

# Evaluation of the Result of an Optimized Method for the Prevention of Pleural Complications After Urgent Thoracotomy

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**Abstract** Urgent thoracotomy, as a form of surgical intervention, retains its clinical significance despite the development of minimally invasive technologies. **The purpose of the study:** improving the results of postoperative treatment of patients after urgent thoracotomy by developing and implementing a set of preventive measures aimed at reducing the frequency of pleural complications. **Materials and methods:** the data of examination and treatment of 98 patients who underwent urgent thoracotomy (UT) for various acute pathological processes in the organs of the thoracic cavity were analyzed. All patients, depending on the treatment method, were divided into 2 groups: control group I and main group II. The control group consisted of 48 patients who underwent traditional surgical tactics, including standard schemes for drainage of the pleural cavity, as well as an approach without using an algorithm to determine the timing of follow-up and drainage removal. The main group included 50 patients who underwent the proposed preventive model, including the author's method of targeted drainage (utility model UZ № FAP 2441 dated 03.19.2024) and an algorithm for postoperative management based on predicting the risk of a complicated course of the postoperative course. **Results:** the duration of drainage in the main group averaged  $4,1 \pm 1,3$  days, while in the control group it was  $5,6 \pm 1,7$  days. In general, the duration of drainage was reduced by 1,4 times, despite the fact that in the main group the proportion of patients with initial intra-pleural bleeding was higher. The average duration of hospitalization in the main group was  $10,6 \pm 2,7$  days, while in the control group it was  $14,5 \pm 4,3$  days. The difference reached almost 4 days, which confirms the clinical stability of the patients' condition at an earlier stage. **Conclusion:** the developed method of drainage of the pleural cavity with the targeted installation of a second drainage through the lumen of the main one provides complete sanitation of hard-to-reach areas with minimal invasiveness. The proposed technique has shown high clinical effectiveness and has become the basis for the formation of a comprehensive preventive approach to the management of patients after UT.

**Keywords** Thoracotomy, Drainage of the pleural cavity, Hemothorax, Pneumothorax

## 1. Introduction

Urgent thoracotomy remains a clinically recognized surgical intervention despite the development of minimally invasive technologies [4]. To date, a number of clear clinical indications have been established in the practice of emergency thoracic surgery. Among them, the main proportion is massive bleeding into the pleural cavity, violations of the tightness of the respiratory circuit and obstructive phenomena that cannot be conservatively corrected. In all these cases, delaying the intervention carries a high risk of fatal consequences, even if the patient has. However, it is important to emphasize that the formal formulations conceal nosologically diverse and anatomically complex situations, each of which requires

a differentiated approach [2,4,9].

Special attention in the literature is paid to patients with combined forms of pathology. Situations involving simultaneous rib fractures, open pneumothorax, and lung damage require complex solutions. One-step sanitation is not enough here. In this case, it becomes necessary to apply well-thought-out drainage routes, take into account the multiplaneity of the lesion and coordinate the volume of intervention with the patient's functional capabilities. It is this category of patients that demonstrates the most unstable postoperative course and the highest risk of complications [3,7,12].

Against this background, the task of developing preventive measures that can not only reduce the incidence of complications, but also be adapted to a diverse and often vulnerable patient population becomes particularly relevant [1,5].

The use of drainage in thoracic surgery makes it possible to solve the issues of diagnosis and treatment of patients who have undergone urgent thoracotomy in a new way, improve

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the results of surgical treatment, reduce postoperative complications and mortality to a minimum and shorten the duration of the patient's stay in the hospital. In surgery of postoperative complications, it has become the method of choice for the correction of pleural complications, which made it possible to significantly reduce the number of repeated interventions [6,8].

The aim of this study is to improve the results of postoperative treatment of patients after urgent thoracotomy by developing and implementing a set of preventive measures aimed at reducing the frequency of pleural complications.

## 2. Material and Research Methods

The data of examination and treatment of 98 patients who underwent urgent thoracotomy (UT) for various acute pathological processes in the organs of the thoracic cavity were analyzed. All patients were treated at the Tashkent City Clinical Hospital № 7 from 2015 to 2025. Depending on the follow-up period and the postoperative management tactics used, the patients were divided into two groups of comparable volume.

All patients, depending on the treatment method, were divided into 2 groups: control group I and main group II. The control group consisted of 48 patients who were treated from 2015 to 2019 inclusive. In this group, traditional surgical tactics were used, including standard schemes for drainage of the pleural cavity, as well as an approach without using an algorithm to determine the timing of follow-up and drainage removal. The main group included 50 patients who received

treatment in 2020-2025. In this group, the proposed preventive model was implemented, including the author's method of targeted drainage (utility model UZ № FAP 2441 dated 03.19.2024) and an algorithm for postoperative management based on predicting the risk of a complicated course of the postoperative course.

The analysis of the age and sex structure of the studied contingent, represented by 98 patients who underwent UT, showed the predominance of older age groups, as well as the dominance of the male sex, which reflects the epidemiological and clinical features of chest pathology (table 1).

The average age of patients in the control group was  $61,3 \pm 1,2$  years, and in the main group it was at the level of  $60,1 \pm 10,6$  years. In both samples, patients over 45 years of age prevailed, while the proportion of elderly and senile people (60 years and older) accounted for more than half of the observations. Thus, 52,1% in the control group and 58% in the main group of patients were elderly and senile patients.

An analysis of the distribution of causes that served as the basis for performing UT in 98 patients showed that a common cause of performing UT as a lung rupture with massive hemothorax, registered in 17 patients, which accounted for 17,3% of the total number. It is noteworthy that all these patients were admitted with obvious signs of bleeding, which underlines the severity of the clinical picture. The second place with an equal frequency (14 cases; 14,3%) was taken by a group of patients with ongoing intrapleural bleeding, mostly of an unclear or multiple nature, including after injuries, biopsies or drainage. It is important to note that here, too, bleeding was detected already upon admission (table 2).

**Table 1.** The nature of the distribution of patients by gender and age

AGE CATEGORY (WHO)	SEX		In total
	Men	Women	
18-44 years old (young)	8 (8,2%)	4 (4,1%)	12 (12,2%)
45-59 years old (average age)	20 (20,4%)	6 (6,1%)	26 (26,5%)
60-74 years old (elderly)	25 (25,5%)	20 (20,4%)	45 (45,9%)
75 years and older (senile age)	5 (5,1%)	10 (10,2%)	15 (15,3%)

**Table 2.** The nature of the distribution of patients for UT reasons

THE REASON FOR THE UT	SUBGROUPS OF PATIENTS		In total (n=98)
	No bleeding	With bleeding	
Multiple rib fractures	11 (11,2%)	3 (3,1%)	14 (14,3%)
Complicated pneumothorax with lung rupture	9 (9,2%)	2 (2%)	11 (11,2%)
Rupture of a lung cyst (including echinococcal cyst)	2 (2%)	6 (6,1%)	8 (8,2%)
Retoracotomy after elective surgery	4 (4,1%)	2 (2%)	6 (6,1%)
Mixed etiology ( $\geq 2$ causes)	3 (3,1%)	4 (4,1%)	7 (7,1%)
Open pneumothorax	7 (7,1%)	0	7 (7,1%)
Ongoing intrapleural bleeding	0	14 (14,3%)	14 (14,3%)
Lung rupture with massive hemothorax	0	17 (17,3%)	17 (17,3%)
Lung injury (isolated)	0	11 (11,2%)	11 (11,2%)
Heart injury	0	5 (5,1%)	5 (5,1%)

Another significant category was patients with multiple rib fractures (14 cases, 14,3%), and in fourth place was complicated pneumothorax with rupture of lung tissue (11 patients, 11,2%). The etiologically mixed group, including a combination of two or more causes (for example, rib fractures and open pneumothorax, or cyst rupture and lung injury), accounted for 7 cases (7,1%). It was in this group that a high risk of complications was most often identified, as well as the need for two-level drainage and longer follow-up.

An analysis of surgical interventions performed in 98 patients included in the study showed that organ-preserving and functionally oriented techniques aimed at eliminating the main source of pathology with minimal injury were most often used (Figure 1).

The most frequently performed intervention was the suturing of lung tissue performed in 38 patients, which is 38,8% of the total sample. This type of surgery was used in situations of local ruptures of the lung parenchyma in stab wounds, blunt trauma, and in some cases spontaneous ruptures.

Wedge-shaped lung resection took the second place in frequency, having been performed in 16 patients (16,3%). Indications were multiple subpleural lesions, foci of crushing and areas of uncontrollable bleeding. Unlike suturing, wedge-shaped resection requires clearer hemostasis and may be accompanied by an increased risk of bronchopleural fistulas, which requires careful drainage.

Lobectomy (the most radical intervention) was performed in 5 patients (5,1%). It was shown in case of total destruction of the lobe of the lung or its vascular-bronchial element, which cannot be restored.

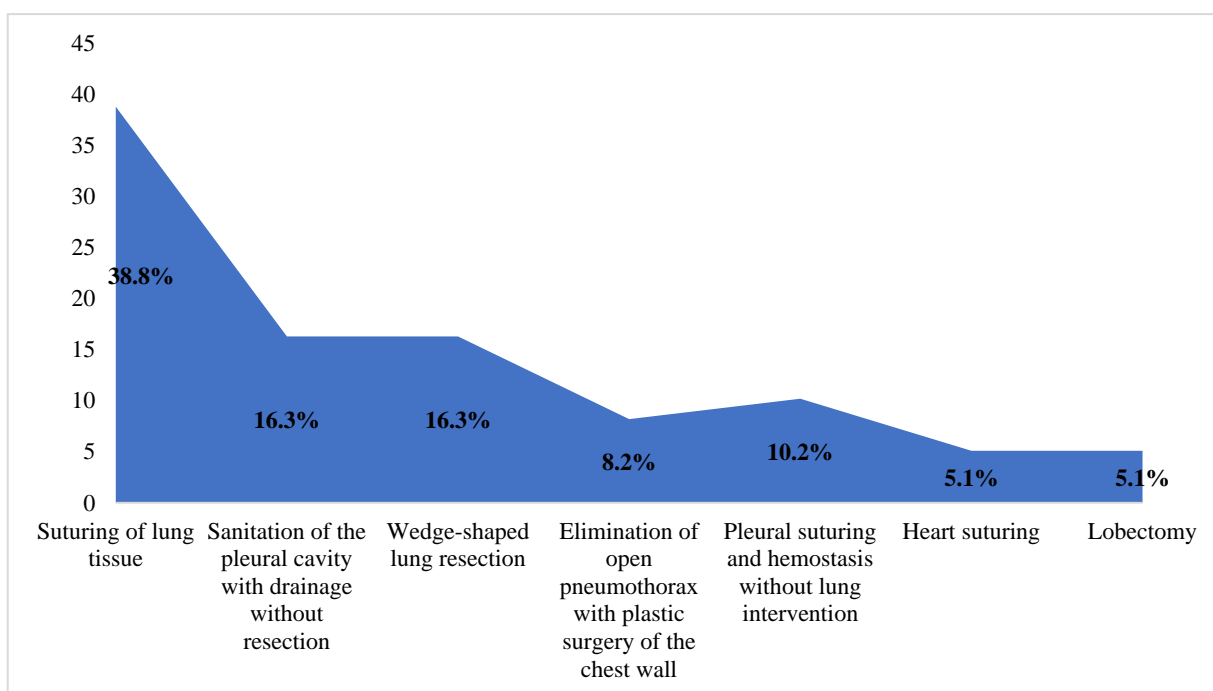
The pleural cavity was rehabilitated with drainage

without resection in 16 patients (16,3%), in whom the surgical focus was limited to the pleural cavity, without damage to the pulmonary parenchyma. This operation was often used for retoracotomy, coagulated hemothorax or its pleural accumulations after injury, which are not subject to puncture and drainage.

Elimination of an open pneumothorax with restoration of the integrity of the chest wall was performed in 8 patients (8,2%). The operations included sealing of the wound defect, suturing of soft tissues and control of the parenchymal component. As a rule, these interventions were local in nature, but required precise installation of a drainage system to prevent recurrence of pneumothorax or infection.

Cardiac wound suturing was performed in 5 patients (5,1%), all of whom were in critical condition upon admission, and pleural suturing and hemostasis without lung intervention were performed in 10 cases (10,2%). They assumed the elimination of the source of bleeding in the chest wall, soft tissues or bone structures without damage to the pulmonary parenchyma. They were often found in elderly and senile patients or in cases of isolated hemothorax without rupture of the parenchyma.

The structure of the applied options for drainage of the pleural cavity in 98 patients who underwent UT showed marked differences both in the number of applied schemes and in the frequency of repeated interventions. Thus, the installation of two drains, in particular, the upper and lower ones, was most often used with the traditional approach, which was noted in 26 patients, which accounted for 26,5% of the entire sample. This tactic was considered the most universal, especially in the presence of intrapleural bleeding, ruptures of lung tissue or after resections.



**Figure 1.** The nature and volume of surgical interventions performed

One lower (basal) drainage was used in 18 patients (18,4%). This scheme was typical mainly for patients without severe pneumothorax or in the case of limited hemothorax, for example, after retoracotomy or in case of injuries without lung rupture. Despite the simplicity of its implementation, such drainage was often insufficient, especially in patients with low respiratory mobility.

One upper (subapical) drainage was installed in only 2 patients (2%) and was used for isolated pneumothorax without signs of exudation. This approach was considered minimally invasive, but it was practically not used with a pronounced inflammatory component or bleeding.

A special category consists of cases of drainage during retoracotomy in 2 cases (2%), where due to limited access or the presence of postoperative adhesions, only one drainage was installed in the most accessible area. Such interventions had an increased risk of complications due to the inability to fully flush and control the discharge, especially in the lower parts of the pleural cavity.

The most clinically significant indicator was the frequency of repeated drainage, which totaled 12 cases (12,2%). Of these, 9 patients belonged to the control group, where repeated intervention was required against the background of ineffective sanitation with the primary two- or one-step approach.

Laboratory methods were used in close conjunction with clinical and instrumental data and were the basis for assessing the severity of the inflammatory response, diagnosing purulent-infectious complications, and determining the timing of drainage removal. An increase in C-reactive protein, leukocytosis, and ESR, combined with imaging data, was the basis for correcting surveillance tactics and re-rehabilitation.

Instrumental research methods played a key role in the diagnosis of the initial pathology, monitoring the effectiveness of the performed interventions and detecting early signs of postoperative complications. They were used both at the preoperative stage and in dynamics after thoracotomy.

### 3. Results and Their Discussions

Surgical tactics under the traditional approach were characterized by variability and lack of unified principles. In some cases, the intervention was limited to pleural cavity sanitation and drainage, while in other cases, lung tissue resections of various volumes, including lobectomies, were performed. Drainage support was also not standardized, as we installed one drainage for some patients, and two drainage tubes in the presence of a hemothorax. Decisions on drainage removal were usually made empirically, without using objective scales for assessing the dynamics of pleural discharge, X-ray picture, or clinical condition.

In the postoperative period, almost all patients had a pronounced inflammatory response, especially in the first three days after the intervention, which was reflected in the dynamics of body temperature, leukocyte formula, C-reactive protein level and erythrocyte sedimentation rate. In patients with initial intrapleural bleeding, compared with patients

without it, there was a higher incidence of complications, including clotted hemothorax (18,8%), EP (12,5%), infected pleurisy, recurrent pneumothorax, as well as the need for repeated interventions, both with drainage and retoracotomy. At the same time, the duration of drainage and hospitalization in this subgroup was statistically significantly higher, and the timing of verticalization and recovery turned out to be later.

The revealed tendency to increase mortality in patients with initial bleeding deserves special attention. If in the group without hemothorax it was 6,3%, then in the presence of bleeding this indicator increased to 12,5%. The causes of death in some cases were directly correlated with pleural complications in the form of EP, sepsis, respiratory failure, which developed against the background of prolonged drainage, decreased activity of the patient and ineffective sanitation of the pleural cavity.

A summary analysis of the data obtained suggests that the existing traditional management scheme for patients after UT is largely based on the individual experience of the surgeon and does not take into account a number of key risk factors. The existing algorithmization of the decision-making system regarding the choice of drainage volume, the timing of drainage removal, as well as the organization of postoperative follow-up in debilitated and elderly and senile patients leads to a high frequency of complicated course and difficult rehabilitation.

Based on the above, it is obvious that there is a need to develop an integrated approach, including the improvement of drainage techniques adapted to the nature of the intervention and the risk zone, based on objective clinical, instrumental and functional criteria. Such a solution should not only increase the efficiency of pleural cavity sanitation, but also ensure timely and safe removal of drainage load, accelerate patient activation and reduce the risk of pleuropulmonary complications.

Based on the identified shortcomings of traditional drainage schemes and in order to increase the efficiency of pleural cavity sanitation, we have developed a new drainage method that is protected as a useful model. The essence of the method is as follows: a basic silicone drain with a diameter of 0,8-1,0 cm and a length of 50 cm is inserted into the pleural cavity through a single access (VII or VIII intercostal space, between the middle and posterior submuscular lines). The drainage has four lateral openings and is carried out along the lateral wall of the chest with a direction to the dome of the pleura. After installing the main drain, a second, thinner silicone drain with a diameter of 6 mm is passed through its lumen, which is precisely positioned in the most critical areas of the pleural cavity, where accumulation of pathological contents is likely.

These areas include: interlobular crevices; spaces between adhesions; stump of the lung after resection (with wedge-shaped resections, lobectomy, etc.).

Thanks to this solution, adequate, targeted drainage is achieved without the need for additional punctures of the chest wall, which reduces invasiveness, improves cosmetic results and reduces pain.

The use of a single skin access avoids injury to the intercostal neurovascular bundles and muscle structures, especially in the upper anterior chest.

A comparative analysis of the postoperative period in patients of the control and main groups, presented in table 3, allowed an objective assessment of the clinical effectiveness of preventive tactics. The comparison was based on four key parameters reflecting the dynamics of recovery, the degree of functional impairment and outcomes. Among them, the duration of drainage, the duration of hospitalization, the timing of patient activation (verticalization) and the frequency of deaths were analyzed.

**Table 3.** Comparative assessment of the postoperative period in the control and main groups

INDICATOR	GROUPS OF PATIENTS	
	Control (n=48)	Main (n=50)
Average duration of drainage (day)	5,6±1,7	4,1±1,3
Average duration of hospitalization (day)	14,5±4,3	10,6±2,7
Average vertical period (day)	3,9±1,1	2,6±0,8
Deaths, n (%)	5 (10,4%)	2 (4%)

The duration of drainage in the main group averaged 4,1±1,3 days, while in the control group it was 5,6±1,7 days. In general, the duration of drainage was reduced by 1,4 times, despite the fact that in the main group the proportion of patients with initial intra-pleural bleeding was higher. Earlier removal of drains became possible due to effective sanitation by targeted drainage, reduction of the frequency of residual cavities and inflammatory exudates, as well as the use of objective criteria to determine the timing of removal.

A similar trend was demonstrated by the length of hospital stay. The average duration of hospitalization in the main group was 10,6±2,7 days, while in the control group it was 14,5±4,3 days. The difference reached almost 4 days, which confirms the clinical stability of the patients' condition at an earlier stage. Reducing the duration of hospitalization is especially significant for acute heart failure and debilitated patients, in whom each additional day of bed rest is associated with an increased risk of hypostatic and thromboembolic complications.

The period of verticalization in the main group also turned out to be significantly shorter: on average, 2,6±0,8 days versus 3,9±1,1 days in the control group.

## 4. Conclusions

The traditional approach to the management of patients after UT is accompanied by a high incidence of pleural complications (79,2%), repeated interventions (25%) and mortality (10,4%), especially in patients with initial intrapleural bleeding upon admission. In this subgroup, coagulated hemothorax, pleural empyema, recurrent pneumothorax, difficult rehabilitation of the pleural cavity and late activation were significantly more common. The data obtained indicate

the insufficiency of the traditional tactics of drainage of the pleural cavity and the postoperative tactics of administration, which justifies the need for its improvement.

The developed method of drainage of the pleural cavity with the targeted installation of a second drainage through the lumen of the main one provides complete sanitation of hard-to-reach areas with minimal invasiveness. The proposed technique has shown high clinical effectiveness and has become the basis for the formation of a comprehensive preventive approach to the management of patients after UT.

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