Thoracic Trauma: Diagnosis And Treatment

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Abstract. The study of chest injuries which profoundly impact quality of life, life expectancy, disability rates, and mortality is of significant importance. In clinical research, the authors analyzed diagnostic results from 527 patients aged 18 to 85 with closed chest trauma, consisting of 82% men and 18% women. The study confirms that traumatic chest injuries are severe conditions that necessitate strict adherence to well-defined diagnostic and treatment guidelines. It is advisable to utilize thoracoscopy and video-assisted thoracoscopy for managing hemothoraxes with small volumes of bleeding, as these minimally invasive techniques can enhance patient outcomes and reduce recovery times. The incorporation of advanced three-dimensional (3D) printing technologies into medical practice for chest injuries is also recommended, as it can improve surgical planning and enable personalized treatment strategies. Moreover, 3D printing can aid in the fabrication of patient-specific implants and prosthetics, thereby enhancing the effectiveness of reconstructive surgeries. Further research is needed on pharmacotherapy when using medications in accordance with the codes of the 11th revision of the International Classification of Diseases, to optimize therapeutic efficacy. Additionally, an in-depth study of the integrated ABC/VEN-analysis of drug prescriptions in pharmacotherapeutic regimens for thoracic trauma treatment dynamics in both inpatient and outpatient healthcare facilities is recommended. This could lead to better resource allocation, improved patient care, and the development of more effective treatment protocols. Emphasizing interdisciplinary collaboration among surgeons, radiologists, and pharmacologists is crucial to advance the management of chest trauma, ensuring that patients receive comprehensive and holistic care throughout their recovery process.

Keywords: quality of life, life expectancy, fatalities, trauma, chest, thoracoscopic surgery, thoracic injuries.

Introduction. In modern conditions, it has been established that during everyday activities of people, domestic and criminal injuries are committed due to carelessness or intentionally. They affect the quality and length of life, the development of concomitant diseases, disability, and fatalities. Include approximately 2/3 of patients with chest injuries of varying degrees of severity, from a simple rib fracture to a penetrating wound of the heart or tracheobronchial rupture [1-8]:

- the most common is a blunt chest injury with a frequency of 90%, of which less than 10% require any surgical intervention;
- mortality ranks 2nd after head injury, which emphasizes the importance, promptness and timeliness of initial treatment;
- after these injuries, patients may experience simple shortness of breath or even respiratory arrest;
- many of these deaths can be prevented by quick delivery of victims to a health care facility, multidisciplinary diagnosis, treatment and pharmacotherapy;

- the more rib fractures a patient has, the higher the mortality rate due to additional damage to the main human organ;
- a difference in injury patterns was revealed: elderly patients are more prone to rib fractures, and young patients have more injuries to internal organs and chest structures;
- significant chest trauma is present in combat-wounded patients, but the vast majority of cases are associated with a penetrating mechanism;
- the most common chest injuries are pneumothorax, pulmonary contusion, and chest wall injury, while lung or major vessel injuries have the highest mortality rates;
- drainage or thoracentesis is indicated as the initial diagnostic and therapeutic intervention for most patients with thoracic trauma;
- with more serious injuries, thoracotomy (mainly anterolateral), sternotomy or other surgical access may be indicated in urgent cases;
- a great role is played by the professionalism of the thoracic surgeon in the management of chest trauma in the seriously injured.

Damage to the chest wall in closed injuries is the most common thoracic injuries, which make up 50-70%, and in combined injuries – 90.8%, and pneumothorax is a frequent complication of thoracic injuries [9, 10].

Thoracic trauma with multiple rib fractures in 80-90% of cases is accompanied by intrapleural complications due to damage to intercostal vessels. At the same time, during hostilities, the frequency of chest injuries reaches 8-12% [11-14].

It should be noted that this type of damage is one of the most severe. It leads to fatal consequences in every 3rd victim [15]. Diagnosis of this pathology is difficult. Thoracic trauma is the cause of death of every third victim with combined injuries. In 25% of inpatients with this pathology, serious diagnostic and tactical errors are allowed. In cases accompanied by fragmented rib fractures, the mortality rate is about 50% [9, 16, 17].

In the most severe forms of chest trauma, impaired oxygenation and ventilation, a severe inflammatory reaction, structural disruption of the musculoskeletal system, aspiration, and subsequent pneumonia are often the result of pathophysiological damage. In addition, this severe complex of injuries is often not isolated and can be combined with a craniocerebral injury, fractures of the spine in the cervical and thoracic regions, injuries of long bones and hard organs [18].

In clinical conditions, various types of external fixation, skeletal traction, or pneumatic stabilization of the floating part of the chest wall are more often used to stabilize the frame of the patient's chest wall [19-21]. However, these treatment methods have significant drawbacks: inadequate repositioning and unstable retention of broken fragments, development of abscesses and suppurations in the locations of fixators, pneumothorax and pneumomediastinum, purulent-inflammatory lesions of the upper respiratory tract, and pleuropulmonary complications [16, 22].

The purpose of the study was to establish clear diagnostic tactics for thoracic trauma and for complications that are a consequence of thoracic trauma. Also, an important aspect is the establishment of a clear diagnostic and treatment algorithm for thoracic trauma.

Materials and methods. A retrospective analysis of the results of treatment of 527 patients who were treated at the following clinical bases (thoracic departments) of the Danylo Halytsky Lviv National Medical University was conducted:

- Lung Health Center (Lviv) [23];
- Lviv Military Medical Clinical Center of the State Border Service of Ukraine, which is the regional center of the western part of the State Border of Ukraine, covers 7 regions [24].

During diagnostic video thoracoscopy and diagnostic thoracoscopy, the visceral and costal pleura, accessible areas of the pericardium, and the diaphragm were examined in detail. Diagnostic video thoracoscopy makes it possible to inspect the lungs, pericardium, and interstitium. diaphragm, chest wall [17, 25]. A standard comprehensive examination of patients was carried out: clinical and radiological, laboratory, using invasive methods, pleural puncture and cytological examination of punctate.

All patients underwent a general clinical complex of laboratory examinations: general blood analysis, biochemical blood analysis, general urinalysis.

Radiography of the chest organs in two projections, electrocardiography [16, 26] were also performed. An ultrasound examination method was used for diagnostic purposes. It was performed after a pleural puncture to control the presence of fluid in the pleural cavity, or to diagnose limited exudative pleurisy. The authors used the method of ultrasound diagnostics to detect residual fluid in the pleural cavity after pleural puncture. Philips HD II XE device was used. As is known, during this examination, the minimum amount of liquid in the pleural cavity that can be detected is 20 ml. [27]. With a larger amount of residual exudate in the pleural cavity, its amount and localization were very clearly established. The last indicators were informative in the aspect of solving the question of the expediency of further elimination of pleural effusion.

Pleural puncture was performed according to the standard technique, under local anesthesia with 0.5% novocaine solution or 2% lidocaine solution. A sensitivity test was mandatory to detect a possible allergic reaction to the specified anesthetics. Patients were, as a rule, in a sitting position. Pleural puncture was performed in 7, 8 intercostal spaces along the upper edge of the rib.

Rivalt's test was performed to differentiate exudate and transudate, the content and level of protein, lymphocytes, leukocytes, the presence of atypical cells, mycobacterium tuberculosis were examined.

To verify the above-mentioned nosologies, we use thoracoscopy or video thoracoscopy. Thoracoscopy was performed with a rigid thoracoscope manufactured by the Berlin Medical Equipment Factory according to the generally accepted method. The examination of the pleural cavity was carried out sequentially by sectors (pleural dome, costosternal, costal, costovertebral surfaces, lungs by segments, diaphragm, pericardium, areas of the upper, front, lower, and back interstitium) [9, 25, 28].

When conducting a thoracoscopy, attention was paid to the color, thickness of the visceral and parietal pleura mucosa, the presence of moorings and adhesions, fibrin layers, the presence of rashes and their nature on the pleura, the presence of tumors. Before carrying out this invasive intervention, if the patient had a hydrothorax, an artificial pneumothorax was not applied.

In the presence of a small amount of exudate – up to 250 ml, up to 200 ml of furacilin solution was additionally injected into the pleural cavity during puncture in order to prevent iatrogenic damage to the visceral pleura and lung tissue during thoracoscopy.

Directly during the thoracoscopy, exudate was removed from the pleural cavity with a suction device, and optical devices with direct and lateral vision were used for visual inspection. As a rule, the tube of the thoracoscope was passed (introduced) into the pleural cavity in the 4^{th} intercostal space along the mid-axillary line.

In the majority of cases, thoracoscopy was performed under local anesthesia in patients with exudative pleurisy. After examination of the organs of the pleural cavity, a biopsy was performed for histological examination from the pathologically changed surface of the costal and visceral pleura, from prosiform vesicles on the pleura, from tumor formations, from the junctions between the parietal and visceral pleura.

This manipulation, as a rule, was not accompanied by bleeding, and only in 15 cases we used a solution of aminocaproic acid and burning with a diathermocoagulator [28].

Video thoracoscopy was performed under general anesthesia using an Olympus YEC-40 video thoracoscope. In cases where endoscopic surgery was predicted in the future, Eshelon 30-50 endosuturing devices were used for resection of lung tissue. If necessary, pneumolysis and stoppage of hemorrhage were carried out by standard methods. In case of exudative pleurisy of tumor origin, the final stage of the operation was the performance of coagulation or chemical pleurodesis [9].

Results and discussion. A chest injury is a pathology that requires special attention from doctors, medical personnel and pharmacists and a meticulous and demanding attitude towards such patients. This is due to the fact that with this pathology, vital organs can be affected and accompanying health disorders can develop.

A closed chest injury and an open chest injury are distinguished [29]. With a closed injury, the internal organs and structures of the chest are affected without wound damage to the skin on the chest.

In case of an open injury, there are wounds on the chest. In addition, penetrating and non-penetrating chest injuries are distinguished [30]. In penetrating lesions, the costal pleura is damaged, in non-penetrating lesions, there is no lesion.

It is possible for patients to develop severe, life-threatening complications, such as massive bleeding, tension pneumothorax with progression of respiratory failure, multiple floating rib fractures [31, 32].

Hemothorax is more often a consequence of damage to the intercostal artery during a rib fracture. However, hemothorax can be a consequence of intrapulmonary bleeding. According to the volume of blood in the pleural cavity, there are small (up to 100 ml), medium (from 100 ml to 500 ml), large (over 500 ml) bleeding. With continuous pulmonary bleeding, puncture blood from the pleural cavity - coagulates. With hemothoraxes that developed a few days ago and do not continue, the puncture blood coagulates (Rouvilois-Gregoire test).

The development of traumatic and post-traumatic exudative pleuritis is quite often observed, which can occur under the "mask" of hemothorax or be combined with the latter [26].

During clinical research, we analyzed the results of diagnosis of 527 injured patients aged 18 to 85 years with closed chest trauma, who were distributed as follows – 432 men (82%), 95 women (18%), who were treated within the last 3 years (2021-2024), of which there were 179 patients (39.9%) with severe chest injuries.

Causes of chest injuries among injured patients (Fig. 1):

- Traffic accidents – 30%;
- Domestic injuries – 59%;
- Catatrauma – 11%.

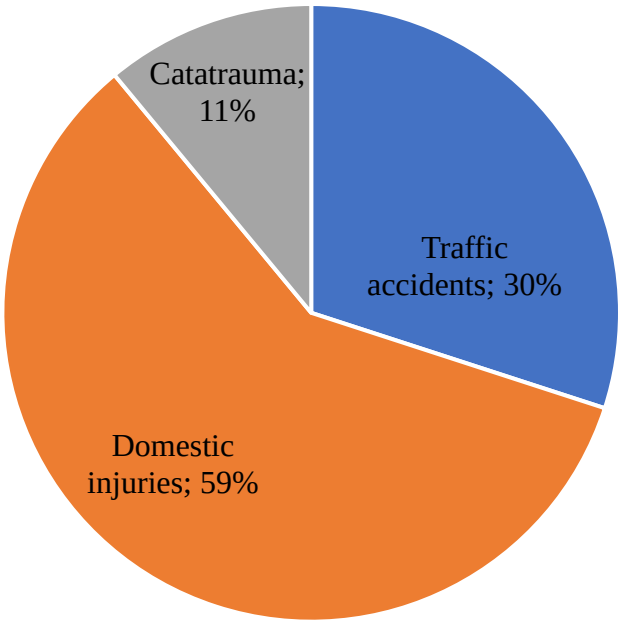

Fig. 1. Causes of chest injuries.

However, studies have shown the following (Fig. 2):

- 32 patients (25%) had multiple rib fractures;
- 47 patients (8.9%) were diagnosed with a fragmentary nature of rib damage with the formation of costal and sternocostal valves;
- 26 patients (4.9%) had a fracture of the body of the sternum with displacement of bone fragments of varying severity.

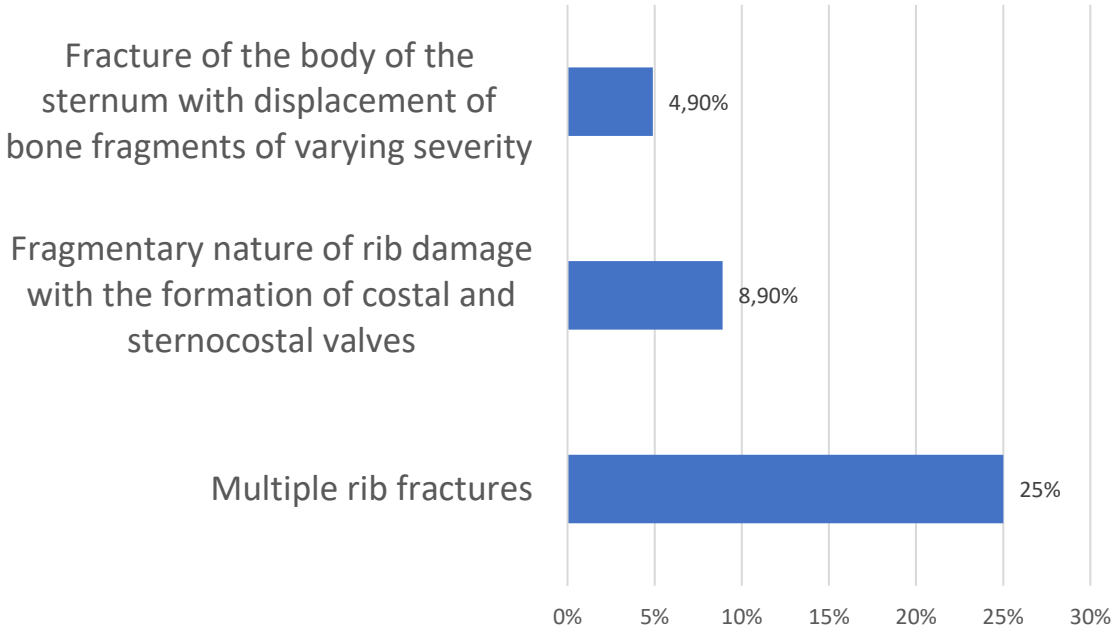

Fig. 2. Types of chest injuries.

Preoperative treatment of patients with multiple and fragmentary rib fractures in the acute period of chest injuries included (Fig. 3):

- Puncture of the pleural cavity – 98 patients (16%);
- Drainage of the pleural cavity – 153 patients (25%);
- Thoracoscopy – 215 patients (35%);
- Rehabilitation tracheobronchoscopy – 171 patients (28%).

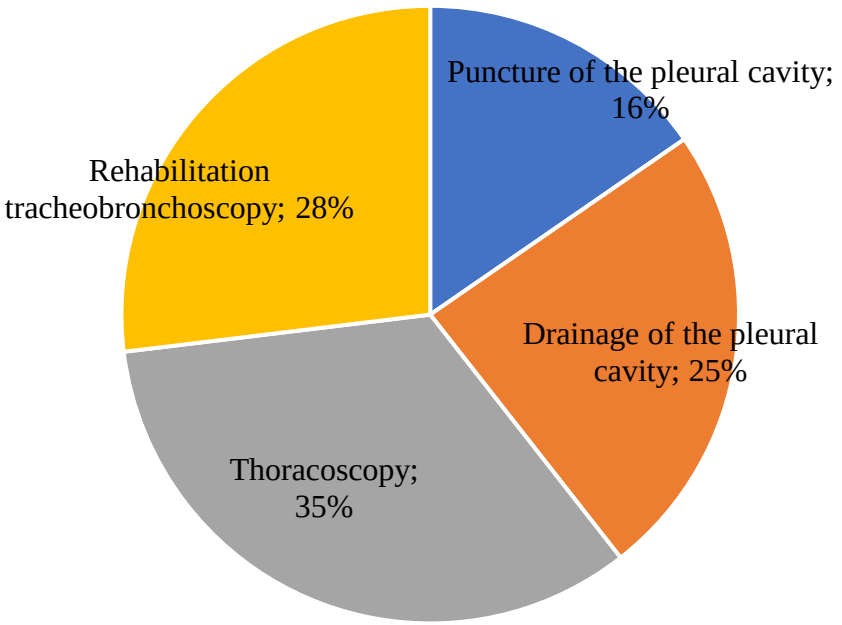

Fig. 3. Types of preoperative treatment of patients with multiple and fragmentary rib fractures in the acute period of chest injuries.

Open chest trauma was observed in 137 patients. Bleeding from soft tissues was observed in all these cases. However, hemothorax as a complication of chest injury was observed in 157 cases.

In case of a chest injury and the presence of a hemothorax, drainage of the pleural cavity must be performed after pleural puncture.

In case of medium and large hemothorax, a thoracotomy was performed with verification and determination of the source of bleeding, and the implementation of the appropriate operative method.

In turn, with a small volume of hemothorax – thoracoscopy or video thoracoscopy was performed. This operation made it possible to clearly establish the source of hemorrhage and determine the further treatment tactics for a specific patient.

In 79 patients, hemorrhage was associated with damage to the intercostal artery. And in 78 patients, bleeding was the result of damage to the lung tissue and, accordingly, injury to blood vessels in the lung tissue.

Clinical case 1. Patient B., 19 years old, blood pressure – 40/0 mm Hg, was urgently admitted to the night shift. art., without consciousness. It is known from the anamnesis that the victims received multiple knife wounds in the left half of the chest and the left half of the abdomen. The injuries were caused by a skewer and a hunting knife. Also, the ulnar artery was completely severed on the left hand. Only bandages were applied to the left elbow, hemostatic tourniquets were not applied. A massive subcutaneous emphysema was found on both sides of the chest, in connection with which the X-ray of the lungs was uninformative. Foamy blood was coming out of the wounds on the left side of the chest during breathing. From the wounds in the left half of the abdomen – the omentum is everted. After placing a tourniquet on the left shoulder, drainage of the left half of the chest was performed. More than 1 liter of blood came out of the drainage. Despite the measures of intensive therapy, raising blood pressure to 70/30 mm Hg century, the patient was unconscious. On auscultation, breathing was practically not heard on the right side of the chest. A right-sided pneumothorax was suspected. This diagnosis was confirmed by right-sided pleural puncture. The mechanism of the injury was as follows: a skewer from the left half of the abdominal cavity "passed" through the dome of the diaphragm on the right, and injured the right lung. After drainage of the right half of the chest, the patient's condition stabilized. Blood pressure rose to 100/65 mm Hg, the patient regained consciousness. This made it possible to perform surgical interventions on the patient: suturing and plastic surgery of the left ulnar artery, laparotomy, stopping bleeding from the mesenteric vessels, thoracotomy and suturing lung wounds.

Traumatic exudative pleurisy was diagnosed in 83 patients. Exudate is hemorrhagic. All patients with traumatic and post-traumatic exudative pleurisy underwent pleural puncture, and 59 patients underwent thoracoscopy or video thoracoscopy, which ended with drainage of the pleural cavity.

When examining the costal and visceral pleural, diaphragmatic and pulmonary surfaces, no signs of hemorrhage were found.

Clinical case 2. Patient V. was admitted to the Military Medical Center of the Border Service with signs of multiple fragmentary window fractures of the chest on the right and left. It is known from the anamnesis that the citizen was involved in a traffic accident. A bus ran over the victim, who was performing customs clearance. The patient has a tracheostomy tube, saturation indicators are 78, the patient is on artificial oxygen breathing. On the radiograph of the lungs – the left hemithorax – is completely shaded throughout (Fig. 4).

Fig. 4. Multiple fragmentary fractures of both lungs, total shadowing of the left hemithorax, tracheostomy tube in the right main bronchus.

In the semi-sitting position of the patient, a pleural puncture was performed in the 6th intercostal space along the front axillary line. A serous-hemorrhagic exudate was obtained. A pleural puncture was performed in the 2nd intercostal space along the anterior axillary line on the left. No free liquid was obtained. Upon a more detailed examination of the X-ray image, it was found that the distal end of the tracheostomy tube was inserted into the right main bronchus, which caused iatrogenic obturation of the left main bronchus and, accordingly, atelectasis of the left lung. The tracheostomy tube is pulled above the level of the bifurcation of the trachea. The patient's blood oxygenation dramatically improved to 88. Subsequently, the patient underwent video thoracoscopic surgery.

While conducting research, it was established that (Fig. 5):

- ✓ traumatic pneumothorax was ascertained in 235 patients and was observed in both closed and open chest trauma (44.6%);
- ✓ 95 victims with symptoms of tension pneumothorax (18%) were admitted to hospital inpatients of health care facilities, in serious condition with the development of acute respiratory failure. During a puncture of the affected half of the chest, air was found in the pleural cavity. Radiologically, the displacement of the interstitium in the healthy direction was ascertained. During drainage of the pleural cavity, air flowed noisily from the affected half of the chest;
- ✓ double drainage of the affected pleural cavity was performed in 47 patients (8.9%);
- ✓ 105 patients were diagnosed with subcutaneous emphysema (19.9%);
- ✓ thoracoscopy or video thoracoscopy for traumatic pneumothoraxes was performed in 183 patients (34.7%).

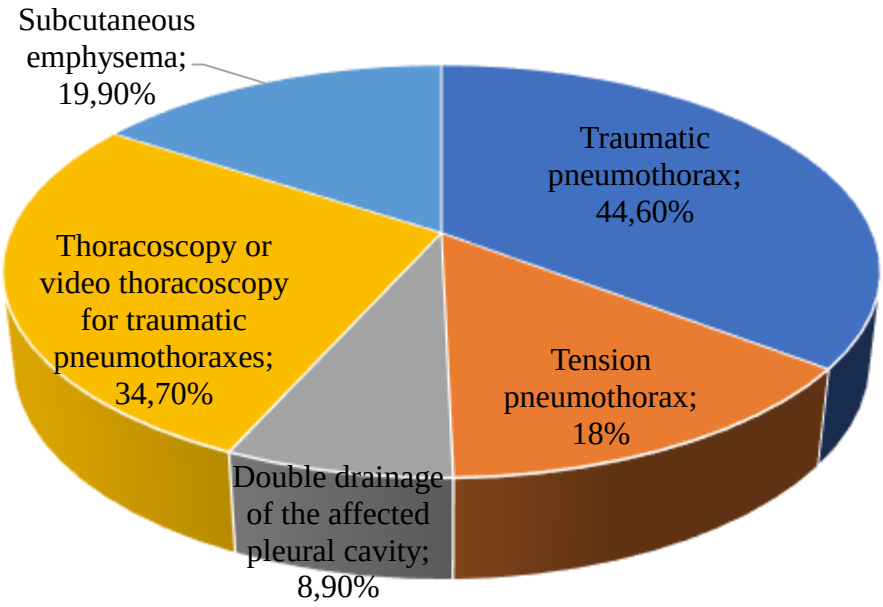

Fig. 5. Types of surgical interventions, types of pneumothoraxes.

Of interest is the experience of Hu M., Sun M., Bao S., Luo J., Zhuo L., Guo M., Department of Cardiothoracic Surgery, Chenggong University Affiliated Hospital (Military Hospital of the 73rd Army, Xiamen, China), who investigate thoracic dissection, which is a common and serious traumatic condition in thoracic surgery, and the treatment of thoracic chain often involves open reduction and internal fixation, which is relatively traumatic, difficult, and expensive [33]. Doctors offer three-dimensional (3D) printing technology, which is widely used in the clinical field. The use of 3D-printed products for chest injuries will become a new treatment technology. The use of 3D-printed thoracic external fixation guides is a promising clinical experience. The short-term effectiveness of the new technology needs to be evaluated. Facilitates thoracic treatment using a customized 3D-printed external fixation guide in conjunction with video-assisted thoracoscopic surgery (Figs. 6, 7).

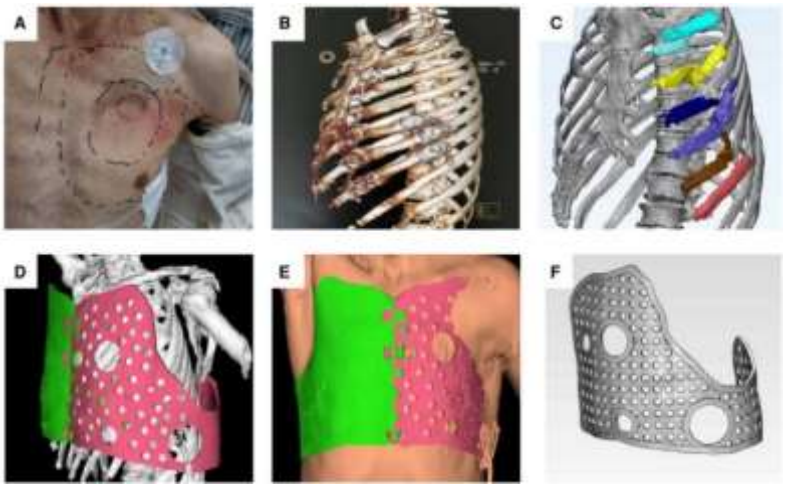

Fig. 6. The range of rib fractures, the localization of paradoxical breathing and the approximate position of the direction printed on a 3D printer were determined:

A – based on the patient's computer tomography data, a three-dimensional reconstruction was performed to determine the specific number and location of rib fractures;

B – data from Digital imaging and Communications in Medicine were modeled, and rib fracture areas were color-coded;

C – based on the morphological data of the healthy side of the chest, an external fixation guide was developed;

D – soft tissue was added to the model and the size of the external fixation guide was adjusted to simulate a tight fit to the chest wall;

E – in the guide, several holes were designed for positioning and fixation (F).

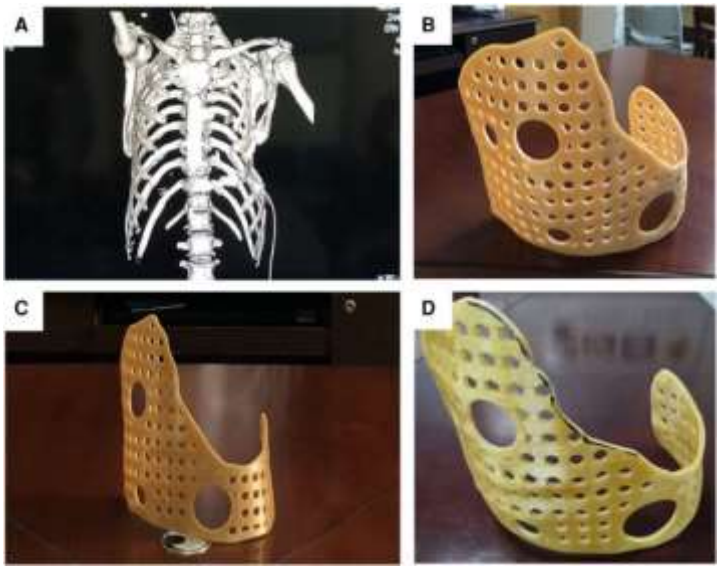

Fig. 7. These models were imported into a laser 3D printer to create an external fixed guide:

A – the 3D printed guide could surround the chest and its surface was designed with positioning and fixed holes for the wire to pass through;

B, C – the guide had a larger front surface and a smaller back surface, which could provide comfortable and effective wrapping;

D – according to the actual situation of the patient, it was modified and polished, and finally a 3D printed guide for the operation was obtained.

Separately, we note that all basic types of medical care (primary, specialized, emergency, palliative) and rehabilitation for adults and children are covered by the Program of Medical Guarantees-2024 [34]. It includes the treatment of health disorders associated with traumatic pneumothorax according to the ICD-11 code [35-37]. Pharmacotherapy is aimed at [38-52]:

- ☑ reduction of pain and inflammation;
- ☑ anti-inflammatory drugs are often used;
- ☑ antibiotics are recommended to combat the disease of infectious origin;
- ☑ localization of some complications;
- ☑ in the presence of large accumulations of fluid, it may be necessary to carry out a drainage procedure;
- ☑ study and generalization of the integrated ABC/VEN-analysis regarding the prescription of drugs during pharmacotherapy.

In this way, the issue of establishing clear diagnostic tactics for thoracic trauma and complications resulting from thoracic trauma, as well as establishing a clear diagnostic and treatment algorithm for thoracic trauma, was considered.

Conclusions. During the daily activities of people, domestic injuries are committed, which are the main reason that affect the quality and length of life, the development of concomitant diseases, disability and death, which include approximately 2/3 of patients with chest injuries of various degrees of severity, from a simple fracture rib to a penetrating wound to the heart or tracheobronchial laceration. Traumatic damage to the chest is a serious injury that can lead to dangerous complications and fatal consequences. It is advisable to follow clearly defined recommendations in the diagnosis

and treatment of traumatic lesions of the chest, especially in case of fragmentary fractures, pulmonary and intrapleural bleeding, in case of tension pneumothorax. Thoracic and video thoracoscopy is recommended for hemothoraxes to be performed only with small volumes of bleeding. The study and introduction into medical practice of three-dimensional (3D) printing technology, which is widely used in the clinical field, that is, the use of 3D-printed products for chest injuries, which will become a new treatment option. The use of 3D-printed external fixation guides for the chest is a promising clinical experience that needs to evaluate the short-term and long-term effectiveness of the new technology. The level of pharmacotherapy when using modern drugs in accordance with the nosological groups of the International Classification of Diseases-11 revision and pharmacoeconomic factors (benefits) that affect the price of drugs used during the course of treatment during the patient's stay in the hospital and in conditions that require further research outpatient treatment. Needs to be studied integrated ABC/VEN analysis of drug prescriptions in pharmacotherapeutic schemes of thoracic trauma relief and dynamics of treatment in inpatient and outpatient conditions of health care facilities.

Declaration of conflict interest. The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. The authors confirm that they are the authors of this work and have approved it for publication. The authors also certify that the obtained clinical data and research were conducted in compliance with the requirements of moral and ethical principles based on medical and pharmaceutical law, and in the absence of any commercial or financial relationships that could be interpreted as potential conflict of interest.

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Ethical approval. Ethical clearance was obtained from the administration of the Danylo Halytsky Lviv National Medical University. Permission statement for conducting the experiments was received from the administration of the Danylo Halytsky Lviv National Medical University. Before any data collection, the main purpose of the study was clearly explained to each department (concerned personnel) in accordance with the Law of Ukraine "On the Protection of Personal Data", which regulates legal relations related to the protection and processing of personal data, and is aimed at protecting the fundamental rights and freedoms of a person and a citizen, in particular the right to non-interference in personal life, in connection with processing of personal data. This Law applies to the processing of personal data, which is carried out in whole or in part using automated means, as well as to the processing of personal data contained in the card file or intended to be entered in the card file, using non-automated means.

Data availability statement. The datasets analyzed during the current study are available from the corresponding author on reasonable request.

References.

1. Ludwig C., Koryllos A. Management of chest trauma. *JTD*. 2017. Vol.9 Suppl. 3. S. 172-177. URL: https://pubmed.ncbi.nlm.nih.gov/28446982/
2. Lundin A., Akram S.K., Berg L. et al. Thoracic injuries in trauma patients: epidemiology and its influence on mortality. *Scand. J. Trauma. Resusc Emerg. Med*. 2022. Vol.30. Article number: 69. URL: https://sjtrem.biomedcentral.com/articles/10.1186/s13049-022-01058-6.
3. Dogrul B.N., Kiliccalan I., Asci E.S. et al. Blunt trauma related chest wall and pulmonary injuries: An overview. *Chinese Journal of Traumatology*. 2020. Vol. 23. Iss. 3. P. 125-138. DOI: https://doi.org/10.1016/j.cjtee.2020.04.003.
4. Edgecombe L., Sigmon D.F., Galuska M.A. et al. Thoracic Trauma. *NCBI*. 2023. URL: https://www.ncbi.nlm.nih.gov/books/NBK534843/.
5. Voloshina N.P., Negreba T.V., Kirzhner V.M. et al. Clinical and mathematical analysis of differences for different types of course in sporadic and familial forms of multiple sclerosis. *International Neurological Journal*. 2020. Vol. 16. No. 4. URL: http://www.mif-ua.com/archive/article/49459.

6. Ryabukha O. Theoretical and Experimental Approaches to Study of Biological Objects by Mathematical Methods Using the Example of Hormone Production in the Thyroid Gland. *SSP Modern Pharmacy and Medicine*. 2024. Vol. 4. No. 3. P. 1-14. DOI: https://doi.org/10.53933/sspmpm.v4i3.153.
7. Ryabukha O. Multidisciplinary Studies of the Thyroid Gland's Synthetic Activity under Conditions of Iodine Deficiency Using Correlation Analysis. *SSP Modern Pharmacy and Medicine*. 2023. Vol.3. No.3. P. 1-15. DOI: https://doi.org/10.53933/sspmpm.v3i3.104.
8. Wartime Thoracic Injury. *TCCC*. 2023. URL: https://tccc.org.ua/en/guide/wartime-thoracic-injury-cpg.
9. Nevzghoda O., Nevzghoda A. Thoracoscopy and Video-Assisted Thoracoscopy in Diagnostics of Pneumothoraxes, Traumatic Defeats of Thorax with Pneumothoraxes. *SSP Modern Pharmacy and Medicine*. 2023. Vol. 3. No. 4. P. 1-10. DOI: https://doi.org/10.53933/sspmpm.v3i4.112.
10. Walia B.S., Dugg P., Sharma S. Clinical Features, Management, and Outcomes of Chest Trauma at a Tertiary-Care Centre in India: A Retrospective Observational Study. *The Scientific World Journal* Vol. 2021. Article ID 8052586, 4 p. URL: https://pubmed.ncbi.nlm.nih.gov/34824560/.
11. Melnychenko O.O. Clinical and nosological structure of chest injury accompanied by flail chest. Current Aspects of Military Medicine. 2023. Vol. 30. No. 2. P. 74-83. DOI: https://doi.org/10.32751/2310-4910-2023-30-2-07.
12. Safonov V.E., Melnychenko O.O., Kravchenko K.V. et al. Features of treatment injured with fractures of the bone skeleton of the thoracic cage at the IVth level of providing medical care. Current Aspects of Military Medicine. 2023. Vol. 30. No. 2. P. 88-94. DOI: https://doi.org/10.32751/2310-4910-2023-30-2-09.
13. Ludwig1 C., Koryllos A. Management of chest trauma. *Journal of Thoracic Disease* [Dedicated to the 25th European Conference on General Thoracic Surgery (ESTS 2017)]. 2017. Vol 9, Supplement 3. URL: https://jtd.amegroups.org/article/view/12949/html.
14. Kim M., Moore J.E Chest Trauma: Current Recommendations for Rib Fractures, Pneumothorax, and Other Injuries. *Curr. Anesthesiol. Rep*. 2020. Vol. 10. No. 1. P. 61-68. URL: https://pubmed.ncbi.nlm.nih.gov/32435162/
15. Beshay M., Mertzlufft F., Kottkamp H.W. et al. Analysis of risk factors in thoracic trauma patients with a comparison of a modern trauma centre: a mono-centre study. *World J. Emerg. Surg.* 2020. Vol. 5. Article number 45. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7393329/
16. Kelemen I.Ya., Nevzhoda O.A. Osteosynthesis for multiple rib fractures. Acta Medica Leopoliensia. 2012. Vol. 18. No. 3. P. 19-23.
17. Nevzhoda O.A., Rak L.M., Nevzhoda A.A. et al. Exudative pleurisy of tuberculous genesis in the structure of extrapulmonary tuberculosis and the total number of exudative pleurisy. Tuberculosis, lung diseases, HIV infection. 2020. No. 1. P. 49-55. URL: http://tubvil.com.ua/article/view/198944.
18. Saillant N.N., Sein V. Management of severe chest wall trauma. *JECCM*. 2018. Vol. 2. URL: https://jeccm.amegroups.org/article/view/4306/4900.
19. Shevchuk I.M., Snizhko S.S., Dronyak M.M. et al. Comparative analysis of the effectiveness of different types of surgical stabilization of the chest wall in case of multiple rib fractures. *World of Medicine and Biology*. 2023. No.1(83). P.179-183. URL: https://womab.com.ua/en/smb-2023-01/9718#&slider1=5.
20. Dehghan N. Challenges in plate fixation of chest wall injuries. *Injury*. 2018. Vol. 49. Suppl.1. P.S39-S43. URL: https://www.sciencedirect.com/science/article/abs/pii/S0020138318303012.
21. Beks R.B., Reetz D., de Jong M.B. et al. Rib fixation versus non-operative treatment for flail chest and multiple rib fractures after blunt thoracic trauma: a multicenter cohort study. *Eur. J. Trauma Emerg. Surg.* 2019. Vol.45. No.4. P.655-663. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6689036/.
22. Lardinois D. General considerations, indications, and potential advantages of chest wall stabilization, rib fixation, and sternum osteosynthesis in selected patients after blunt trauma. *SHC*. 2018. Vol.2. URL: https://shc.amegroups.org/article/view/4462/html.

23. Communal non-commercial enterprise of the Lviv Regional Council Lviv Regional Phthisiopulmonology Clinical Treatment and Diagnostic Center. Website of the Lung Health Center (Lviv). 2024. URL: https://lunghealthlviv.com/.
24. Military Medical Clinical Center of the State Border Service of Ukraine in Lviv. Official website of the State Border Service of Ukraine. 14.04.2016. URL: https://dpsu.gov.ua/ua/klinichniy-gospital-zahidnogo-regionalnogo-upravlinnya-derzhavnoi-prikordonnoi-sluzhbi-ukraini-m-lviv/
25. Nevzhoda O.A., Ladny O.Ya. Modern concept of diagnosis of exudative pleurisy. *Practical medicine.* 2004. No. 2 (volume X). P. 31-33. URL: https://www.dissercat.com/content/videotorakoskopiya-v-diagnostike-i-lechenii-opukholevykh-ekssudativnykh-plevritov
26. Griffard J., Kodadek L.M. Management of Blunt Chest Trauma. *Surg. Clin. North. Am*. 2024. Vol.104. Iss.2. P.343-354. URL: https://pubmed.ncbi.nlm.nih.gov/38453306/. URL: https://www.sciencedirect.com/science/article/abs/pii/S0039610923001627?via%3Dihub
27. Nevzghoda O., Nevzghoda A., Rak L. et al. Ultrasound Method for Pleural Punctures in The Diagnosis and Treatment of Exudative Pleuritis. *SSP Modern Pharmacy and Medicine*. 2024. Vol.4. No.2. P.1-11. DOI: https://doi.org/10.53933/sspmpm.v4i2.146
28. Nevzghoda O.A. Thoracoscopic diagnosis of exudative pleurisy. *Acta Medica Leopoliensia. 2010*. Vol. 16. No. 3. P. 24-27.
29. Marro A., Chan V., Haas B. et al. Blunt chest trauma: classification and management. *Emergency Radiology*. 2019. Vol. 26. No. 5. P. 557-566. URL: https://pubmed.ncbi.nlm.nih.gov/31280427/.
30. Dogrul B.N., Kiliccalan I., Asci E.S. et al. Blunt trauma related chest wall and pulmonary injuries: An overview. *Chin. J. Traumatol*. 2020 Jun. Vol. 23. No. 3. P. 125-138. DOI: https://doi.org/10.1016/j.cjtee.2020.04.003.URL: https://pubmed.ncbi.nlm.nih.gov/32417043/.
31. Edwards J.G., Clarke P., Pieracci F.M. Taxonomy of multiple rib fractures: Results of the chest wall injury society international consensus survey. *The Journal of Trauma Injury Infection and Critical Care*. 2020. Vol. 88. No. 2. e40-e45. URL: https://pubmed.ncbi.nlm.nih.gov/31590175/. URL: https://journals.lww.com/jtrauma/citation/2020/02000/taxonomy_of_multiple_rib_fractures__results_of_the.20.aspx.
32. Martin T.J., Eltorai A.S., Dunn R. Clinical management of rib fractures and methods for prevention of pulmonary complications: A review. *Injury*. 2019. Vol. 50. No. 6. P. 1159-1165. URL: https://pubmed.ncbi.nlm.nih.gov/31047683/.
33. Hu M., Sun M., Bao C. et al. 3D-printed external fixation guide combined with video-assisted thoracoscopic surgery for the treatment of flail chest: a technical report and case series. *FrontierSin.* 27.09.2023. DOI: https://doi.org/10.3389/fsurg.2023.1272628.
34. The Medical Guarantee Program for 2024 comes into effect on January 1. *Government portal.* 01.01.2024. URL: https://www.kmu.gov.ua/news/z-1-sichnia-pochynaie-diiaty-prohrama-medychnykh-harantii-na-2024-rik
35. WHO Advances Implementation and Integration of ICD-11 and Related Medical Classifications and Terminologies. *WHO*. 2024. https://www.who.int/standards/classifications/classification-of-diseases
36. Shapovalova V. The ICD-11 For the Twenty-First Century: The First View from The Organizational, Legal, Clinical and Pharmacological Aspects. *SSP Modern Pharmacy and Medicine*. 2022. Vol. 2. No. 1. P. 1-13. DOI: https://doi.org/10.53933/sspmpm.v2i1.37.
37. Ivanishyn-Hayduchok L., Shapovalova V., & Shapovalov V. ICD-11: Organizational and Legal, Medical and Pharmaceutical, Social and Economic Issues of Implementation of the Program of State Guarantees of Medical Care in 2022 in Ukraine, Based on The Fundamental Principles of the European Union. *SSP Modern Pharmacy and Medicine*. 2022. Vol. 2. No. 2. P. 1-14. DOI: https://doi.org/10.53933/sspmpm.v2i2.53.

38. Shapovalova V. Pharmacotherapy of Depressive Disorders in Conditions of Coronavirus Disease: Pharmacoeconomic Experimental Study. *SSP Modern Pharmacy and Medicine*. 2023. Vol. 3. No. 3. P. 1-11. DOI: https://doi.org/10.53933/sspmpm.v3i3.101.
39. Zbrozhek S.I., Shapovalova V.O., Shapovalov (Jr.) V.V., Andrieieva V.V., & Shapovalov V.V. Processing of the control regime of medicines for pharmacotherapy of chronic pain syndrome in the field of palliative aid. *Likars'ka Sprava*. 2019. No. 5-6. P. 111-118. DOI: https://doi.org/10.31640/JVD.5-6.2019(15).
40. Gudzenko A., Shapovalov V., Shapovalov V. et al. Forensic pharmacy: Analysis of complaints about the pharmaceutical provision for privileged categories of patients in Ukraine (Experimental research). *Science Review.* 2021. No. 2(37). DOI: https://doi.org/10.31435/rsglobal_sr/30042021/7517/.
41. Shapovalova V. Extemporaneous Preparations in the Pharmacotherapy of Nervous System Disorders: Pharmaceutical Management, Marketing, Analysis, Application. *SSP Modern Pharmacy and Medicine*. 2023. Vol. 3. No. 4. P. 1-7. DOI: https://doi.org/10.53933/sspmpm.v3i4.111
42. Chuiev Y., Shapovalova V. Integrated ABC/VEN-Analysis of Drug Prescriptions in Pharmacotherapeutic Schemes for Relief of Drunken Forms of Alcohol Dependence. *SSP Modern Pharmacy and Medicine*. 2022. Vol. 2. No. 1. P. 1-14. DOI: https://doi.org/10.53933/sspmpm.v2i1.35.
43. Chuiev Y., Shapovalova V. Interdisciplinary Pharmacoeconomic Study of Pharmacotherapy of Cupping of Drunk Forms of Alcohol Dependence: Clinical and Pharmacological, Organizational, Legal and Marketing Experiment. *SSP Modern Pharmacy and Medicine*. 2021. Vol. 1. No. 2. P. 1-12. DOI: https://doi.org/10.53933/sspmpm.v1i2.24.
44. Gudzenko A., Shapovalov V., Shapovalova V. et al. Organizational and Legal Aspects of the Use of Marketing Analysis of Multivitamin Complexes for Pharmaceutical Provision of Health Diseases Among Combatants. *Acta Scientific Pharmaceutical Sciences.* 2021. Vol.5. Iss.4. P.74-80. DOI: 10.31080/ASPS.2021.05.0704.
45. Shapovalov V., Gudzneko A., Shapovalov V. et al. Organizational and legal aspects of the use of Pharmacoeconomic analysis of multivitamin complexes for pharmaceutical provision of military personnel. *The Pharma Innovation Journal*. 2018. Vol.7. Iss.10. P.166-169. URL: https://www.thepharmajournal.com/archives/?year=2018&vol=7&issue=10&ArticleId=2588.
46. Shapovalov V., Gudzenko A., Komar L. et al. Concerning the importance of forensic and pharmaceutical researches to improve patients' accessibility to medicines. *Pharmacia*. 2017. Vol. 65. No. 2. P. 23-29. URL: https://www.researchgate.net/publication/352121257_Concerning_the_importance_of_forensic_and_pharmaceutical_researches#fullTextFileContent
47. Shapovalov V.V., Gudzenko A.O., Shapovalova V.O. et al. Clinical and pharmacological, classification and legal, nomenclature and legal distribution of medicines for pharmacotherapy of depression among combatants (F 32-33). *Health of Society*. 2021. Vol. 7. No. 4. P. 181-186. DOI: https://doi.org/10.22141/2306-2436.7.4.2018.148361
48. Ryshchenko O., Shapovalov V., Shapovalova V. et al. Organizational and legal implementation World Health Organization recommendations for pharmaceutical correction of patients with chronic pain syndrome the principles of medical and pharmaceutical law. *Ukrainian herald of psychoneurology*. 2015. Vol. 23. Iss. 2(83). P. 100-104. URL: https://uvnpn.com.ua/arkhiv-nomeriv/2015/tom-23-vipusk-2-83/organ-zats-yno-pravova-mplementats-ya-rekomendats-y-vse-sv-tno-organ-zats-okhoroni-zdorov-ya-shchodo.
49. Shapovalova V.A., Sosin I.K., Butenko H.M. et al. Pharmaceutical law in narcology. *Kharkov: «Fact»*. 2004. 800 p.
50. Polireddy K., Hoff C., Kinger N.P. et al. Blunt thoracic trauma: role of chest radiography and comparison with CT - findings and literature review. *Emerg. Radiol.* 2022. Vol. 29. 4. P. 743-755. DOI: https://doi.org/10.1007/s10140-022-02061-1.

51. Battle C.E., Hutchings H., Evans P.A. Risk factors that predict mortality in patients with blunt chest wall trauma: a systematic review and meta-analysis. *Injury.* 2012. Vol. 43. No. 1. P. 8-17. DOI: https://doi.org/10.1016/j.injury.2011.01.004.
52. Resolution of the Cabinet of Ministers of Ukraine of April 13, 2024 No. 428 "On Amendments to the Procedure for Implementing the Program of State Guarantees of Medical Services for the Population in 2024. Verkhovna Rada of Ukraine. 13.04.2024. URL: https://zakon.rada.gov.ua/laws/show/428-2024-%D0%BF#Text.