of broad-spectrum antibiotics and anti-inflammatory drugs [12]. When performing repeated VTS, the condition of the visceral and parietal pleura is assessed, and a biopsy is performed for morphological monitoring of the dynamics of the inflammatory process. Dislocation of drainage is also addressed. Tuberculous pleural empyema stage I—II requires a more comprehensive collection of material for bacteriological, cytological and histological examination. After all, the removed granulomas are quite loose, and a small number of them can distort the diagnosis of TB [8]. By nature, TB empyema is divided into four types: 1) asymptomatic, characterized by a cold suppuration type with no tuberculous changes in the lungs and without the development of broncho-pleural fistulas; 2) progressive pleural TB empyema, marked by significant changes in the lungs and the presence of broncho-pleural fistula; 3) recurrent pleural TB empyema, which occupies a middle position between asymptomatic and progressive types. Fistulas in recurrent cases are generally not observed, and the exacerbation of the condition depends on the received conservative treatment and sanation of cavities of TB empyema; 4) mixed pleural TB empyema, manifesting as a severe course due to the adherence of secondary putrefactive infection.

In mixed pleural TB empyema, dystrophic changes of the internal organs develop very quickly. Performing a completely closed VTS is often challenging, and VATS is frequently utilized. In this type of surgical intervention, the camera introduced into the pleural cavity through the same thoracoport. However, for the convenience of performing closed decortication, the surgery is supplemented by mini-computable access [11].

**Conclusions**

To enhance the surgical treatment of pleural TB empyema through minimally invasive diagnostics and VATS.

The most significant diagnostic challenges arose in patients with pleural TB empyema localized in the region of active tuberculous and metatuberculous changes. In 48.7% of patients, the diagnosis of pleural TB empyema is made at an advanced stage of the purulent process.

The author declare no conflict of interest.
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Відео-хірургічне лікування туберкульозних еміпіям при плевролегеневому туберкульозі

За даними ВООЗ, через формування резистентності мікроорганізмів, змішаної специфічної та неспецифічної флори до основних протитуберкульозних препаратів у світі спостерігається поява гнійних захворювань із суперінфекцією. Раціональний вибір діагностики та хірургічного втручання значно зменшує формування резистентності нагноєння при туберкульозній емпіємі плеври.

Мета роботи — поліпшити хірургічне лікування туберкульозної емпієми плеври залежно від етиології, стадії, локалізації залишкової порожнини завдяки використанню малоінвазивної діагностики та відеоасистованих резекцій.

Матеріали та методи. Проведено ретроспективний аналіз 685 випадків лікування хворих із туберкульозною еміпіємою плеври І—ІІІ стадії, а також огляд діагностики та проведених за останнє десятиріччя операцій. Хворих розподілили на дві групи: 1-ша група — 351 (51,25 %) пацієнт, прооперований із застосуванням малоінвазивних технологій (відеоторакоскопія (VTS), відео-асистована хірургічна резекція (VATS)), 2-га група — 334 (48,75 %) хворих, прооперованих з використанням відкритої широкої торакотомії. У першій групі у 301 пацієнта діагностовано гостру туберкульозну емпієму плеври, у 50 — хронічну, у другій групі — відповідно в 284 та 50.


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Висновки. VTS і VATS — закрита плевректомія, декортикація із термоабляцією нориць є перспективними операціями для діагностики збудника та малоінвазивного хірургічного лікування туберкульозної емпієми плеври.

Ключові слова: відеоторакоскопія, відео-асистована хірургічна резекція, туберкульоз, Mikobacterium tuberculosis.