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ADVANTAGES AND DISADVANTAGES OF DIFFERENT THORACOSCOPIC APPROACHES IN DIAGNOSTIC AND TREATMENT OF PLEURAL EFFUSIONS

THESIS SUMMARY

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The dissertation is written of 125 standard typewritten pages, with 10 pages dedicated to the presentation of the utilized literature sources. The bibliography includes 228 titles, with 10 in Cyrillic and 218 in Latin script.

The material is illustrated with 18 tables, 10 diagrams, and 20 photographs.

The dissertation has been discussed, accepted, and scheduled for defense by the Departmental Council of the Department of Surgery, Medical University - Varna on July 5th, 2023.

The author of the dissertation works as a medical assistant at the Clinic of Thoracic Surgery in UMBAL "Sveta Marina" - Varna and the Department of Surgery, Medical University - Varna.

The public defense of the dissertation will take place on October 16th, 2023, at 11:00 AM at UMBAL "Sveta Marina" - Varna, in front of a scientific jury.

Note: The numbers of tables and figures in the abstract do not correspond to those in the thesis.

CONTENTS

1. INTRODUCTION

„The history of Minimally Invasive Surgery in the thorax is one of evolution, not revolution“
Alan D. L. Sihoe

Pleural effusion is the most common disease of the pleura and one of the most frequently diagnosed and treated conditions in the field of thoracic surgery. It represents an excessive accumulation of fluid in the pleural cavity, which impairs the normal functioning of the lung. The frequency and distribution of the disease depend on various factors, including age, gender, underlying conditions, and geographical location. According to a systematic review and meta-analysis of 34 studies published in the Journal of Thoracic Disease in 2017, the overall frequency of patients with pleural effusion is estimated at 320 cases per 100,000 people per year. The frequency is higher in men than in women and increases with age, with the highest levels observed in individuals aged 60 years or older. The most common causes of pleural effusion include congestive heart failure (the leading cause and complication in 10 to 50% of cases in developed countries), pneumonia, malignancy (complicating 15 to 50% of cases), pulmonary embolism, and tuberculosis (the leading cause in developing countries).
There are numerous and diverse possibilities in the diagnosis and treatment of pleural effusions, but the timing and precise choice of intervention are still under discussion. In recent years, with the development of minimally invasive techniques, there has been a shift from traditional approaches, with thoracoscopic approaches being increasingly used instead of conventional surgical techniques due to their benefits such as shorter hospital stays, reduced post-thoracotomy pain with its associated unpleasant consequences (restricted breathing, difficulty in coughing, retention of secretions, predisposition to atelectasis of the lung parenchyma, infiltrates, increased medication requirements, and poorer cosmetic outcomes). Video-Assisted Thoracic Surgery (VATS) techniques aid in a comprehensive solution to the problem of pleural effusion and offer an individualized approach based on the specific type of effusion and the individual patient.

VATS, is a minimally invasive surgical technique used for the diagnosis and treatment of various conditions in the chest, both benign (pleural effusion, empyema, pneumothorax, etc) and malignant (most commonly lung cancer worldwide, mesothelioma, among others). A significant milestone in the historical development of this surgery was achieved by Jacobaeus, who in 1910 invented and successfully introduced light into the regular cystoscope, creating

the first thoracoscope. Hans Christian Jacobaeus is considered the first physician to use the so-called single-port technique for accessing and working within the pleural cavity, performing biopsies and releasing pleural adhesions. Since then, VATS techniques have undergone significant progress and evolution, including the development of specialized instruments and greatly improved imaging technology, with new optical systems and modern energy sources that aid meticulous hemostasis and dissection. In recent years, these techniques have become increasingly popular and can now be considered a standard approach or method of choice for nearly the entire range of thoracic operations, including interventions for biopsy, radical treatment of benign and malignant lung diseases, including major anatomical resections such as lobectomy and pneumonectomy, as well as smaller but more complex procedures like segmentectomies and many other specific resections. There are numerous publications and scientific works in Bulgaria and worldwide that describe various aspects of the advantages of minimally invasive techniques over conventional ones, especially when it comes to the treatment of lung cancer. However, there is no work or systematic analysis showing the selection of a specific endoscopic approach when it comes to this frequently encountered condition - pleural effusion. There is still no definitive answer as to when exactly an effusion should be surgically intervened and with which thoracoscopic approach - single-port, double-port, or multi-port. Moreover, the advantages and disadvantages of each approach are not yet clearly defined, especially when dealing with complicated effusions such as empyema requiring decortication or chronic/recurrent effusions, particularly those caused by malignancies that partially or completely "encase" (trapped lung) the lung.

2. AIM AND OBJECTIVES

- **AIM**

The aim of the study is to present and discuss the advantages and disadvantages of different thoracoscopic approaches in the diagnosis and treatment of pleural effusions and personalizing the choice of a specific access and technique depending on the nature and type of the pleural effusion, in order to achieve optimal results.

To achieve this goal, we have defined the following main objectives:

- **OBJECTIVES**

1.To study the global experience and trends in the diagnostic and therapeutic approach, as well as the modern methods for the treatment of pleural effusions.

2.To analyze and refine, based on our own experience, the indications and contraindications for the use of thoracoscopic techniques in the diagnosis and treatment of pleural effusions.

3.To determine the advantages and disadvantages of each thoracoscopic approach depending on the localization, type, and nature of the pleural effusion.

4.To develop a diagnostic and therapeutic algorithm for patients with pleural effusions, taking into account the modern trends and practical reality in Bulgaria.

3. MATERIAL AND METHODS

3.1 MATERIAL

Over a period of 10 years (from 2012 to 2022), a total of 325 patients with pleural effusions of various origins were treated using VATS (Video-Assisted Thoracic Surgery) techniques at the Clinic of Thoracic Surgery in UMBAL "Sveta Marina". Among them, 207 were male and 118 were female, ranging in age from 15 to 88 years, with an average age of 64.5 years. We conducted a retrospective analysis of these patients. For this purpose, the available database, reflected in the patients' medical records stored in the hospital archive, as well as the operative journals of the Clinic of Thoracic Surgery, were used.

3.2 METHODS

3.2.1 CLINICAL, PARACLINICAL AND INSTRUMENTAL STUDIES

For accurate diagnosis of the condition, selection of the most appropriate therapeutic approach, choosing the right timing and specific type of surgical treatment, and postoperative monitoring, the following protocol was developed, which includes the following steps:

PREOPERATIVE DIAGNOSTIC ALGORITHM:

• **Medical history** - Information is gathered regarding the age and health status of the patients, the nature and duration of their complaints, the onset of the illness, family history of oncological diseases, prior surgical interventions or treatments, and any accompanying diseases. Any available medical documentation, previous imaging and other tests, previous biopsies, or the need for revision by a reference pathologist are required.

• **Clinical examination** - Physical examination is conducted to identify signs of reduced breathing unilaterally or bilaterally, dull percussion note, and diminished movement of the affected chest during respiration.

• **Paraclinical examinations** - All patients undergo standard laboratory tests including complete blood count, biochemistry, electrolyte levels, coagulation status, erythrocyte sedimentation rate (ESR), and if there are accompanying diseases, additional necessary investigations are performed.

• **Instrumental examinations**

IMAGING MODALITIES:

• Chest X-ray - performed to assess the current condition of the patient when previous CT images are available within a certain timeframe.

• Pleural ultrasound - performed when indicated and aims to assess the current condition of the patient when previous CT images are available within a certain timeframe. It also helps to complement the diagnosis by determining the presence of free or loculated effusion, with or without septations.

• Chest CT scan - unenhanced or with intravenous contrast media for better evaluation and examination of the pleural effusion, whether it is free or loculated, precise localization of all pleural loculations, presence of thick pleural rinds in empyema, staging or follow-up in oncological diseases.

• PET-CT - for comprehensive staging and follow-up in the presence of oncological diseases.

Biopsy methods - performed if necessary preoperatively (transthoracic core needle biopsy under imaging control).

Pathomorphological and immunohistochemical examinations:

• Cytological result from pleural fluid analysis for preoperative diagnosis.

• Histological result from core needle biopsy for preoperative diagnosis.

• Urgent histological examination (frozen section) for intraoperative diagnosis and permanent histological preparation.

• Immunohistochemical examination if tumor typing is necessary or when searching for the primary focus.

Microbiological examination of pleural fluid in complicated pleural effusions and empyema cases.

3.2.2 SURGICAL METHODS

Video-assisted thoracoscopic surgeries (VATS) have been performed for the purpose of evacuating pleural effusion, performing biopsies, pneumolysis, pleurectomy, decortication, or chemical pleurodesis through different approaches:

- Multiportal VATS (MVATS)
- Biportal VATS (BVATS)
- Uniportal VATS (UVATS)

The type of surgical approach was selected based on the nature of the effusion - etiology, whether it is free or loculated, specific radiographic findings, patient habitus, and the desired extent of surgery.

3.2.4 STATISTICAL METHODS

The methodology of the statistical analysis in the dissertation work is based on several classical methods of statistics, such as descriptive statistics, grouping, $\chi 2$ analysis, tabular method, and graphical representations.

4 RESULTS

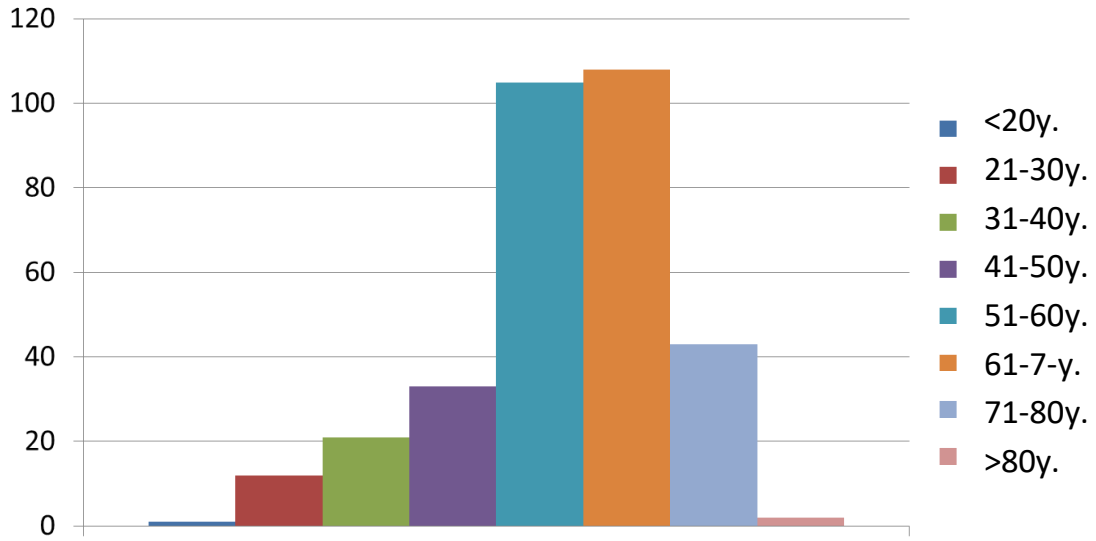
4.1 SOCIO-DEMOGRAPHIC INDICATORS OF THE PATIENTS

As the subject of the present research work, a total of 325 patients with pleural effusion who underwent thoracoscopic treatment were retrospectively analyzed. The following demographic characteristics were investigated:

4.1.1 Age

The calculated average age of all patients is 64.5 years. The youngest patient is 18 years old, while the oldest is 88 years old. Figure 1 shows the distribution of the number of patients by age groups.

Figure 1: Histogram of the distribution of patients(n = 325) by age groups



The pronounced right-skewed distribution curve indicates an increased number of affected patients in the age ranges of 51-60 years and 61-70 years. This corresponds to the well-known increase in the incidence of almost all oncological diseases in these age intervals, which can present with malignant pleural effusion.

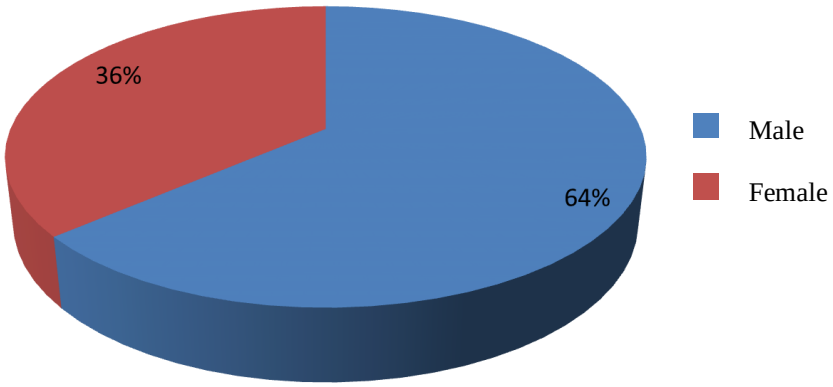
4.1.2 Gender

The distribution of patients by gender is as follows: out of a total of 325 patients, 207 are male and 118 are female. This gender ratio is presented as a percentage in Table 1 and Figure 2.

Gender	Number	Percent	95% Confidence interval
Male	207	63.7%	[58.2%; 68.9%]
Female	118	36.3%	[31.1%; 41.8%]
All	325	100%	

Table 1: Distribution of patients wuth pleural effusion by gender

Figure 2: Distribution by gender

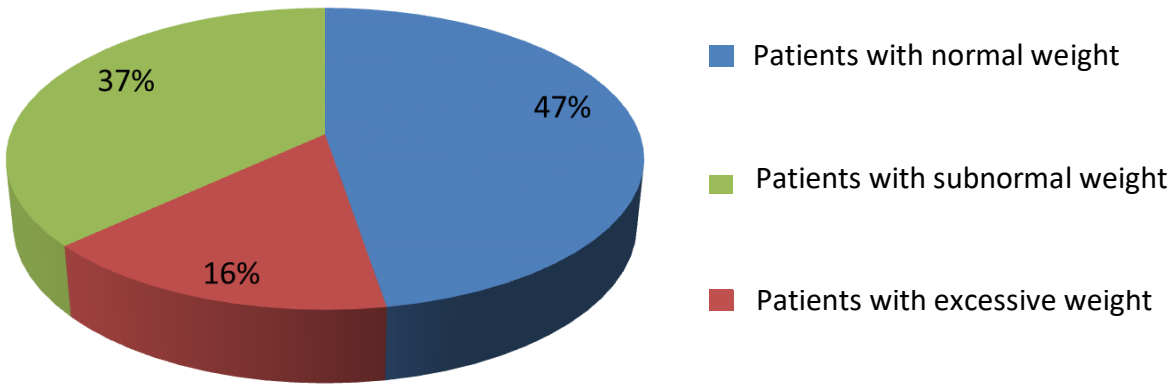


4.2 CLINICAL AND DIAGNOSTIC CHARACTERISTICS. CLINICAL OBSERVATIONS

4.2.1 Body weight and BMI

As known from numerous studies on overweight and obesity, their strong association with an increased risk of developing various forms of malignant diseases has been established, along with an increased frequency of postoperative complications related to local and general factors. Our results indicate that 47% of the patients we have treated have a normal body mass index (BMI < 18.5), 16% are underweight (BMI = 18.5-25), which we attribute to the advanced stage of their oncological disease most commonly, and 37% are overweight (BMI > 30). Additionally, significant obesity is a relative contraindication for the uniportal VATS technique due to the critical need for specific and longer instruments to access more distant anatomical areas, as well as the difficulty of working in the deep and narrow surgical field caused by the thick chest wall and narrow intercostal spaces in these patients. This distribution of patients according to their body weight is illustrated in Figure 3.

Figure 3: Distribution of patients by Body mass index /BMI/

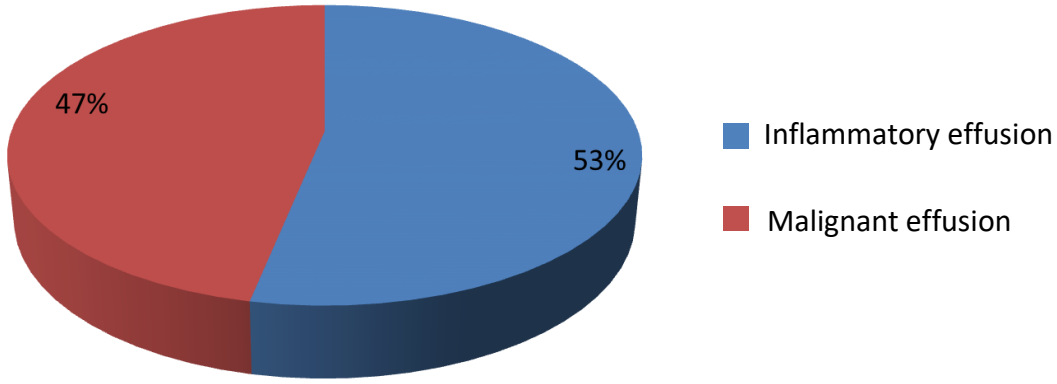


4.2.2 Nosological units

Out of all the patients with pleural effusion who underwent thoracoscopic treatment, an inflammatory nature was confirmed in 173 cases, while a malignant nature (primary and

metastatic) was observed in 152 cases. Primary malignant effusion was histologically confirmed in 21 patients with pleural mesothelioma, while the remaining 131 cases were classified as secondary malignancies. The distribution of patients according to the type of effusion is illustrated in Figure 4.

Figure 4: Distribution by the type of the effusion



The inflammatory effusions that were treated using minimally invasive techniques included recurrent free inflammatory effusions (resulting from inflammation or complications of systemic diseases), tuberculous effusions, inflammatory effusions complicated by septation and the formation of pleural loculations, and classical empyemas at various stages of development. The distribution of patients with these types of pleural effusions is illustrated in Table 2

Inflammatory effusions treated with VATS-techniques	**Number of patients (N)**	**%**	**95% Confidence interval**
Recurrent free effusions /inflammatory or complication of systemic diseases/	21	13.8	[8.8%;20.3%]

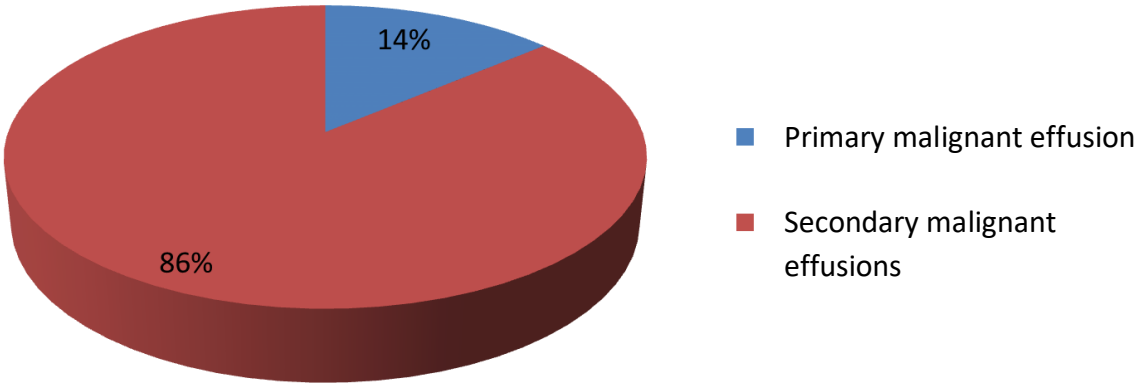
Inflammatory effusions complicated by septation and loculation formation	78	51.3	[43.1%;59.5%]
Classic empyemas in different stages of development	67	44.1	[36.0%;52.4%]
Tuberculous specific effusions	7	4.6	[1.9%; 9.3%]

Table 2 : Distribution of patients with inflammatory types of pleural effusions treated by VATS

We have treated a total number of 152 malignant effusions. Among 21 patients, we have confirmed a primary malignant effusion with a histological diagnosis of pleural mesothelioma, and in 7 of them, this diagnosis was not suspected or diagnosed in the preoperative imaging studies, highlighting once again the role of VATS in establishing a specific diagnosis.

In the remaining 131 patients, the effusion was secondary or metastatic. The most common primary sites were breast cancer, lung cancer, lymphomas, gastrointestinal tumors, and ovarian carcinomas. Less frequently, we detected prostate cancer, kidney cancer, and other even rarer types of malignancies. The distribution of primary and secondary malignant effusions is shown in Diagram 5 below.

Figure 5: Malignant effusions



Distribution of patients operated by VATS according to the final histological result has been systematized in Table 3.

	MULTIPORTAL	BIPORTAL	UNIPORTAL
Number of patients	27	193	105
Pleural empyema	27	92	26
Nonspecific pleuritis	0	0	21
Tuberculous pleuritis	0	7	0
Pleural metastasis from pulmonary cancer	0	33	15
Pleural metastasis from breast cancer	0	17	12
Pleural metastasis from gastrointestinal cancer	0	10	4

Pleural metastasis from ovarial cancer	0	7	3
Pleural metastasis from kidney cancer	0	2	2
Pleural metastasis from prosate cancer	0	3	2
Pleural metastasis from other rare cancers	0	8	3
Pleural mesotelioma	0	9	12
Metastasis from lymphoprolferative disease	0	5	0

Table 3: Distribution of patients operated by VATS according to the final histological result

4.2.3 IMAGING INVESTIGATIONS

Preoperatively, at least one imaging modality was applied to all patients to assess the size, density, localization, and extent of the pleural effusion (whether it was free or loculated), the presence of large pleural cavities, as well as to evaluate or locally stage the thoracic oncological disease, such as primary pleural mesothelioma or lung carcinoma. Sometimes, depending on the specific case, all three main imaging methods - radiography, pleural ultrasound, and chest CT scan (native or contrast-enhanced) or a combination of them - were used. Pleural ultrasound examination was performed on only 3 patients, and a combination of ultrasound and radiography was performed on 38 patients. Radiography was used for evaluation in 44 cases, while the largest number of patients, 148, underwent chest CT scan. CT scan was used for further clarification after previous ultrasound and radiography in 44 patients, and in combination with prior radiography only in 38 individuals. The distribution of the types of imaging techniques used preoperatively is shown in Table 4 below.

Imaging modality	Number	%	95% Confidence interval
Ultrasound of pleural spaces	3	0,9	[0.2%; 2.7%]
Chest X-ray	44	13,5	[10.0%; 17.7%]
Chest CT	148	45,5	[40.0%; 51.1%]
Chest X-ray and CT	48	14,8	[11.1%; 19.1%]
US, X-Ray	38	11.7	[8.4%; 15.7%]
US, X-Ray, CT	44	13,5	[10.0%; 17.7%]

Table 4: Distribution of the performed preoperative imaging studies

It should be noted that in UMBAL "Sveta Marina," as a rule, all patients with oncological diseases undergo preoperative PET-CT, which explains the high number of conducted examinations - 157. Additionally, PET-CT is not included as a separate category in combination with the other techniques because it is not fundamentally included in our clinic's preoperative algorithm.

Regardless of whether it is performed preoperatively or postoperatively, there are different indications for selecting one of the available methods, which vary depending on the specific case. The following groups can be distinguished:

• Assessment of the size and density of the effusion, as well as whether the effusion is truly free or not.

• Evaluation of the localization of each pleural loculation in the presence of complicated effusion, aiming to determine the specific thoracoscopic access and the precise location of the primary working incision and other ports in bi- or multi-port techniques.

• Application in cases where a finding has been diagnosed through another imaging method, in order to further clarify its specific characteristics and determine the most suitable surgical strategy.

• Assessment of the spread of empyema and the condition of the lung (presence or absence of large infiltrative zones within the parenchyma or areas of abscess formation).

• Evaluation of the extent of mesothelioma involvement in the pleura (involvement of the chest wall, mediastinum, diaphragm) to develop the best surgical approach and determine the extent of intervention in tumor-debulking palliative resections.

• Postoperative monitoring during the early postoperative period until drain removal.

4.2.4 PREOPERATIVE STAGING ACCORDING TO ASA (American society of anesthesiologist).

The American Society of Anesthesiologists (ASA) created a scale in 1963, which is still used today to assess the risk level of a surgical intervention based on the patient's overall condition, the extent of impairment related to the primary and accompanying diseases. All operated patients are preoperatively consulted by an anesthesiologist and evaluated according to the ASA classification. The highest percentage of cases is represented by patients classified as ASA III (52.9%), followed by ASA II (23.7%) and ASA IV (16.9%). This diverse result can be explained by the lower level of impairment in patients with uncomplicated inflammatory effusion and fewer accompanying diseases, in contrast to severely impaired patients with severe empyema and especially advanced oncological conditions. The assessments of all patients are reflected in the table and diagram below.

ASA - grades	Number	Percents %	95% Confidence interval
I	18	5,5	[3.3%; 8.6%]
II	77	23,7	[19.2%; 28.7%]
III	172	52,9	[47.3%; 58.5%]
IV	55	16.9	[13.0%; 21.5%]
V	3	1	[0.2%; 2.7%]
VI	0	0	-

Table 5 : Classification of the patients according to ASA

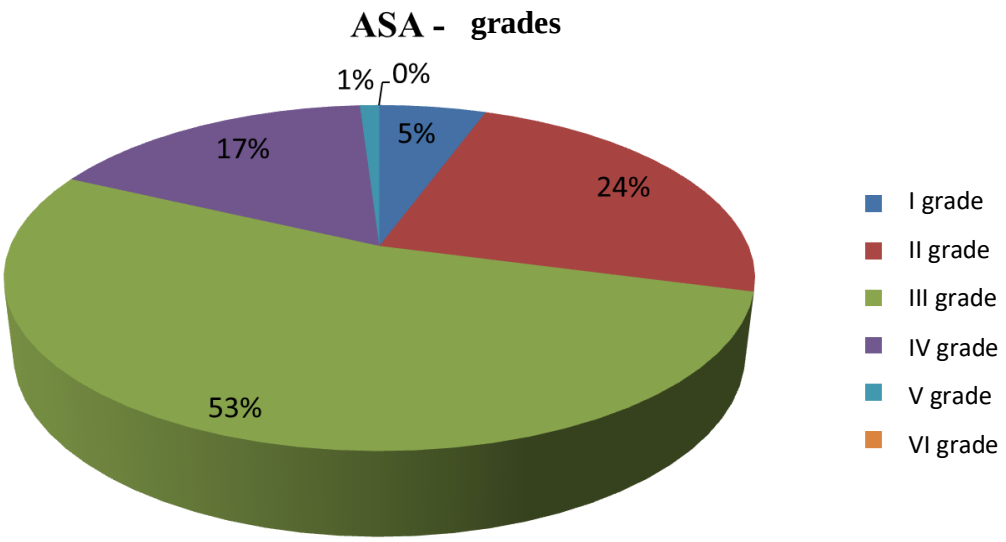


Figure 6 : Classification of the patients according to ASA

4.2.5 Indications and contraindications

The specific indications and contraindications that we have followed in the selection of patients for minimally invasive thoracoscopic treatment are based on our personal clinical experience and traditions in our clinic. They have been consolidated into Table 6.

Indications	Contraindications
Small pleural effusions unresponsive to conservative treatment	Patients in a severely impaired general condition (inoperable patients)
Massive pleural effusions	Patients with a single lung
Malignant pleural effusions with an unclear primary focus and suspicion of a tumor,	Patients who cannot tolerate separate intubation anesthesia with accompanying

located in the organs in the chest and to achieve a histological diagnosis	diseases of a local nature - COPD, Pulmonary fibrosis, etc.
Malignant pleural effusions for the purpose of talc pleurodesis	Patients with non-massive pleural effusions of proven cardiac, renal or hepatic origin
Chronic stage of pleural empyema for decortication	Patients with multiple concomitant diseases of a systemic nature who cannot tolerate general anesthesia
Chronic-recurrent pleural effusions of unknown origin	
Loculated or multiseptate pleural effusions	
Complicated inflammatory pleural effusions and purulent pleural effusions	
Chylous effusions for the purpose of intervention on the thoracic duct	
Hemorrhagic pleural effusions	

Table 6 : Indications and contraindications for thoracoscopic treatment of pleural effusions.

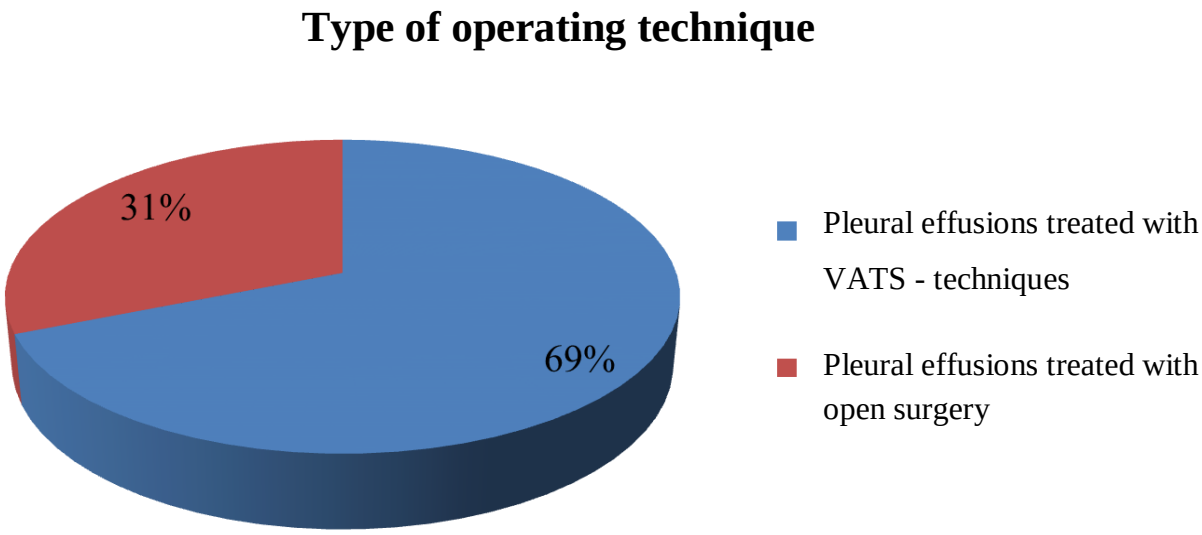
4.2.6 Surgical approach.

The type of surgical approach was selected based on the nature of the pleural effusion - its etiology and accompanying pathology, whether it was free or loculated, the radiographic findings, the patient's habitus, and the desired extent of surgery. From 2012 to 2022, a total of 472 patients with pleural effusion underwent surgery, with 147 undergoing open conventional surgery and 325 undergoing minimally invasive thoracoscopic techniques with different approaches. The distribution of all surgically treated patients is graphically presented in Table 7 and Diagram 7.

Type of operating technique	Number of patients (N)	%	95% Confidence interval
Pleural effusions treated with minimally invasive VATS - techniques	325	68,9%	[64.5%; 73.0%]
Pleural effusions treated with open surgery	147	31.1%	[27.0%; 35.5%]
Total number of pleural effusions treated by surgery	472	100%	-

Table 7: Distribution of all patients treated surgically

Figure 7: Distribution of all patients treated surgically



During the same 10-year period, a total of 628 patients were treated in the clinic using pleural drainage alone. Among them, 147 patients were treated with a tube thoracostomy, while the remaining 481 patients had long-term pigtail catheters inserted. This large number of patients treated with pleural drainage reflects the clinic's commitment to treating patients in a minimally traumatic manner whenever possible and avoiding unnecessary surgical interventions under general anesthesia. Another reason for using pleural drainage as the sole surgical approach is the compromised general condition of some of these patients and their expected short life expectancy, particularly in cases of malignant effusion in terminally ill oncology patients. The distribution of patients according to the type of pleural drainage is presented visually in Table 8 and Figure 8.

Type of pleural drainage	**Number of patients (N)**	**%**	**95% Confidence interval**
Pleural effusions treated by tube thoracostomy	147	23.4%	[20.3%; 26.9%]
Pleural effusions treated by long-term pigtail catheters	481	76.6%	[73.1%; 79.9%]
Total number of pleural effusions treated by pleural drainage alone	628	100%	-

Table 8 : Dustribution of patients by pleural drainage alone

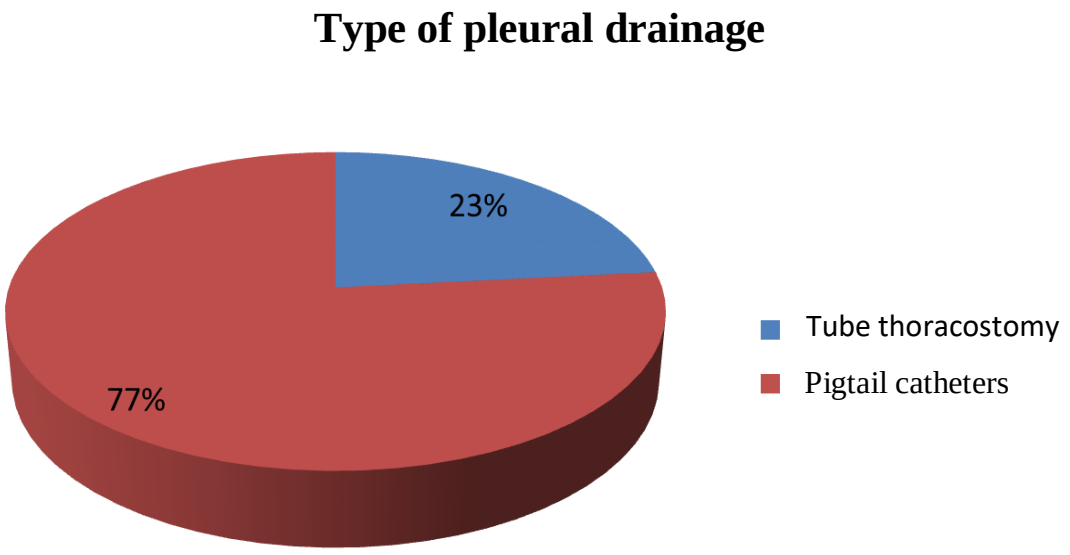


Figure 8: Dustribution of patients by pleural drainage alone

Among the 325 patients treated with VATS techniques, the smallest number of patients were treated using a three-port or multi-port approach, with only 27 patients. The highest number of patients, 193 in total, underwent surgery using a biportal approach. A uniportal technique was used for surgery in 105 patients. The distribution of patients according to the specific minimally invasive thoracoscopic approach used is presented in Table 9 and Figure 9.

Type thoracoscopic approach	**Number of patients**	**%**	**95% Confidence interval**
Multiportal	27	8,3	[5.5%; 11.9%]
Biportal	193	59,3	[53.8%; 64.7%]
Uniportal	105	32,4	[27.3%; 37.7%]
Total	325	100	-

Table 9 : Distribution of patients with operations performed using different types of thoracoscopic access.

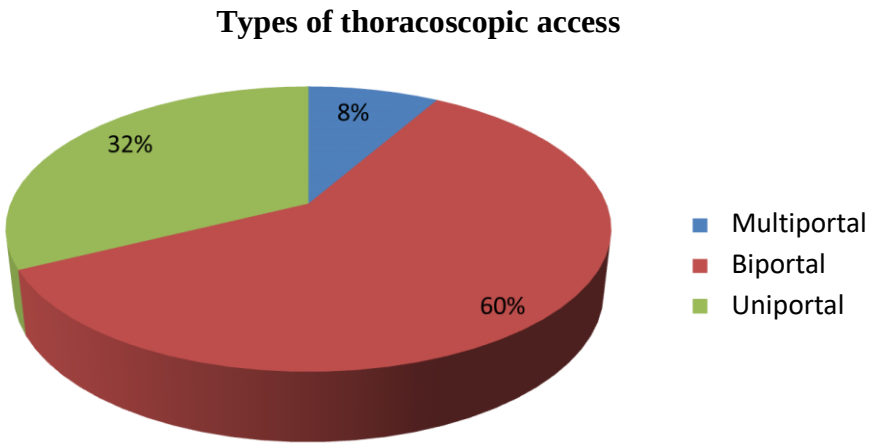


Figure 9 : Distribution of patients with operations performed using different types of thoracoscopic access

4.2.7 INTRAOPERATIVE TIME.

The intraoperative time is an indicator that we have monitored for patients undergoing surgery using different types of thoracoscopic approaches. The longest duration was observed in three-port VATS surgeries, with a minimum time of 45 minutes and a maximum time of 112 minutes. This is primarily due to the fact that partial to extensive decortication procedures were performed in practically all patients in this group. In the uniportal and biportal intervention groups, the duration of surgery was almost the same, with a difference of 10 minutes. The distribution of patients across groups based on the type of surgical approach and intraoperative time is demonstrated in the table below.

	MULTIPORTAL	BIPORTAL	UNIPORTAL
Number of patients	27	193	105
Intraoperative time	45-112 min	30-90 min	40-100 min

Table 10 : The distribution of patients by group according to the type of surgical access and the intraoperative time.

4.2.8 HOSPITAL STAY

We have examined the length of hospital stay for all patients and have made a distribution based on the type of operative technique used. It is noticeable that patients who underwent uniportal and biportal resections had relatively similar hospital stays, while patients who underwent multiportal access had slightly longer stays. This can be explained not only by the specific operative technique but also by the patients themselves. Specifically, patients treated with three-port access had extensive empyema after thorough decortication, leading to a more compromised general condition. The distribution of patients according to their hospital stay and different minimally invasive techniques is presented in Table 10.

[Table demonstrating the distribution of patients by hospital stay and different minimally invasive techniques]

Type of access	**MULTIPORTAL**	**BIPORTAL**	**UNIPORTAL**
Number of patients	27	193	105
Hospital stay	3-12 days	3-9 days	3-8 days

Table 11: Distribution of patients according to type of access and hospital stay.

4.2.9 DURATION OF PLEURAL DRENAGE

One of the main factors determining the length of hospital stay is the duration of postoperative pleural drainage for the patient. The shorter this period, the faster the potential for discharge, provided that the patient is in good overall condition and the primary wound is healing well.
In particular, during decortication procedures, there are more cases of increased alveolar permeability and prolonged drainage leakage, resulting in a longer duration of hospital stay with pleural drainage. This is also the reason for the majority of days in the multiportal access group, where all patients underwent decortication. The number of days with pleural drainage is illustrated in Table 12.

	MULTIPORTAL	BIPORTAL	UNIPORTAL
Number of patients	27	193	105
Time to remove the drain	2-10days	2-7days	2-7days

Table 12 : Length of stay with pleural drainage in the different accesses.

4.2.10 INTRAOPERATIVE COMPLICATIONS.

During the procedures performed using biportal thoracoscopic access, we encountered one case of intraoperative complication characterized by significant bleeding from an interlobar vessel with extensive bleeding throughout the pleural cavity. This necessitated a conversion to open conventional surgery. We did not observe any other similar complications, which we attribute to the specific anatomical challenges presented in that case, the technical skills of the surgeon, and the available instrumentation, rather than the specific type of minimally invasive access used.

	MULTIPORTAL	BIPORTAL	UNIPORTAL
Number of patients	27	193	105
Intraoperative complications	N/A	Bleeding from interlobar vessel /1/	N/A

Table 13 : Intraoperative complications

4.2.11 POSTOPERATIVE COMPLICATIONS.

We observed early postoperative complications in 18 patients. Persistent air leakage after surgery was present in 16 patients, treated with all three surgical techniques, with the lowest incidence observed in patients who underwent uniportal technique. This can be attributed to a lower number of patients requiring extensive decortication rather than the surgical access itself. One patient developed arrhythmia after surgery following a multiportal VATS procedure for pleural empyema. While this complication can be partially attributed to the underlying cardiovascular pathology, its occurrence in the early postoperative period led to its categorization in this group.

Suppuration of the surgical wound occurred following a uniportal VATS procedure for empyema, and it should be noted that the accompanying rare autoimmune disease may have acted as a predisposing factor for both empyema and wound infection. The postoperative complications are systematically presented in the table below (Table 14).

	MULTIPORTAL	BIPORTAL	UNIPORTAL
Number of patients	27	193	105
Postoperative complications	• Persistent leakage after decortication /6/ • Arrhythmia /1/	• Persistent leakage after decortication /6/	• Persistent leakage after decortication /4/ • Suppuration of the operative wound /1/

Table 14: Distribution of the types of postoperative complications

4.2.12 COSMETIC RESULT.

We have assessed the achieved postoperative cosmetic results using a 4-point scale based on the subjective perception of the patients themselves, as we believe that ultimately it is the most relevant factor. The evaluation options for the cosmetic outcome are as follows: excellent, good, satisfactory, and poor. We observed excellent and good cosmetic results in the majority of patients. Satisfactory results were seen in a small group of patients, mainly due to the type of cosmetic suture used, specifically Algover, as opposed to the intradermal continuous suture

used in other cases. This type of wound closure was employed in patients with severe empyema to prevent postoperative infections. In practice, we had one patient with a poor cosmetic outcome in the area of the incision. The distribution of cosmetic results according to the type of thoracoscopic approach is presented in Table 15.

	MULTIPORTAL	**BIPORTAL**	**UNIPORTAL**
Number of patients	27	193	105
Cosmetic result **EXCELLENT**	6 (22.2%)	105 (54.4%)	88 (83.8%)
Cosmetic result **GOOD**	4 (14.8%)	55 (28.5%)	14 (13.3%)
Cosmetic result **SATISFACTORY**	16 (59.3%)	33 (17.1%)	3 (2,9%)
Cosmetic result **BAD**	1 (3,7%)	0	0

Table 15: Distribution according to the type of thoracoscopic access and the cosmetic result

5. DISCUSSION:

In recent years, with the development of thoracic surgery on a European and global scale, the use of minimally invasive thoracoscopic techniques has shifted from being relevant to becoming mandatory, due to their advantages and positive characteristics compared to conventional open surgery. Over the course of about two decades, there has been a transition from the initial 3- or even 4-port technique to a focus on reducing the number and size of incisions and ports. Initially, the biportal technique was discovered and developed, followed by the least invasive technique, namely the uniportal approach.

Bulgaria, as a country with slower and more challenging economic development due to various factors such as its location, history, and policies, introduced and developed endoscopic techniques in the field of thoracic surgery, unlike, for example, gynecological, urological, and abdominal endoscopic surgery. The difference in working in the two domains - abdominal and pleural - with their respective instruments, technical and energy sources, as well as the type of endoscopic sutures used, is of significance. The first scientific papers on the introduction of thoracoscopic surgery in Bulgaria date back to 1998 with Prof. G. Kalaidjiev's dissertation [5]. Regarding the treatment of pleural effusions using minimally invasive techniques, the first scientific article was published in 2002 by Prof. Deyan Yordanov [3].

Up until the time of writing this dissertation, it should be noted that there is still a lack of any healthcare funding for consumables used in performing thoracic endoscopic interventions, unlike the aforementioned specialties, and they have higher costs themselves compared to others. All consumables to date must be fully paid for by the patients themselves, which is quite demotivating, especially when it comes to oncology patients. Despite these difficulties, as well as local challenges in the clinic related to the availability of instruments, thoracoscopic interventions have been performed for over 25 years. Even one of the first scientific papers in this field was published by the former long-time head of the thoracic surgery clinic - Professor Radoslav Radev, one of the pioneers in Bulgaria [10].

The development of various operative approaches - multiport, biportal, and uniportal - in our country follows the development trend existing in Europe, albeit at a slower and more challenging pace. Initially, like in other centers, slightly larger incisions and accordingly more ports were used. Today, efforts are made to follow the established maxim of world thoracic surgery, "less is more," and each intervention starts as a uniportal approach based on indications, with the addition of more ports if necessary after discussion. In our clinic, decisions

are made aiming to individualize the approach to each patient, even though some people consider it trivial and elementary when it comes to pleural effusion.

Considering the situation in Bulgaria, the lack of a lung cancer screening program, as well as the developed mentality of underestimating personal prevention and timely attention to initial symptoms, a significant portion of patients present with advanced inflammatory or malignant diseases complicated by pleural effusion. Therefore, this condition is one of the most common diseases in the field of thoracic surgery in the country, perhaps not much different from the global perspective. It is also a priority in some divisions of internal medicine, pulmonary diseases, cardiology, nephrology, and other medical specialties.

There are numerous options in the diagnosis and treatment of effusions, but the timing and precise choice of operative intervention remain on the agenda. Pleural effusions resulting from complications of systemic cardiovascular, renal, and gastrointestinal diseases should be treated conservatively by the respective specialists, rather than through thoracic drainage or other operative techniques, especially at first glance. When conservative management is not possible or when the body's resources are exhausted in refractory diseases, surgical treatment becomes necessary.

In our clinic, we adhere to strict indications for the operative treatment of pleural effusions, which align with the recommendations of the two international guidelines from the British Thoracic Society (BTS) and the American College of Chest Physicians (ACCP). All small pleural effusions that do not respond sufficiently to conservative treatment in terms of time and volume, chronic-recurrent effusions, as well as large or so-called massive effusions that manifest symptomatically, undergo surgical treatment. As the British Thoracic Society advises, small and moderate transudative effusions should be treated according to the underlying disease that caused them. Regardless of their nature, large (massive) effusions should be treated surgically.
Complicated inflammatory pleural effusions and purulent pleural effusions, as well as all empyemas, are accepted in our clinic as indications for VATS (video-assisted thoracoscopic surgery) treatment.

The indications for VATS treatment in relation to malignant pleural effusions are as follows: effusions with unclear primary focus and suspicion of neoplasm in the organs within the chest

cavity, and for achieving a histological diagnosis (undifferentiated malignant effusions), all proven malignant effusions indicated for chemical pleurodesis.

Some other rare indications for VATS treatment of pleural effusions include: achieving a pleuro-peritoneal shunt when all other options have been exhausted in oncology patients or those with chylous effusions, intervention on the thoracic duct in chylous effusions, hemorrhagic effusions, as well as cases of closing diaphragmatic defects to prevent recurrent accumulation of pleural effusion in patients with ascites.

The contraindications that we have established as a rule and adhere to in the clinic are mainly related to the overall condition of the patients, to what extent they are compromised due to the nature and severity of accompanying systemic diseases, to the point where they cannot tolerate general anesthesia. Patients with specific local conditions such as COPD, asthma, pulmonary fibrosis, and others, as well as those with a single lung, are also carefully evaluated and discussed. As mentioned above, and according to us, as well as the recommendations of the British Thoracic Society and the American College of Chest Physicians, as well as numerous scientific studies like that of Kamran Boka, ordinary small and moderate-sized transudative effusions of cardiac, renal, and hepatic origin are not treated thoracoscopically [28].

During the period from 2012 to 2022, we have operated on a total of 472 patients with pleural effusion, of which 147 underwent open conventional surgery and 325 underwent minimally invasive thoracoscopic techniques with different approaches. The preference for the latter is based on following global and European trends in the development of thoracic surgery. The conventional approach was used in patients where the use of thoracoscopic techniques was practically impossible, such as in cases of completely obliterated pleural cavities with multiple pleural loculations or in patients with severe empyema or extensively encased lung requiring extensive decortication due to significantly altered anatomy in the chest.

In patients with more compromised overall condition, particularly those with severe inflammation or effusions due to advanced oncological diseases, minimally invasive thoracoscopic techniques are considered due to the possibility of faster recovery, a lighter postoperative period with less trauma and consequently less pain. All our patients have experienced faster recovery and shorter hospital stays compared to those treated with open techniques, with an average hospital stay reduced by 2-4 days, as their average hospital stay ranges from 7-13 days. All the advantages of VATS techniques that we have observed fully

coincide with those described in numerous scientific studies by Mineo, Augostini, Bendixen, Qiang, Jawitz, and others [15,22,98,144,161].
We have categorized all these advantages for the patients in the following manner:

- ✓ Smaller surgical trauma with lower intensity of acute or chronic postoperative pain.
- ✓ Shorter postoperative period with improved physical and psychoemotional comfort.
- ✓ Reduced hospital stay.
- ✓ Better cosmetic outcome of the skin and chest wall.
- ✓ Lower morbidity and mortality rates.
- ✓ Faster overall recovery.
- ✓ Quicker return to home and professional responsibilities.
- ✓ Improved quality of life.

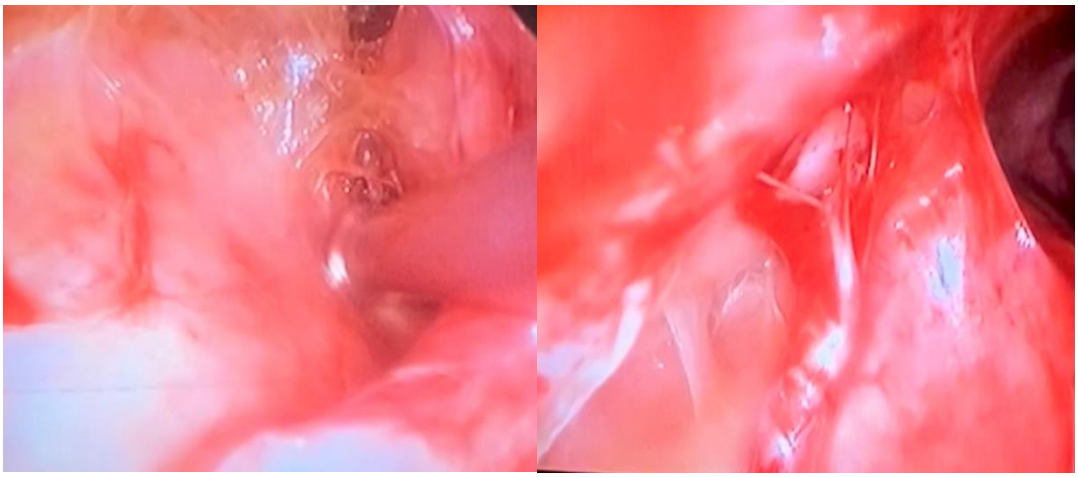
We have observed the same trend that Mineo[144] has noticed regarding the advantages of minimally invasive techniques and their detailed explanation and presentation to the patient, which contributes to agreement even among some individuals who initially refuse surgical treatment despite indications for such treatment. We consider all of this as a prerequisite for an informed and shared decision between the surgeon and the patient in the name of the best possible solution given the existing condition. It is also crucial to note that by including patients who have not consented to surgical treatment, the possibility of missing the correct diagnosis is prevented, in addition to achieving treatment.

Although there are several algorithms for comprehensive examination, evaluation, and diagnosis of pleural effusions, sometimes certain patients remain undiagnosed or diagnosed under the category of "nonspecific pleuritis." It is essential to know the exact cause of the occurrence and development of each pleural effusion, in other words, to conduct an accurate diagnosis.

In our study, we have treated and confirmed a total of 152 patients with malignant effusions. In 21 patients, we have confirmed primary malignant effusion with a histological diagnosis of pleural mesothelioma, and in 7 of them, such a diagnosis was not previously made or suspected based on preoperative imaging studies. In the remaining 131 patients, the effusion was secondary or metastatic. Among them, we are the first medical specialists to confirm malignant disease with a secondary effusion in the absence of preoperative suspicion in 8 cases. That is, these cases account for 9.8% of all confirmed malignant effusions. All of these patients would

likely have been diagnosed and treated with significant delay, once again demonstrating the role of VATS (video-assisted thoracoscopic surgery) techniques in establishing a specific diagnosis. Venekampf and colleagues have published similar results from their retrospective study, demonstrating that out of 75 patients evaluated as having nonspecific pleuritis, 8.3% of them were later diagnosed with malignant disease during the 2-year follow-up [208]. These 8-10 percent of all patients are a significant percentage since timely initiation of systemic treatment leads to significantly better outcomes in terms of survival and mortality, especially in the era of immunotherapy or targeted therapy as a subset of oncological systemic therapies. Such studies highlight the significance of VATS in the clarification and treatment of pleural effusions, as it allows for a more thorough examination and targeted biopsy of suspicious areas, as well as direct transition to therapeutic intervention in cases of definite malignancy through performing pleurodesis. Typically, we take between 3 and 7 tissue biopsies of suspicious areas, including blind biopsies of those without visible suspicion. Within a 1-year follow-up period, we have no patients with undiagnosed malignant disease who were treated with VATS techniques, which demonstrates the effectiveness and benefits of these techniques with good tolerability and safety for patients. The benefits of VATS for malignant effusions have also been reported in Sayir's analysis [185].

During a 10-year period from 2012 onwards, VATS has been increasingly used in our clinic for pleural inflammation within complicated effusions, as well as in the early stages of empyema as an alternative to open techniques, with comparable results in terms of good visualization and thorough pneumolysis and debridement. Initially, empyemas were treated exclusively in the chronic stage with the aim of pneumolysis and, most importantly, decortication of already formed stable pleural adhesions to release partially or completely blocked or "armored" lung tissue. Nowadays, we increasingly aim for early treatment in the clinic to prevent the formation of these adhesions and complications, following global trends (Picture 1).



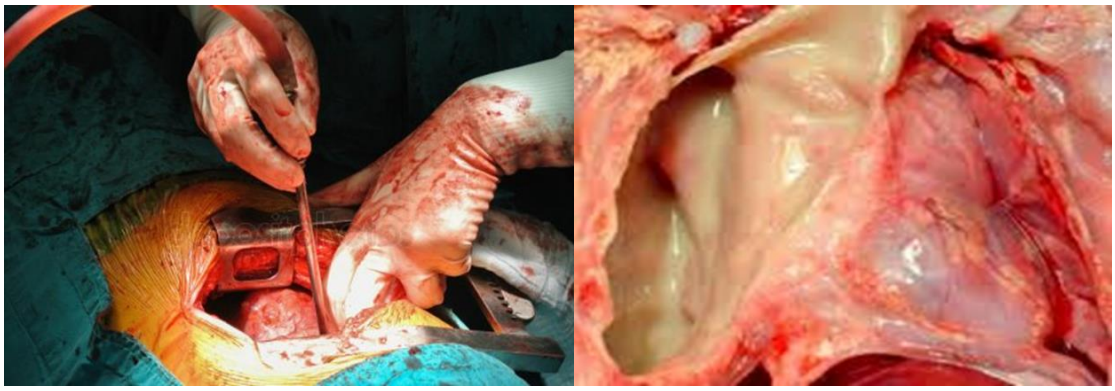
Picture 1: Early VATS pneumolysis

Early surgical treatment demonstrates much better chances of cure compared to conservative therapy or standalone drainage, even when combined with fibrinolytic therapy. This is supported by studies by Waller and Wojniak [212, 218]. Numerous scientific publications, such as those by Lu and Wait, confirm the positive outcomes of VATS (Video-Assisted Thoracoscopic Surgery) in complicated parapneumonic effusions and pleural empyema as an effective and safe procedure. When applied early in the treatment strategy, it leads to shorter hospital stays and reduced overall treatment costs, which is of immense importance for both patients and healthcare facilities [125, 210]. This is particularly significant for countries like Bulgaria, considering the challenging financial state of some medical centers and the healthcare system as a whole. Our clinic's strategy aligns with the surgical treatment algorithm for complicated effusions by Prof. Deyan Yordanov [4].

Increasingly, minimally invasive techniques are being employed in patients with late-stage pleural empyema, who have underlying coagulation disorders, compromised homeostasis, or other accompanying conditions that categorize them as high-risk candidates for open surgeries aiming to free the lung via decortication. In our series, a total of 67 patients with empyema were treated, with 37 or more than half of them being in relatively severe overall condition due to both the underlying disease and accompanying pathology. These 37 patients were deemed contraindicated for open surgery, further confirming the advantage of VATS techniques. Similar results and recommendations are found in Takoni's study [198]. In such comorbid and intoxicated patients, we observe significantly faster recovery when using minimally invasive techniques, with less surgical trauma to the chest wall and shorter intraoperative time

(particularly the reduced lung collapse time through general separate-lung ventilation). According to our assessment, early thoracoscopic treatment is often sufficient and serves as a prerequisite to avoid extensive open surgeries, thus promoting faster recovery, shorter hospital stays, and reduced overall treatment costs. These findings align with the scientific research by Bilgin et al. [25].

However, when it comes to the full development of empyema with significant adhesions and lung entrapment, it is important to note that multiple factors play a role in the successful VATS decortication. These factors include the duration of the disease, prior treatment, the experience and capabilities of the operator, the availability of specific instrumentation, and good collaboration with other specialists involved in the treatment process, particularly anesthesiologists. In cases of unsatisfactory results with the VATS technique or recurrence, there should be no hesitation to convert to an open procedure. This is also recommended by leading Bulgarian specialists like Prof. Petrov [8]. In our practice, we have not observed any cases of conversion, mainly due to good preoperative planning, excluding doubtful cases that were immediately determined as suitable for a classical open intervention. Numerous studies highlight the significance of fewer recurrences or re-interventions in specific and complicated cases of empyema, especially in post-pneumonectomy empyema, which is highly specific. Such is the study by Zahid et al. [225]. It should be noted that we have not treated post-pneumonectomy empyema. It is worth mentioning that despite the development of thoracic minimally invasive surgery, open decortication is still considered the gold standard in treating empyema with documented lung entrapment or "trapped lung" (Figure 11). According to us, it is crucial for achieving a favorable outcome and restoring normal lung function, as well as proper respiratory mechanics, to select the right timing for surgical intervention, namely after the organization phase to prevent extensive parenchymal lacerations with the formation of multiple fistulous openings but before the formation of end-stage fibrothorax. These findings are supported by the results of Bölükbas 's study [29]



Picture 2 : Open decortication

In our clinic, all three standard types of thoracoscopic approaches are used - single-port, two-port, and three- or multi-port, along with their modifications for anterior and posterior access. However, we prefer and almost exclusively use the anterior approach (Pictures 3 and 4).

Picture 3: Uniportal VATS

Picture 4: Biportal VATS

The type of surgical approach is always selected based on the nature of the effusion, its etiology, and any accompanying lung pathology, if present. It is crucial to consider whether the pleural effusion is free or loculated, the exact radiographic findings, the patient's habitus and performance status, as well as the desired extent of surgery.

For all patients, the following indicators have been monitored, measured, and discussed, including the preoperative period, operative time, postoperative period, total hospital stay, time to drain removal, observed intra- and postoperative complications, as well as the achieved comprehensive result in terms of diagnosis and treatment.

- **PREOPERATIVE PERIOD**

• Discussion of the clinical value of the diagnostic methods used:

In contemporary diagnosis of pleural effusions, there is an increasing reliance on advanced imaging studies. However, the patient's history and physical examination have not completely lost their diagnostic value. Significant weight loss with progressive dyspnea and weakness over the past few weeks, without an acute onset, and in the absence of other systemic accompanying conditions, may indicate a malignant nature of the pleural effusion. On the other hand, complaints with an acute onset, viral infection, and subsequent bacterial pneumonia with accompanying febrile episodes suggest an inflammatory character of the effusion.

During the preoperative period, standard laboratory blood tests, including biochemistry, coagulation status, electrolyte levels, complete blood count, C-reactive protein, and, if necessary, extended markers specific to the patient's accompanying pathology, have been performed to prepare and assess the condition of all patients. The data from these investigations allow us to present patients for preoperative consultation with an anesthesiologist to assess the potential surgical risk and to arrange necessary consultations with specialists based on the accompanying pathology. All these measures enable us to identify high-risk patients and categorize them according to whether they can tolerate an open surgical intervention, if indicated, or if they can only undergo minimally invasive thoracoscopic intervention, or if they are absolutely contraindicated for any surgical treatment. Patients who are not suitable for surgery have been primarily treated with long-term catheters such as "pigtail" catheters, and less frequently with standard tube thoracostomy (20 or 24 French).

However, there are numerous studies that examine the benefits and drawbacks of treating malignant pleural effusions with long-term drainage and compare them with other treatment methods. As mentioned in the literature review, the randomized controlled trial TIME2 compared a group of patients treated with long-term catheters to those treated with video-assisted thoracoscopic surgery (VATS) talc pleurodesis. The results showed no significant difference between the two groups in terms of improvement in respiratory function during the first 42 days, which is vital for such patients to have a rapid alleviation of dyspnea and respiratory insufficiency. Another study indicates that up to the 6th month, there is no significant difference in quality of life and improvement in breathing between the two groups, but afterward, it is believed that patients with a long-term catheter may have some advantage due to the potential for spontaneous pleurodesis. Spontaneous pleurodesis can occur in 40 to 70% of patients with a catheter, allowing for its removal.

The percentages mentioned before are indeed significant, which is why we have used pigtail catheters to drain 481 out of a total of 628 patients during this period. We believe that in cases of high surgical risk and severely compromised overall patient condition, the use of pigtail catheters is fully justified and leads to an improvement in quality of life. It allows for better psychosocial comfort by enabling a quick return home, which, of course, benefits both the patients and the hospital facility through the economic advantage of shorter hospital stays. Those who were deemed suitable for surgery and could tolerate an open procedure were operated accordingly. For the remaining patients who were not candidates for open surgery, a decision was made to perform a minimally invasive intervention despite the high risk, with the clear intention of achieving a lighter postoperative period with these techniques. A total of 320

patients with a compromised overall condition, classified as ASA III, IV, and V, underwent surgery without postoperative mortality. This once again confirms the claim that minimally invasive surgeries are better tolerated, and patients recover faster, regardless of their initial severity. This is supported by studies conducted by Mineo, Augostini, Bendixen, Qiang, Jawitz, and others [15,22,98,144,161].

The majority of cases are patients classified as ASA III (172 individuals, accounting for 52.9% of all surgeries), but there are also 55 individuals classified as ASA IV (16.9% of all surgeries) and 3 individuals classified as ASA V (1% of all surgeries). The American Society of Anesthesiologists (ASA) classification system assists in the decision-making process regarding the choice of thoracoscopic access, all other factors being equal. Due to the more compromised overall condition, we prefer to use the least invasive approach, namely the uniportal technique.

In preoperative diagnostics, we include and find quite helpful the **body mass index (BMI) indicator**. There is evidence suggesting that BMI may be associated with an increased risk of developing pleural effusion. Several studies have found that people with higher BMI are more prone to developing pleural effusion compared to those with lower BMI. One possible explanation for this association is that obesity can lead to changes in lung function, including decreased lung compliance and increased airway resistance, which can increase the risk of pleural effusion development. Additionally, obesity is also associated with other conditions such as heart failure and diabetes, which can further increase the risk of pleural effusion recurrence. There is also evidence suggesting that BMI may be associated with an increased risk of developing malignant pleural effusion. A study published in the Journal of Thoracic Oncology found that people with higher BMI are more likely to develop malignant pleural effusion compared to those with lower BMI. One possible explanation for this association is that obesity can lead to chronic inflammation, which may contribute to the development and progression of cancer. Furthermore, obesity is associated with insulin resistance, which can promote tumor growth and spread. Overall, the relationship between BMI and malignant pleural effusions is complex and can be influenced by other factors, such as the type and stage of cancer and the presence of other comorbidities. Nevertheless, it is important for us to assess body weight because there is a categorical association with increased rates of postoperative complications related to local and general factors, and significant obesity is a relative contraindication for uniportal VATS (video-assisted thoracoscopic surgery) technique due to the critical need for specific and longer instruments, as well as the difficulty of working in a deep and narrow surgical field caused by thick chest walls and narrow intercostal spaces in

these patients. Our results indicate that 47% of the patients we have treated have a normal body mass index (BMI <18.5), 16% are underweight (BMI = 18.5-25), which we explain by the advanced stage of their oncological disease most often. In these patients, we mainly used two-portal and uniportal techniques. Among 37% of individuals, we observed overweight (BMI>30). For them, we mainly used the two-portal technique, and in three cases, the three-portal technique was applied.

- **IMAGING STUDIES**

Ultrasound examination is a harmless, accessible, and cost-effective diagnostic method for detecting and characterizing pleural effusions. The advantages of this method are related to its speed of execution, lack of need for patient preparation, safety, and possibility of repeated application. Ultrasound diagnosis of pleural effusions provides information in four directions: determining the presence of fluid in the pleural cavity, echographic characteristics of the internal structure of the pleural effusions, approximate assessment of the amount of pleural fluid, and determining the optimal site for pleural puncture or port placement. The limitations of the technique are associated with diagnosing diaphragmatic effusions, which require transhepatic or transliver acoustic access, while encapsulated interlobar and mediastinal effusions are entirely inaccessible to ultrasound examination.

Only three patients have undergone ultrasound examination of the pleura as the sole diagnostic method because we believe that in certain complex cases such as purulent effusions or those with malignant involvement of the visceral pleura and "encasement" of the lung, this examination alone may be sufficient for us to make a decision on the choice of operative access. These three patients had small free, recurrent, undetermined effusions, indicated for VATS (video-assisted thoracoscopic surgery) clarification and radical treatment. We were able to objectify these effusions in 100% of cases solely through ultrasound, as this examination surpasses radiographic methods in distinguishing small effusions from pleural thickening, with high specificity. Our data correlate with those from the literature [46, 119, 177, 219].

Unlike this correlation, determining the malignant or benign nature of the effusion is not achieved solely through ultrasound examination in our cases and in all three cases, as in the

study by Qureshi et al., which demonstrates 95% specificity for a malignant diagnosis. The overall sensitivity of ultrasound in the differential diagnosis of malignant versus benign effusions was 79% with a specificity of 100%, compared favorably to computed tomography (89%) [162].

Chest X-ray is an easily accessible and relatively inexpensive diagnostic method that we use to independently examine moderate to large free effusions. To visualize a pleural effusion on a conventional posteroanterior chest X-ray, the amount of fluid should be above 250-300 ml. We have used this method as a standalone examination in 44 patients. Difficulty is observed in massive effusions that cause complete opacity of the hemithorax, and we do not believe that they should be further specified solely by X-ray. Separated pleural effusions are more challenging to diagnose on standard chest X-rays. They appear as opaque shadows with various sizes and shapes, sometimes difficult to differentiate from pulmonary parenchymal processes, atelectasis, or consolidation. Therefore, we prefer to combine X-ray with another method in such cases. We have used a combination of X-ray and ultrasound in 38 patients and X-ray and CT in 48 patients. Additional clarification in these patients helps in specifying loculations in sepsis and aids in the choice of thoracoscopic access, as well as determining the incision and drainage sites.

Chest CT provides us with the best and most detailed assessment of the condition of the pleural cavity, pleura, and lungs. We have used CT as a standalone preoperative method in 148 patients. We prefer to use contrast-enhanced CT in patients without contraindications for contrast material. It allows for the differentiation of benign from malignant thickening of the pleura, and CT is preferably performed before complete drainage of the effusion for better visualization of pleural changes. Our observations correlate with data from the literature. Leung et al. [114] show that malignant diseases present on CT with nodular thickening of the pleura, thickening of the mediastinal pleura, thickening of the parietal pleura more than 1 cm or circumferential pleural thickening with specificity of 94%, 94%, 88%, or 100% and sensitivity of 51%, 36%, 56%, and 41%. The accuracy of Leung's criteria for detecting pleural malignancy is confirmed by several other prospective studies [186, 204].

Distinguishing pleural effusions in malignant mesothelioma from those in metastatic involvement of the pleura from a different primary carcinoma is significantly more difficult and often impossible since the scintigraphic appearance is quite similar in both conditions. Our data also demonstrate this, namely that 7 out of 21 cases with confirmed mesothelioma were not suspected during preoperative imaging.

Computed tomography allows for easier differentiation between exudative pleural effusions and established empyema. Therefore, CT is the diagnostic method we always use when there is suspicion of impending empyema and for staging. This is also demonstrated in the scientific study by McLoud [136, 211]. We also use CT to assist in decision-making during preoperative discussions regarding the placement of the surgical incision in cases where we suspect, based on X-ray, that the empyema cavity is localized in the area of the primary incision, as well as for assessing the need for additional ports.

- **Discussion of the clinical value of preoperative diagnosis of nosological groups.**

Good preoperative preparation with an accurate diagnosis and assessment of the patient's condition and the respective stage of the disease allows for a quality discussion and decision-making regarding the most appropriate surgical approach.

In our clinic, a total of 325 patients with pleural effusions underwent surgery based on indications. The **inflammatory effusions** that we operated on using minimally invasive techniques included recurrent free inflammatory effusions (resulting from inflammation, pneumonia, or complications of systemic diseases), tuberculous effusions, inflammatory effusions complicated by sepsis and the formation of pleural loculations, and classic purulent effusions (empyema) at various stages of development.

All 21 cases of recurrent free effusions underwent preoperative cytology examination of pleural fluid, which was confirmed during the surgical procedure by taking several biopsies from the parietal and visceral pleura. All these patients were discussed and evaluated for video-assisted thoracoscopic surgery (VATS) with a uniportal approach due to the fact that the effusion was free, easily drained, and only pinch biopsies were taken. The operation concluded with chemical pleurodesis to prevent recurrence. Most of these patients had documented cardiac or renal origin of the effusion, including patients on chronic dialysis, who were in a compromised, "fragile" overall condition and were ideal candidates for the least invasive method. The benefits of a lighter postoperative period with rapid recovery and shorter hospital stay were undeniable in these cases, and it also allowed for a quicker return to normal dialysis routines around the time of surgery.

We treated 7 patients with tuberculous pleural effusions thoracoscopically. In 2 cases, the tuberculous origin of the effusion was not suspected during preoperative imaging and

cytological examinations. In one patient, the effusion had signs of sepsis, while in another, it was initially presented with an air component or hydro-pneumothorax following unsuccessful treatment with pleural drainage and the opening of a significant fistula necessitating surgical intervention. In the remaining 5 patients, we had high values of adenosine deaminase in pleural fluid and imaging findings of pleural loculations in addition to the free component of the effusion. All 7 patients were discussed and considered for VATS with a biportal approach due to the need to address difficult-to-reach anatomical areas with loculations and to better position the pleural drain at the end of the procedure, lower and at a site different from the primary incision, considering the nature of the disease.

We have had clinical and imaging data for 145 patients with inflammatory effusion complicated by sepsis and the formation of pleural loculations with varying density and biochemical features indicative of purulent effusion. Among these patients, 67 developed into classic empyema based on clinical presentation and imaging findings. We believe that early thoracoscopic treatment in patients with complicated effusions and evolving empyema is fully sufficient and radical, preventing extensive operations with decortication. In these cases, we used both minimally invasive techniques, uniportal and biportal, with individualized selection based on the specific patient. These techniques favor faster recovery in the early stage, reduce hospital stay, and overall treatment costs. Our observations correlate with the study conducted by Bilgin et al. [25].

Partial decortication was required in some patients, which is entirely feasible and safe using these techniques. It is important to note that numerous factors contribute to the success of VATS decortication, such as the duration of the disease, prior treatment, the experience and capabilities of the operator, the availability of specific instruments, and good collaboration with other specialists involved in the treatment process, especially anesthesiologists.

In 27 patients with severe empyema, empyemectomy with total decortication was performed. Due to their compromised condition and the need for extensive surgical intervention, all these patients were discussed and evaluated for multiphase VATS. This approach allows us to use multiple instruments to maneuver within the extensively fibrotic lung tissue, which would otherwise be challenging to access. It also allows for better placement of two drains through incisions different from the main working incision, which we consider a significant advantage for better lung expansion and prevention of postoperative wound suppuration. The multiphase technique can also reduce the operative time, which is the longest during decortication, as this

intervention is practically the most complex when it comes to treating purulent effusions. If a single incision were used, performing extensive decortication with the necessary additional instruments would take longer, especially if it is not possible to use specific instruments for uniportal or biportal techniques. Thus, the multiphase technique reduces the time while performing a complex intervention. The reduction in operative time and the use of common instruments have advantages both for the patients in terms of their compromised condition and the shorter time under general anesthesia with all the associated benefits [150] and an economic bonus in terms of resource utilization [125, 210].

The **malignant effusions** we have treated thoracoscopically are a total number of 152. The high accuracy of VATS techniques in diagnosing malignant effusions is well-known, with an unquestionably high sensitivity of 95% compared to other diagnostic methods, and equally important, a significant effectiveness in preventing recurrence after VATS chemical pleurodesis [124].

When it comes to malignant effusions and pleural mesothelioma, the diagnostic value of VATS with multiple tissue biopsies from different areas is unmatched. Diagnosis through cytological examination of fluid is achieved in only 20-32% of cases, particularly challenging in more specific variants of the disease such as sarcomatoid, where more diagnostic material is always needed for additional immunohistochemical differentiation [164, 170].

In our 21 patients, the data correlate with those mentioned in the literature above, and among all of them, we have subsequently confirmed a primary malignant effusion with histological diagnosis - pleural mesothelioma. It is important to note that in 7 of them, such a diagnosis was not made or suspected in the preoperative imaging studies, which once again demonstrates the role of VATS in establishing a specific diagnosis. However, in this case, we believe that the approach used is not significant. These cases represent 33.3% of all patients with confirmed mesothelioma or 4.6% of all patients with confirmed malignant effusions, which is slightly lower than the number cited by Venekamp in his retrospective study. He examined 75 patients for missed malignant effusions, untreated endoscopically, and found that 8.3% of them were diagnosed with malignancy during their 2-year follow-up [208].

In the remaining 131 of our patients, the effusion was secondary or metastatic. The most common primary sources were breast cancer, lung cancer, lymphomas, gastrointestinal tumors, as well as ovarian carcinomas. Less frequently, we detected prostate cancer, kidney cancer, and other even rarer types of malignancies.

In all patients, the procedure was completed with chemical pleurodesis, and the choice of surgical approach was selected based on the specific patient and disease stage.

In our practice, we prefer using talc as the chemical agent. In cases of allergy to talc, we prefer using 5 ampoules of Doxycycline dissolved in 50 ml of sterile saline, and less frequently, a solution of Braunol with sterile saline. Usually, we use a maximum dose of 4 to 10 grams of sterile talc powder, which we evenly insufflate throughout the pleural cavity. The visual effect we aim for is like a "beautiful winter snow fairy tale/storm." As widely known, talc has the highest effectiveness compared to other agents in preventing effusion recurrence, with proven efficacy ranging from 81 to 100%. In our cases, we performed talc pleurodesis in all patients with malignant effusions except for 3, for whom we used the other two agents (2 were treated with Doxycycline and 1 with Brownol). With talc, we achieved 100% effectiveness, and with the antibiotic agents, we also had positive results, while the one patient treated with the iodine agent experienced an early recurrence. It should be noted that, regarding this intervention, we do not consider the specific VATS approach to have a positive or negative impact. Regardless of the approach, we can achieve uniform and high-quality distribution of talc powder to maximize its effect, unlike using talc solution during the intervention through a pleural drain. In most cases, we used a smaller quantity of talc than the maximum allowed, averaging 4-6 grams, based on our observations that even at these doses, the effect is fully sufficient with a reduced risk of adverse reactions in patients. These findings are consistent with the study by Ja et al., who investigated the use of a lower dose of 5 grams of talc compared to the maximum dose of 10 grams in two groups of patients [99]. The results showed no significant difference ($P>0.05$) in terms of effusion recurrence within 6 weeks and immediate 48-hour mortality. Acute respiratory distress syndrome (ARDS) was not observed in either group.

In our clinic, VATS - parietal pleurectomy as a standalone procedure for pleurodesis or cytoreduction in patients with secondary metastatic effusions is not performed. Literature studies also do not recommend the routine use of this technique in patients with metastatic involvement of the pleura from a primary non-pleural oncological origin due to their expected shorter life expectancy. Despite the expected better prognostic value, this cytoreductive method can lead to multiple accompanying side effects in patients with compromised general condition due to systemic therapies [159].

In some patients with advanced oncological disease, significant thickening of the visceral pleura occurs under certain circumstances. Malignant "encased" lung is considered an indication for

decortication in our practice, which promotes re-expansion of the affected lobe or lobes. We believe, as described in the literature, that there is a difference between inflammatory and malignant "encased" lung. Visceral pleurectomy in malignant diseases is performed at a level one step lower compared to empyema of the pleura, which is widely described in the literature [123]. Like any cytoreductive surgery, this procedure has both therapeutic and palliative functions and leads to tumor progression delay and prolonged survival [123, 165]. In our practice, the intervention is most commonly performed using a biportal approach because it allows for easier manipulation of the lung and more instruments can be used through the working incision. Overall, for malignant effusions, we prefer the two minimally invasive techniques, uniportal and biportal, with a preference for biportal approach for decortication and uniportal approach for other cases. Considering the condition of patients with oncological diseases - physical and mental, any reduction in trauma, optimization of the postoperative period, and shortening of hospital stay are of great importance. This statement is supported by the scientific work of Assoc. Prof. Daniel Valchev [2], according to which reducing the number of ports leads to a decrease in postoperative pain and consequently increases patient satisfaction after VATS for malignant effusions. For all these patients with expected short life expectancy, the goal is to improve their quality of life with minimal hospital treatment and maximize the possibility of being at home with care from their loved ones and emotional comfort. We believe that this is best achieved through the two minimally invasive techniques, namely uniportal and biportal. The leading role of minimally invasive techniques in optimizing the management of malignant effusions is universally recognized and has proven its effectiveness [1].

In our study, we have examined a variety of parameters for all patients. The most important ones have been summarized in Table 16, and in the discussion that follows, we discuss them in more detail.

ACCESS	MULTIPORTAL	BIPORTAL	UNIPORTAL

Number of patients	27	193	105
Intraoperative time	45-112 min	30-90 min	40-100 min
Hospital stay	3-12 days	3-9 days	3-8 days
Intraoperative complications	N/A	Bleeding from interlobar vessel /1/	N/A
Postoperative complications	-Persistent leakage after decortication/6/ -Arrythmia /1/	-Persistent leakage after decortication /6/	-Persistent leakage after decortication /4/ - Suppuration of the operative wound /1/
Time to remove the drain	2-10 days	2-7 days	2-7 days

Table 16: Summary of the examined parameters

- **INTRAOPERATIVE TIME**

Intraoperative time is an indicator that we have monitored for all patients undergoing different thoracoscopic approaches. The longest duration was observed in the three-port VATS operations, with a minimum duration of 45 minutes, maximum duration of 112 minutes, and an average operative time of 79 minutes. We believe that the reason for this is the extensive decortication performed in all these patients. This surgical intervention is the most technically complex and time-consuming compared to all other thoracoscopic diagnostic and therapeutic procedures for pleural effusions, as mentioned above and widely known.

In the groups undergoing uniportal and biportal interventions, the duration of the procedures is almost the same, with a negligible difference of 10 minutes on average (ranging between 30 and 90 minutes for biportal and between 40 and 100 minutes for uniportal techniques in terms of minimum and maximum duration). When comparing the two techniques, we observe that the shorter intraoperative time is associated with easier maneuvering of instruments in the biportal technique for equally complex interventions. However, in practice, this reduction in time does not have significant clinical implications. Nevertheless, we prefer the biportal technique when it comes to decortication. This preference also applies to cases with anatomical locations that

are more challenging to reach and involve separate pleural loculations, where reaching them with conventional instruments is practically impossible in the absence of specific instrumentation for uniportal VATS. In contrast, the biportal method, although still difficult, offers some optimization possibilities, such as exchanging the camera's location with certain instruments in specific situations.

➢ POSTOPERATIVE PERIOD

• Length of hospital stay

We have examined the duration of hospital stay for all patients and categorized it based on the type of surgical technique used. For multiport access, the hospital stay ranged from 3 to 12 days, with an average of 7.5 days. In the case of biportal access, the stay ranged from 3 to 9 days, with an average of 6 days. The shortest postoperative stay was observed in patients who underwent uniportal VATS, with a range of 3 to 8 days and an average of 5.5 days.

There is a relatively similar hospital stay for patients undergoing uni- and biportal interventions, while patients operated using multiport access had slightly longer stays. This can be attributed not only to the specific surgical technique but also to the condition of the patients treated with three-port access. These patients typically have extensive empyema requiring meticulous decortication and are in a significantly compromised overall state. The shortest hospital stay was observed in patients with uniportal access (3 days), followed closely by those with biportal access when performing equally complex and challenging interventions. Naturally, there is a tendency for a longer stay (averaging 3 to 9 days) in cases involving partial or extensive decortication for empyema or extensive malignant involvement of the visceral pleura, regardless of the access used.

Comparing each access method, the hospital stay is longest for multiport access due to the complexity and severity of the cases, often involving extensive empyema requiring extensive decortication and the use of multiple ports and instruments for lung manipulation. Decortication is also associated with a higher incidence of prolonged air leak through the drain (22%) and the need for later drain removal, further lengthening the hospital stay. We acknowledge the well-known advantages of uniportal technique over the other two approaches, including minimal surgical trauma and less postoperative pain intensity, resulting in a lighter and shorter postoperative period with a reduced hospital stay. We believe that reducing the length of

hospital stay is of great importance for the overall well-being and psychological comfort of patients, especially those with oncological diseases, who already spend a significant amount of time in hospital centers.

- **Duration of Pleural Drainage Time**

One of the key factors in determining and reducing the duration of hospital stay is the time a patient spends with a pleural drain under passive or active aspiration. The shorter this period, the faster the possibility of discharge with normal recovery, good overall patient condition, and a healing wound.

Patients who require decortication and are prone to the formation of small fistulas tend to have a longer duration of air leak through the drain and, consequently, a longer hospital stay. The individual technique of the operator and the preoperative condition of the lung parenchyma (presence or absence of COPD, bronchiectasis, or other local or systemic comorbidities) also play a role. This explains the majority of cases with extended drainage time (between 2 and 10 days) for multiport access, where all patients undergo decortication. For uni- and biportal techniques, we observe an equal duration of pleural drainage, typically between 2 and 7 days, indicating that the operative access does not significantly affect the duration of increased alveolar permeability and time with a pleural drain.

It should be noted that the management technique of the pleural drain also significantly influences the duration. Proper daily management tends to optimize and shorten the drainage period. As a rule, all pleural drains in our clinic are removed based on clinical and imaging evidence of fully expanded lung parenchyma after a 24-hour period, and if necessary, a 48-hour test for air leak integrity is conducted.

- **Complications**

The complications we have observed during the period can be divided into two groups: intraoperative and postoperative complications. Intraoperative complications were manifested by significant bleeding from an interlobar vessel with extensive bleeding throughout the pleural cavity, observed in one patient who underwent surgery using a biportal thoracoscopic approach. An attempt was made to control the bleeding endoscopically, but it was unsuccessful. This necessitated conversion to open conventional surgery to address the issue. We have not observed other significant intraoperative complications, and we attribute this to the disrupted

anatomy in that particular case, the technical skills of the operator, and the limited instrumentation available. In this case, we do not consider the specific type of minimally invasive approach (biportal) to be the cause of the complication or the inability to manage it. We deemed it impossible to address the problem by adding an additional port and opted for open hemostasis.

Early postoperative complications were observed in 18 patients. Persistent air leak after surgery was observed in a total of 16 patients, regardless of the three surgical techniques used (6 in biportal and multiport, 4 in uniportal), with the fewest cases seen in uniportal VATS. We attribute these results to the smaller number of patients who underwent extensive decortication rather than the choice of a specific surgical approach. Cardiac arrhythmia on the first day after surgery was observed in one patient following multiport VATS for severe pleural empyema. This complication was more likely related to the accompanying cardiovascular pathology rather than the type of access used. However, since it presented in the early postoperative period, it was categorized as a postoperative complication. Postoperative infection of the skin and subcutaneous tissue with suppuration of the surgical wound occurred in one patient after uniportal VATS for empyema. It should be noted that the rare autoimmune disease accompanying the patient could be a possible cause or predisposing factor for both the empyema and the wound infection, although there is no definitive evidence for this.

We believe that the low number of inflammatory complications is also due to our preference for the biportal or multiportal technique, with placement of the pleural drain in a different intercostal space rather than through the working incision, as a preventive measure against postoperative wound infection in patients with severe inflammation and empyema. This approach also allows for better and more airtight closure of the surgical wound, preventing the development of subcutaneous emphysema, which primarily affects the patient's pain assessment and subjective comfort rather than having significant clinical implications. However, as mentioned above, psychological comfort is of great importance to us and our patients. **Late postoperative complications** have not been observed in minimally invasive thoracoscopic interventions.

- **Cosmetic Outcome**

The subjective perception of patients regarding the restoration of the operative wound, including the skin, subcutaneous tissue, and soft tissues, is an important aspect of every surgical intervention. There is no basis for comparison regarding the cosmetic outcome between minimally invasive techniques and open thoracotomies with large incisions and extensive tissue trauma in the chest wall area.

The reduction in operative incisions and the possibility of cosmetically closing the wounds in VATS techniques, which involve less surgical tissue trauma, contribute to improved outcomes. We evaluated the achieved postoperative cosmetic results using a 4-point scale based on the subjective perception of the patients themselves, considering it the most relevant factor. The evaluation options included excellent, good, satisfactory, and poor.

We observed excellent and good cosmetic outcomes in the majority of patients (199 patients rated the outcome as excellent, and 73 rated it as good). The highest number of excellent results, 83.8% of patients, were observed in UNIVATS cases, followed by 54.4% in patients who underwent biportal VATS. This can be easily understood considering the single incision in the former technique. The lowest number of patients with excellent outcomes, 22.2%, were observed in cases involving the multiportal technique, which can be explained by the highest number of incisions (3). Satisfactory results were obtained in a small group of patients, mainly due to the type of cosmetic closure used, specifically Algover-type sutures, unlike the others that utilized intradermal continuous or interrupted sutures. We preferred this type of wound closure in patients with severe empyema to prevent postoperative infection. In practice, we observed this complication in one patient at the incision site, resulting in a poor cosmetic outcome.

- **Comprehensive Diagnostic and Therapeutic Results**

The above findings serve as evidence that thoracoscopic techniques are applicable, safe, and yield good results in terms of diagnostic and therapeutic value for pleural effusions, as well as in terms of the absence of observed recurrences following talc pleurodesis and antibiotic therapy. Our results confirm the findings of several studies that VATS techniques are the method of choice in the diagnosis and treatment of pleural effusions, particularly complex and complicated cases. Different access approaches offer a range of advantages and disadvantages for both the surgeon and the patient's body. Preoperative discussions and the selection of a

specific access and therapeutic strategy are important and complex decisions, the ultimate goal of which should be a personalized and optimized approach to each patient, aiming to achieve the most appropriate, safe, fast, and radical treatment. We have systematized the advantages and disadvantages of each access approach as follows:

THE MAIN ADVANTAGES OF THE CLASSICAL MULTIPORT APPROCH, WHICH WE HAVE HIGHLIGHTED AND SYSTEMATIZED, ARE AS FOLLOWS:

- Ability to reach all anatomical areas in the chest cavity. This is crucial when dealing with isolated loculations or empyemic cavities in hard-to-reach and distant zones. It is also important for performing decortication in certain areas. Unlike anatomical resections where the focus is on the pulmonary hilum, which contains the main anatomical structures that need to be dissected, interventions for pleural loculations or empyemas can involve apical or diaphragmatic regions, recesses, etc. In individuals with large chests or thick chest walls, this necessitates a distant main incision and instrument entry points.

- Standard thoracoscopic instruments can be used, which are significantly cheaper, more easily accessible, and readily available in most hospital centers. This is an important argument, especially considering the current situation in the Bulgarian healthcare system.

- Greater involvement of assistants in the operation compared to other thoracoscopic approaches where assistants are primarily limited to the role of a camera operator. In three-port VATS, the assistant can use additional instruments, manipulate or retract the lung.

- Technical facilitation of effective decortication and easier control of bleeding in case of complications. This is achieved by the ability to use multiple instruments, change the

camera's position and that of some instruments if necessary, and manipulate the lung from different angles, especially in remote and difficult-to-access areas.

- Improved selection of the port through which the chest tube is placed, facilitating its placement in a specific area and allowing for appropriate declination. This advantage is particularly important when dealing with pleural effusions with loculations or empyemas, unlike cases of pneumothorax or bullous changes or those following anatomical resections, where the focus is on apical placement.

- Palpation of the lung is possible when needed, unlike other VATS approaches where this may be challenging or even impossible. This advantage plays a role in cases requiring intraoperative biopsy of small and poorly defined intraparenchymal formations, as well as in patients with effusion and undiagnosed carcinoma.

THE MAIN EXPECTED DISADVANTAGES ARE AS FOLLOWS:

- Operator discomfort is compromised for two primary reasons:

-Due to the trapezoidal configuration of the three-port approach, a new optical plane is created, which is different from the natural plane. This generates a torsional angle that is unfavorable when viewing on two-dimensional monitors. This significantly hinders beginners transitioning from open conventional surgery to thoracoscopic surgery.

-The surgeon has to twist their neck to some extent and, most importantly, work with raised shoulders and elbows to maneuver the instruments. All of this leads to easier fatigue and increased unnecessary movements. These circumstances also imply a higher likelihood of technical errors.

- Assistant discomfort arises when they have to work from the opposite side of the patient and have an even more varied visual and working axis.

- The more ports used, the higher the probability of damaging the intercostal nerves, resulting in a greater pain syndrome compared to techniques with fewer ports. This is particularly relevant for the posterior port due to anatomical peculiarities of the area. Several studies indicate that this port is associated with the highest number of neural injuries or more severe postoperative pain.

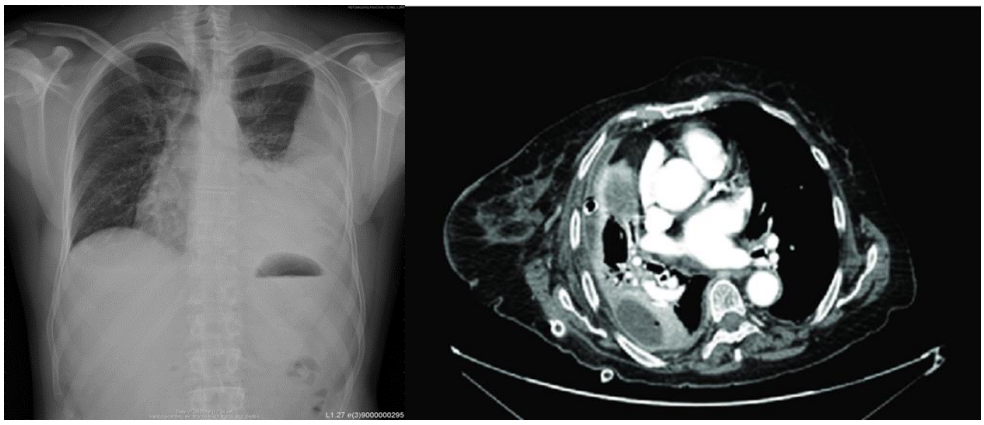
During preoperative discussions, these advantages and disadvantages are always taken into account. Therefore, the clinic has operated on the fewest number of patients using multiport thoracoscopic access (27 cases) compared to relatively higher numbers for the other two approaches. There is a moderate predominance of patients operated on with two-port access over those with single-port access (193 versus 102 patients). Despite our efforts to minimize the number and size of incisions and ports, it should be noted that this access is specifically used for the most complex and challenging cases with extensive empyema requiring meticulous decortication to release the trapped lung. Manipulating the lung with instruments and periodic expansion with the help of the anesthesiology team is crucial in these cases.

The largest number of patients were operated on using two-port access since, as we understand it and as described in the literature, this technique serves as a "bridge" between the three-port technique and the most minimally invasive approach, namely the uniportal approach by reducing the number of ports. Moreover, this methodology has proven advantages that are of great importance in our specific material-technical setting.

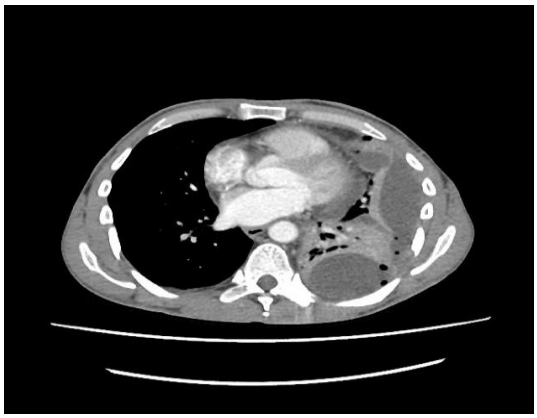
THE MAIN ADVANTAGES WE HAVE ACHIEVED REGARDING THE USE OF TWO-PORT APPROACH ARE AS FOLLOWS:

- It utilizes the same anterior approach as open surgery, with the advantage of improved visualization through high-tech cameras. The advancements in technology greatly aid in enhancing the view, especially when dealing with small structures.

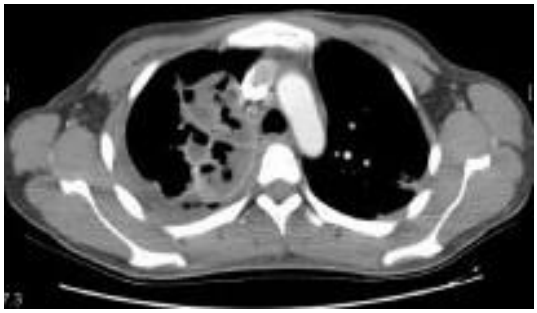
- It allows easier access to anatomically challenging areas in localized pleural effusions or empyema (as shown in images 14, 15, 16), similar to the three-port technique. However, unlike the uniportal technique, where this can be slightly more difficult, especially when using only standard thoracoscopic instruments, the use of specialized instruments for uni- or biportal access greatly facilitates the intervention. Nonetheless, it is important to note that it is still possible to perform the procedure using standard instruments, which is significant to us.



Picture 5: Pleural empyema



Picture 6: Pleural empyema

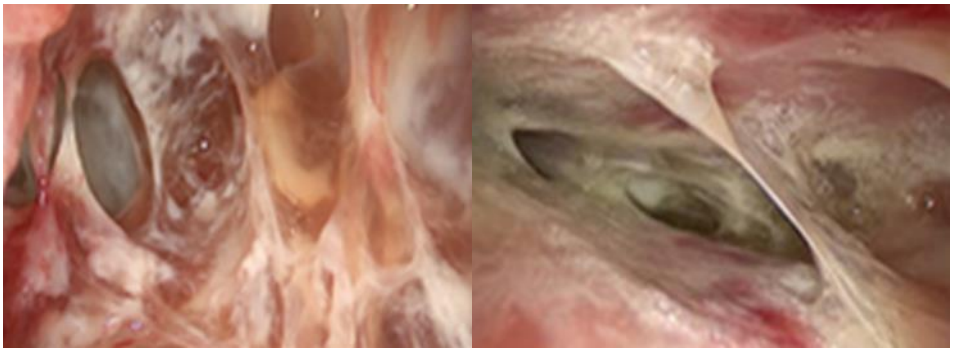


Picture 7: Pleural empyema

- It allows for the placement of the thoracic drain in the 6th, 7th, or 8th intercostal space along the posterior axillary line (as shown in image 8), which we consider more appropriate for patients with effusions compared to those undergoing anatomical resections or with bullous emphysema and recurrent pneumothorax, where this is less significant and, in some cases, it is advantageous to use a higher placement.

Picture 8: Postoperative picture of patient after biportal VATS

- Placing the drain in a different location, separate from the surgical field, allows for better sealing of the drain, which is crucial for patients with inflammatory conditions and after extensive decortication. This is particularly important for patients with thin chest walls or those who are weak and cachectic, which often includes those with advanced oncological diseases.



Picture 9: Significant adhesions between the visceral and parietal pleura requiring thorough and extensive decortication

- A lighter and shorter recovery period compared to the multiport technique, thanks to the reduction in the number of incisions and thoracoscopic ports, which potentially reduces the risk of intercostal nerve injury and postoperative pain. It is important to note the elimination of the posterior port in this regard.
- Reduced hospital stay due to faster recovery and significantly fewer complications resulting from pain, as well as preservation of breathing function with fewer

postoperative stagnant or atelectatic changes, allowing for earlier mobilization and ambulation. The elimination of even just one port makes a noticeable difference.

- Decreased postoperative immunosuppression due to shorter duration of general anesthesia with separate intubation and intraoperative ventilation of the lungs.

SIGNIFICANT LESS IMPORTANT DISADVANTAGES COMPARED TO THE OTHER TWO SURGICAL METHODS ARE AS FOLLOWS:

- Although the approach is anterior, the camera and working incision are in different positions, and the surgeon still has a different visual perspective than what they are accustomed to in open surgery. This is particularly significant for surgeons who are at the beginning of their learning curve or have experience only with open thoracic surgery.
- There is a high potential risk of instrument and camera collision in certain specific anatomical areas where pleural loculations can be located. This is especially noticeable when using standard straight endoscopic instruments, as the benefits of longer and curved specialized instruments are eliminated.
- The procedure becomes significantly more expensive when using specialized instruments. Most training centers recommend the use of instruments specifically designed for the uni- or biportal technique. The use of standard instruments is associated with technical difficulties and increases the possibility of errors. We believe that this difficulty is amplified when working in certain pathologies/pleural loculations and empyemic cavities, especially in challenging peripheral areas, compared to working in the hilum, as the angles that can be reached by placing the instruments through the working incision are quite different in the two focuses.

In recent years, there has been a growing trend towards minimally invasive techniques. The concept of "less is more" gained popularity, emphasizing the value of minimal invasiveness. With the introduction of uniportal access for various surgical interventions in 2010 by Prof. Diego Gonzalez-Rivas, this technique gained tremendous popularity and was implemented worldwide through his dedication to travel, promote, and train in an increasing number of

diagnostic and treatment centers for lung diseases on both small and large scales. Despite the more challenging technical and technological preparation required, the methodology became quite modern and trendy. Bulgaria was also one of the countries visited by Prof. Rivas several times, organizing training seminars in various hospital centers, including live surgeries. Our clinic also welcomes the opportunity to minimize surgical trauma by working through a single incision measuring up to 4.5-5 cm, although we acknowledge the difficulties in implementing the technique due to the lack of a specific uniportal VATS thoracoscopic set. The advantages of the technique, which we recognize, overlap with those recommended by Prof. Rivas and his team, as well as with an increasing number of surgeons worldwide who use it, and he unifies them into supportive communities.

ADVANTAGES OF UNIPORTAL APPROACH:

- When the camera and instruments are placed parallel to each other in the same plane, it becomes easier for the surgeon to adapt to the endoscopic work, increasing their psychological comfort, especially during the transition from open to thoracoscopic surgery. The operator's position is ergonomically optimal and creates a natural eye-hand coordination, which is a favorable basis for mastering the technique more easily. This eliminates the different visual axes during work and the discomfort associated with them, both for the operator and the assistant, as they are always positioned on the same side in front of the patient.
- Significantly reduced pain syndrome: The entire operation is performed through a single incision without the use of any ports, which significantly reduces the amount of postoperative pain. Even minimal reduction in pain is of great importance in preventing postoperative atelectasis, pneumonia, or arrhythmias in severely ill patients with multiple comorbidities. In practice, there is no reason for intercostal damage, and for convenience, only silicone wound protectors or retractors that do not damage the underlying tissues can be used. For greater comfort and slight retraction, if such expanders are not available, the skin edges can be fixed laterally using sutures, a technique that also does not cause any damage and assists the surgeon.

- Shorter hospital stay: This is associated with faster recovery and significantly fewer complications related to respiratory sparing due to pain and postoperative changes such as atelectasis, as well as early mobilization and ambulation.
- Best cosmetic result compared to other thoracoscopic techniques, due to the small single incision.
- Fewer intraoperative errors: Since this approach requires a high level of experience and technical skills from the performing surgeons, maneuvering of all instruments and the camera through a single small incision is expected to result in fewer cases of intraoperative complications and significant blood loss.
- Reduced postoperative immunosuppression: This is due to the shorter time under general anesthesia with separate intubation and intraoperative ventilation of the lungs.

In contrast to the two-port method, there are also some unavoidable disadvantages associated with uniportal access. For example, it requires a specific and expensive set of instruments without which these operations are either extremely difficult or impossible. Additionally, visits to specialized training centers are necessary, which require significant resources and time. One example is the largest and most significant training program in the Chinese city of Shanghai, where over 100 cases of major anatomical resections are operated on daily in more than 10 operating rooms. Such a volume of work and the opportunity for practical training does not exist in any European center.

For a country like Bulgaria, unfortunately, economic parameters are of great importance. Without investing in the training of doctors practicing this minimally invasive method, without acquiring expensive equipment such as high-resolution cameras, energy sources, and specific instruments, the true development and utilization of all the wonderful advantages offered by the minimally invasive thoracoscopic approach become impossible.

DISADVANTAGES OF UNIPORT APPROACH:

- Training requires attending courses and training programs at specialized centers that teach and introduce the uniportal technique, which lengthens and increases the cost of the learning curve. This is absolutely necessary because it is the only way to learn

specific tricks that practically facilitate the otherwise more complex technical methodology.

- It is more difficult to place more than one camera and 2 or 3 instruments through the single incision, which is approximately 2.5 - 4.5 cm long. This is accompanied by some difficulty in maneuvering, especially for inexperienced surgeons and those in the early stages of their training. It should be noted that there is a difference when working in the hilum area of the lung regarding anatomical resection or when performing empyemectomy and decortication in peripheral and hard-to-reach locations.
- The technique is more challenging to apply in obese patients or those with a large chest, as the thick chest wall further complicates maneuvering through the long and narrow wound canal. Additionally, it creates a greater distance between the targeted areas and the end of the instruments. Without longer and more curved instruments, reaching all anatomical zones becomes practically impossible. It is not coincidental that the technique has seen significant development and expansion in Asian countries, where most individuals have smaller and slender chest cavities.
- The 4th and 5th intercostal spaces typically used for the single working incision are often higher in location for placing pleural drains in patients with pleural effusions, unlike those undergoing anatomical resections or with bullous emphysema and recurrent pneumothorax.
- Placing a drain through the operative incision sometimes hampers proper sealing of the chest wall, especially in weak and cachectic patients or those expected to have prolonged air leaks due to decortication or existing bronchopleural fistulas caused by other conditions.
- In cases of localized effusions, it can be quite difficult or even impossible to reach certain anatomical zones. As mentioned earlier, there is a difference in target zones between anatomical resections and effusions, which explains the difficulty.
- Performing thorough decortication in patients with trapped lung or severe empyema with the formation of thick pleural adhesions and empyemic cavities requires the use of multiple instruments and manipulation of the lung parenchyma. It also necessitates periodic lung retraction, which prolongs and complicates the procedure when using only one working incision where the instruments and camera are positioned.

6. CONCLUSION

From the analyzed data, it can be concluded that the factors determining the most effective treatment of pleural effusions through minimally invasive methods are the accurate diagnosis and assessment of their type and localization, the overall and local status of the specific patient, the presence or absence of accompanying pathology, as well as the type, volume, and timing of surgical intervention.

Based on the summary of the advantages and disadvantages of each individual thoracoscopic approach, it becomes clear that the choice of technique is an important element in comprehensive and individualized treatment. It helps improve the comfort and peace of mind of the surgeon and maximizes the results for the patient based on the specific pathology.

Minimizing the number of ports inevitably contributes to faster patient recovery by reducing pain, shortening the postoperative period, and decreasing the duration of hospital stay. This is of great importance for both patients and reducing the cost of treatment, providing economic benefits for the hospital center. However, there are some unavoidable disadvantages that particularly influence the current situation of thoracoscopic surgery development in Bulgaria.

Additionally, it should not be an absolute requirement in every case to work through a single incision when adding one or two more ports may optimize the procedure, shorten the intraoperative time, and prevent unpleasant complications.

In complicated effusions, especially in pleural empyema, the ability to change the working angle through a different incision facilitates easier performance of pneumolysis and decortication in all anatomical zones of the chest.

Thorough preoperative discussion of the advantages and disadvantages of each thoracoscopic access, as well as all aspects related to the specific pathology at the local level and the overall condition of the patient, allows for personalized and optimized surgical treatment decisions, which contribute to favorable final outcomes. All these important steps have been systematized and visualized in the algorithm for the treatment of pleural effusions through Video-Assisted Thoracoscopic Surgery (VATS).

DIAGNOSTIC-THERAPEUTIC ALGORITHM

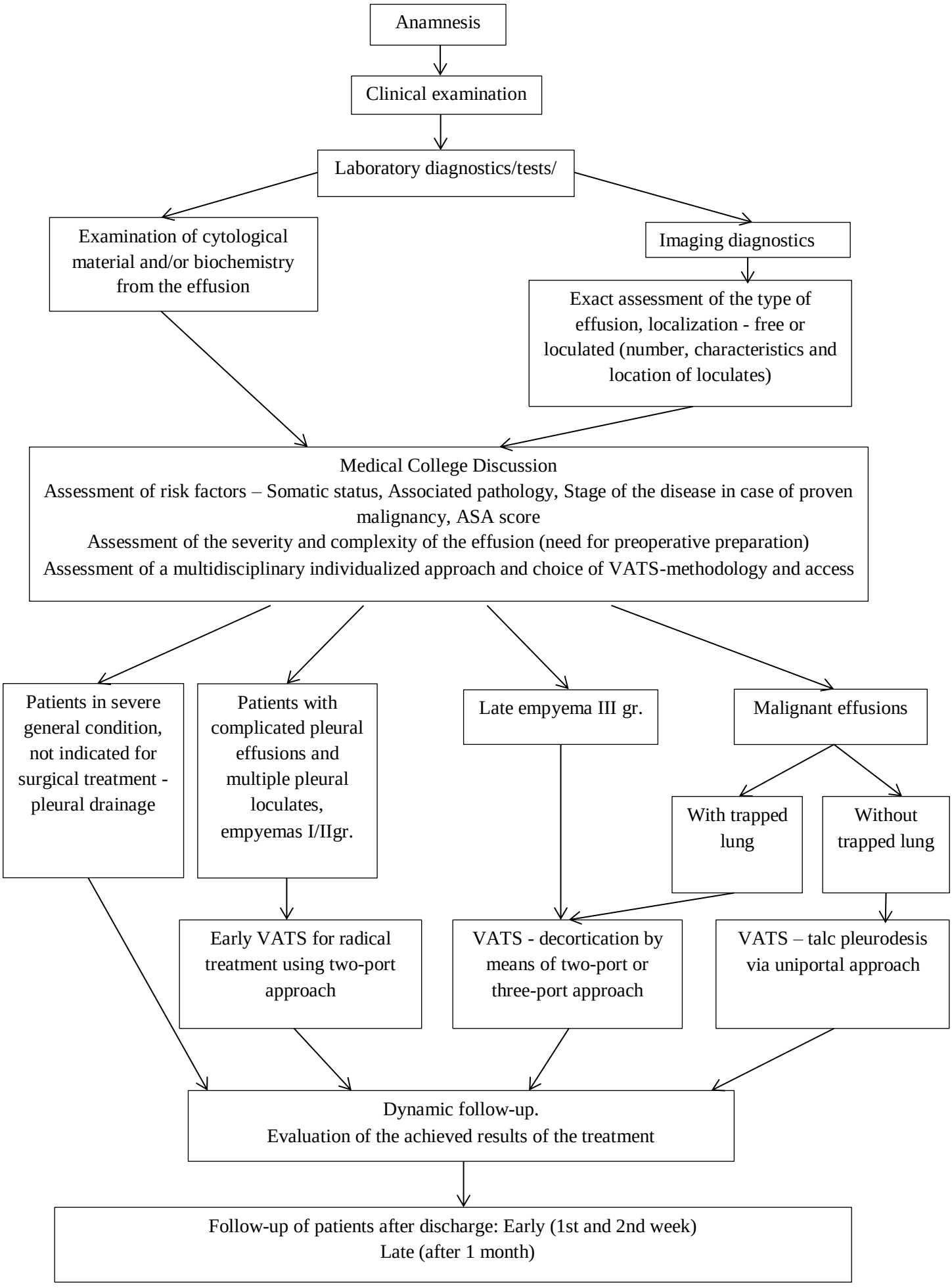


Figure 10: Diagnostic-therapeutic algorithm for the treatment of pleural effusions by VATS.

CONCLUSIONS

1. A significant portion of patients referred for VATS (Video-Assisted Thoracic Surgery) treatment have complicated pleural effusions with the formation of pleural loculations with high density, classic empyema, or malignant effusions with the formation of trapped lung.
2. VATS techniques using the three main approach points, performed according to the respective indications, are equally effective as conventional interventions. At the same time, they offer several indisputable advantages such as reduced surgical trauma, faster recovery period, shorter hospital stay, and improved cosmetic outcomes.
3. The use of multiple incisions in complicated cases leads to shorter intraoperative time, especially in cases requiring decortication, due to easier manipulation of the lung and the use of multiple instruments from different angles.
4. The use of a single-port approach in heavily compromised patients with oncological diseases and other accompanying pathologies helps in faster recovery and discharge, enhancing their psycho-emotional comfort.
5. The lack of specific instrumentation limits single-port approach and significantly complicates the use of two-port and multi-port approaches, making it feasible only in highly specialized centers.
6. There are numerous and diverse options in the diagnosis and treatment of pleural effusions, but timing and precise selection of operative techniques are crucial for individualizing the approach and optimizing the outcome. Extensive preoperative discussion of the patient's condition and constitution, the type of pleural effusion, and the choice of specific VATS approach with its advantages and disadvantages contribute to achieving good final results and preventing recurrences.
7. The developed diagnostic and therapeutic algorithm for the management and follow-up of patients with pleural effusion in clinical practice includes modern minimally invasive techniques, allowing for standardization of the treatment process and reducing the likelihood of clinical omissions and errors.

SCIENTIFIC CONTRIBUTIONS:

1. A comprehensive study was conducted on 325 patients who underwent Video-Assisted Thoracic Surgery (VATS) for pleural effusion, both uncomplicated and complicated cases.
2. Minimally invasive techniques with different access points have been developed and implemented in the clinic's clinical practice, defining their indications and contraindications compared to conventional interventions.
3. A diagnostic-therapeutic algorithm for managing patients with pleural effusion, including modern minimally invasive surgical techniques, has been developed and integrated into the clinic's clinical practice.
4. We analyze the advantages and disadvantages of each VATS approach in the diagnosis and treatment of pleural effusion, especially complicated cases, have been discussed and systematized, considering both patient-related factors and surgical operations.

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