

Nehoduiko V., Tsema Ie., Humenyuk K., Kravchenko K., Yurkiv O., Dubenko D., Khuda M., Myrhorodskiy D., Bunin Yu. **Bilateral Gunshot Wounds to the Chest at Different Levels of Medical Care.** *Journal of Education, Health and Sport.* 2021;11(04): 92-100. eISSN 2391-8306. DOI <http://dx.doi.org/10.12775/JEHS.2021.11.04.010>  
<https://apcz.umk.pl/czasopisma/index.php/JEHS/article/view/JEHS.2021.11.04.010>  
<https://zenodo.org/record/4741127>

The journal has had 5 points in Ministry of Science and Higher Education parametric evaluation. § 8. 2) and § 12. 1. 2) 22.02.2019.  
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The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 26.02.2021. Revised: 31.03.2021. Accepted: 30.04.2021.

## **Bilateral Gunshot Wounds to the Chest at Different Levels of Medical Care**

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### **Abstract**

The article provides a definition of a bilateral gunshot wound to the chest, the features of diagnosis and treatment according to the level of medical care. The isolation of this pathology into a separate nosological unit is justified due to the peculiarities of the lesions of the respiratory system and mediastinum, severe injury, high mortality, long duration of treatment and the existing complications of the same type.

**Keywords: gunshot wound; bilateral chest injury; level of medical care; echelon care.**

### **Introduction**

A penetrating gunshot wound to the chest is considered one of the most severe, has a higher mortality rate compared to blunt trauma [15]; historically, the mortality rate from these wounds has exceeded 50% [6, 13]. Early mortality was usually associated with blood loss and catastrophic trauma to internal organs. The use of individual body armor has made injuries less common than in previous wars, but these injuries can be devastating, and proper treatment is paramount for survival [9]. According to ATO data, gunshot wounds to the chest

in the general structure of combat surgical trauma in eastern Ukraine account for 11.7%, an overwhelming majority of them were non-penetrating wounds (83.6%) [1, 3].

Bilateral gunshot penetrating wounds of the chest, in which one projectile injures both pleural cavities and mediastinum, are among the most severe wounds and lead to 70% mortality rate [11, 13]. Such injuries most often occur during sniper attacks, the use of large-caliber small arms and the explosion of ammunition with a high kinetic energy of fragments. They are mainly accompanied by damage to vital organs of the chest, massive blood loss, development of tension pneumothorax and pneumomediastinum, which extremely limits the time for a diagnostic search [5, 6]; at the same time, errors in the diagnosis and identification of complications of these injuries are more than 30% [4].

According to the experience of the Anti-Terrorist Operation (ATO) and the Operation of the combined forces (OCF) on the territory of Donetsk and Lugansk regions of Ukraine, if death did not occur in the first minutes after injury and the patient could be delivered to the second stage of medical care, then the surgeon faced an extremely difficult task of diagnostic search, limited by performing chest X-ray cells and ultrasound, modeling of the projection of the wound channel. Performing computed tomography, fibrobronchoscopy, fibroesophagoscopy, echocardiography with these conditions was not always possible, which did not allow to accurately determine the nature of damage to internal organs and choose the optimal treatment tactics [7, 8].

Surgical treatment of such wounded in the early stages consists in performing surgical treatment of gunshot wounds, draining the pleural cavities, if indicated - emergency thoracotomy, sternotomy, or their combination [10, 12]. A promising direction is the use of a videothoracoscopic method of treatment; however, it is limited by an insufficient technical base and partly by the absence of a thoracic surgeon in these conditions [2, 14].

Unfortunately, in the modern medical literature there is not enough data for this type of chest injury, therefore, each case of a bilateral gunshot wound is unique and should be carefully studied and analyzed to determine the optimal tactics of surgical treatment.

**The aim** is to define and show the features of diagnosis and surgical treatment for gunshot wounds of the chest with damage to both pleural cavities and mediastinum at various levels of medical care.

### **Materials and methods**

The study was based on the results of treatment of 36 cases with bilateral chest wounds, of which 20 were fatal. The age of the wounded ranged from 21 to 47 years and averaged  $(32 \pm 0.8)$  %. All wounded with bilateral gunshot wounds to the chest were male

and were treated in the conditions of district and city hospitals, military mobile hospitals, military medical clinical centers of the Northern and Southern regions, the National Military Medical Clinical Center "GVKG" from July 2014 to July 2020. The duration of treatment of this pathology with rehabilitation averaged  $(110 \pm 7)$  % days. Lethal cases were studied according to the data of the forensic medical bureaus of the Donetsk and Lugansk regions and the Kharkiv city.

Clinical studies included the study of complaints, anamnesis, data from a physical examination of the wounded. General clinical blood and urine tests, biochemical, immunological (determination of blood group and Rh factor, hepatitis B and C, HIV) blood tests were performed, and a coagulogram was also performed. Hematological examinations of the wounded were carried out on an ABX Micros 60 apparatus (France). General urine analysis of the wounded was performed routinely. Biochemical analysis of wounded was carried out using Respons 920 (Germany) and Lab Analyt (China) devices. The study of the coagulogram of the wounded was carried out on a HumaClot Duo Plus apparatus (Germany). Immunological studies of the wounded were carried out on Labline 40 (Austria) and Sunrise (Austria) devices with additional equipment BIORAD and BIOSAN.

At the qualified level of medical care, examinations were carried out by the ultrasound method using a portable ultrasonic device M-Turbo Ultrasound System "SonoSite" (USA) and using a mobile X-ray apparatus "Arman-1" (USSR).

At the specialized level of the provision of thoracic surgical care, the wounded were examined by the ultrasound method using an ultrasonic scanning expert class "Voluson ® E6" (General Electric) with sensors SP10-16 and AB2-7, by the X-ray method using the X-ray machine "MEDIX" (Ukraine), a complex of X-ray diagnostic KRD-50 "INDIASCOP-01" (Ukraine) and by the method of multispiral computed tomography on a spiral tomograph "Toshiba-Activion 16", following standard automated protocols in accordance with the examination area with subsequent processing in the "Vitrea 6.1" program.

The concept of a bilateral gunshot wound to the chest includes the presence of a bullet or shrapnel penetrating through or blind wound of the chest with damage to the organs of both pleural cavities and mediastinum along the movement of the wounding projectile.

## **Results**

The wounded received first aid in a period of  $(10 \pm 0.2)$  % minutes, followed by transportation to the next level of medical aid. At the II level of medical care, they arrived in time  $(35 \pm 0.4)$  % minutes in a serious and extremely serious condition. Half of the wounded (18) were admitted in critical condition; they have already undergone resuscitation measures.

Half of the wounded (18) were admitted to the III level of medical care within a period of  $(236 \pm 12.8)$  % minutes. At the IV level of medical care, the wounded were admitted on  $(6 \pm 0.1)$  % of the day from the injury.

According to the projectile type, wounds in  $26 (72.2 \pm 0.3)$  % of patients were bullet-type, and  $10 (27.7 \pm 0.2)$  % were shrapnel-type. According to the course of the wound channel, through wounds accounted for  $2/3 - 24 (66.6 \pm 0.3)$  % and blind  $1/3 - 12 (33.3 \pm 0.2)$  % of cases. Among the bullet wounds, 24 were 7.62 mm and 2 - 5.45 mm. Sniper wounds prevailed. According to the localization of the inlet, left-sided wounds accounted for  $21 (58.3 \pm 0.4)$  %, right-sided -  $15 (41.6 \pm 0.3)$  % of cases. Ribs were injured in 36 (100%), sternum in  $10 (27.7 \pm 0.2)$  %, and vertebrae of the thoracic spine in  $6 (16.6 \pm 0.3)$  % of the wounded. Shoulder injuries were noted in  $28 (77.7 \pm 0.3)$  % of cases, of which only  $3 (10.7 \pm 0.1)$  % had no gunshot fracture of the humerus. Damage to the organs of the anterior mediastinum was in  $14 (38.8 \pm 0.2)$  %, posterior - in  $22 (61.1 \pm 0.3)$  % of cases.

Clinical signs and severity of the condition of the wounded on admission to the II level of medical care were determined by varying degrees of severity of pain syndrome, respiratory failure, hemodynamic disorders, which depended on the volume of damage to the respiratory and mediastinal organs, the volume and rate of blood loss. All patients were admitted with II-III-degree hemorrhagic shock. Bilateral hemopneumothorax was observed in 36 (100%) cases. The volume of hemopneumothorax was different: on the side of the larger lesion, there was a large or total hemopneumothorax, on the opposite side - medium or small.

Due to massive blood loss, central venous catheterization was not always successful, therefore, venesection of the jugular or femoral veins was performed. Autohemotransfusion, blood transfusions, thoracocentesis, Bulau pleural drainage, and, if indicated, emergency thoracotomy were performed.

The appearance of the wounds and the data of SCT (spiral computed tomography) of a bilateral gunshot wound to the chest in the first day after the injury are shown in Fig. 1.

At the first level of medical care, occlusive dressing, anesthesia, infusion therapy, oxygen therapy, and resuscitation were carried out. Mortality on it was  $14 (70 \pm 0.5)$  % of cases.

Surgical interventions at the II level of medical care for bilateral gunshot wounds of the chest were performed in  $22 (61.1 \pm 0.3)$  % of cases: bilateral thoracocentesis, Bulau pleural, primary surgical treatment of wounds and emergency thoracotomy in  $10 (45.5 \pm 0.5)$  % of cases. The mortality rate at this level was  $4 (20 \pm 0.2)$  % of cases.

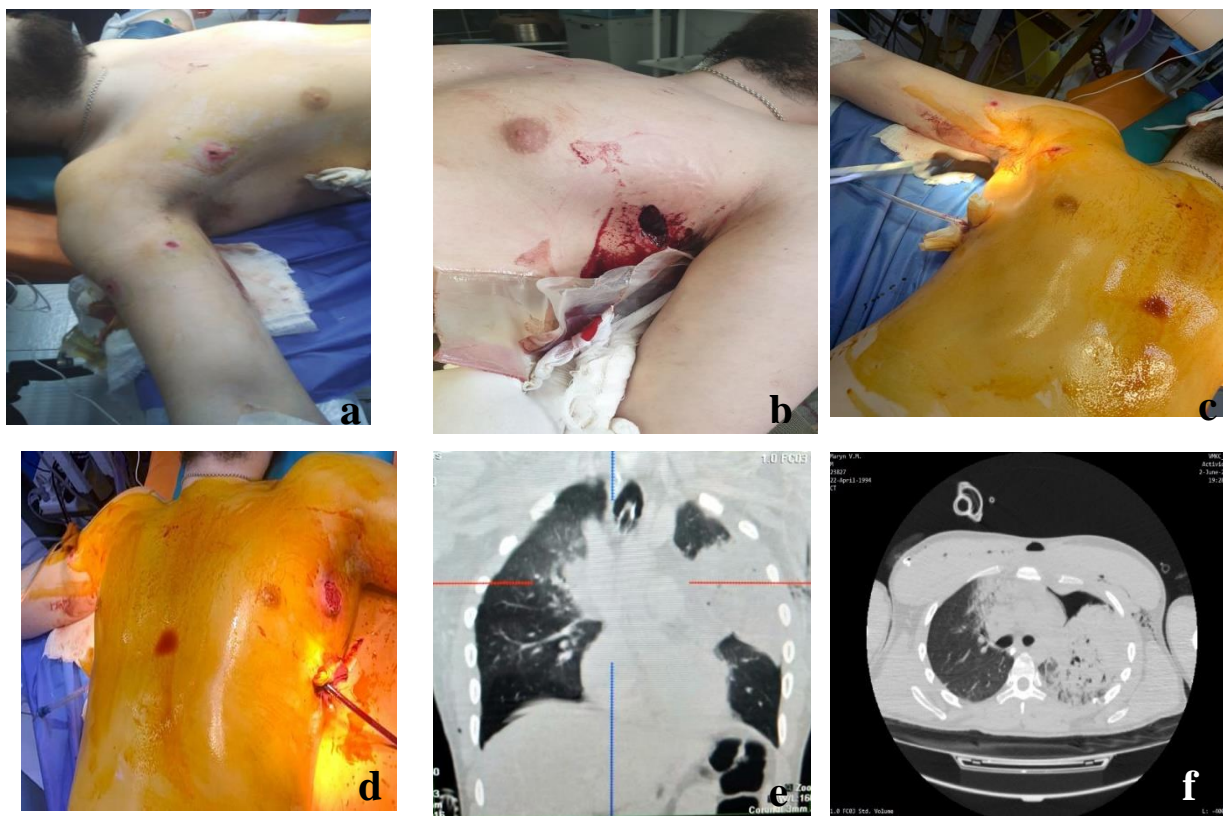


Fig 1. The appearance of the wounds and the data of the CT scan of a bilateral gunshot wound to the chest in the first days after the injury: a - inlet and outlet openings d. And on the shoulder with an inlet opening on the right lateral surface of the chest; b - outlet on the left lateral surface of the chest; c - drainage of the right pleural cavity with Bulau; d - drainage of the left pleural cavity with Bulau; e - displacement of the mediastinum to the right, post-traumatic pulmonitis of the upper lobe of the right lung, post-traumatic pulmonitis of the upper lobe of the left lung; f - displacement of the mediastinum to the right, post-traumatic pulmonitis of the upper lobe of the right lung, post-traumatic pulmonitis of the upper lobe of the left lung, in the bounded pneumohaemothorax on the left

Injuries to the lungs and mediastinal organs, which were detected intraoperatively during thoracotomy, are shown in Fig. 2.

Surgical interventions at the III level of medical care for bilateral gunshot wounds of the chest were performed in 18 ( $50 \pm 0.3$ ) % of cases: video thoracoscopy from the more affected side, suturing of lung wounds, resection of bone fragments, removal of foreign bodies, sanitation and drainage of the pleural cavity and according to indications - delayed thoracotomy with atypical lung resection in 4 ( $22.2 \pm 0.2$ ) % of cases. Mortality at the III level of medical care was 2 ( $10 \pm 0.2$ ) % of the cases: the first – 4 hours after injury and the second - on the 3rd day after injury.

Surgical interventions at the IV level of medical care for bilateral gunshot wounds of the chest were performed in 10 ( $27.7 \pm 0.3$ ) % of cases: retraining of lung abscesses or residual cavities in 3 ( $8.3 \pm 0.1$ ) % of cases, lobectomy - in 2 ( $5.6 \pm 0.1$ ) % of cases, and

thoracotomy with the removal of a foreign body of the pericardium - in 1 ( $2.8 \pm 0.1$ ) % of cases.

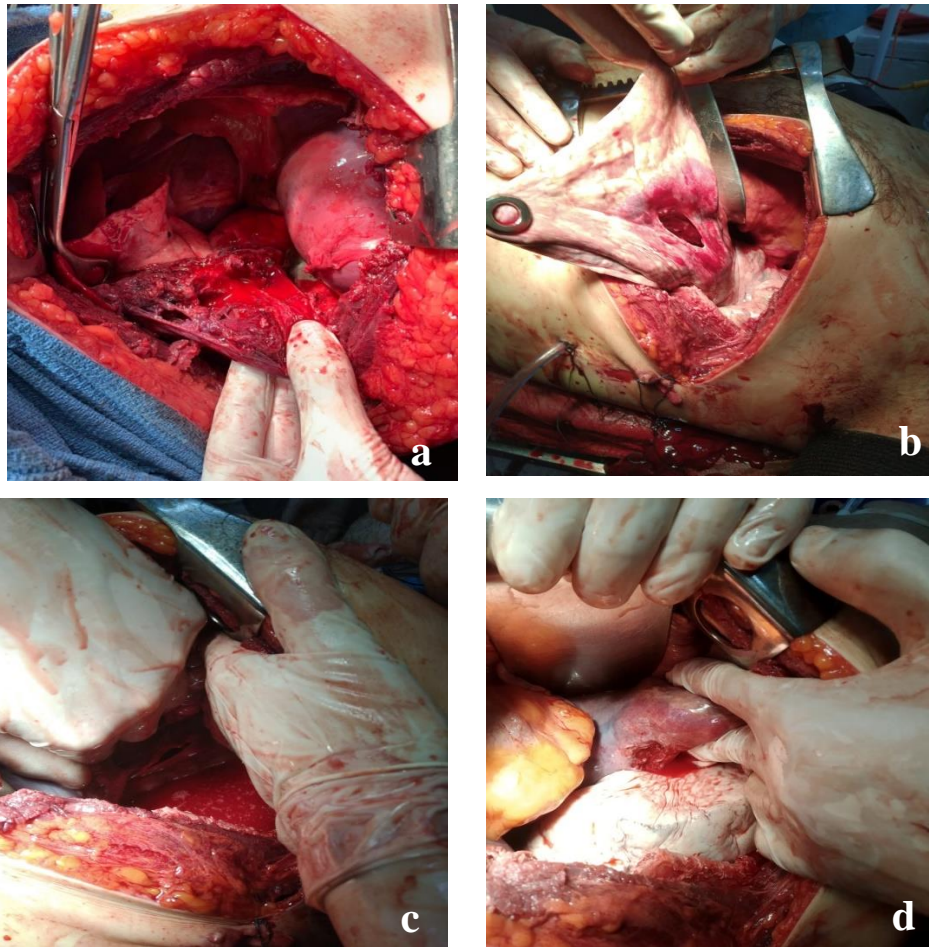


Fig 2. Damage to the lungs and mediastinal organs, which were detected intraoperatively during thoracotomy: a - a through wound of the lower lobe of the right lung with damage to the posterior mediastinum, view after pericardiotomy; b - a through wound of the lower lobe of the left lung with damage to the lung root; c - injuries of the posterior mediastinum, large haemothorax; d - injury to the root of the left lung

Complications after bilateral chest gunshot wounds were both early and late. Early complications were observed in all 16 wounded survivors, namely: coagulated hemothorax, recurrent post-traumatic pleurisy, empyema of the pleura, purulent endobronchitis, lung abscess, destructive pneumonia, mediastinitis, pneumocele, postoperative wound suppuration. Pneumofibrosis, as a late complication, was noted in all 16 cases, residual cavities - in 3 wounded.

The X-ray of the complication of a bilateral gunshot wound to the chest on day 30 in the form of a pneumocele of the upper lobe of the left lung is shown in Fig. 3.

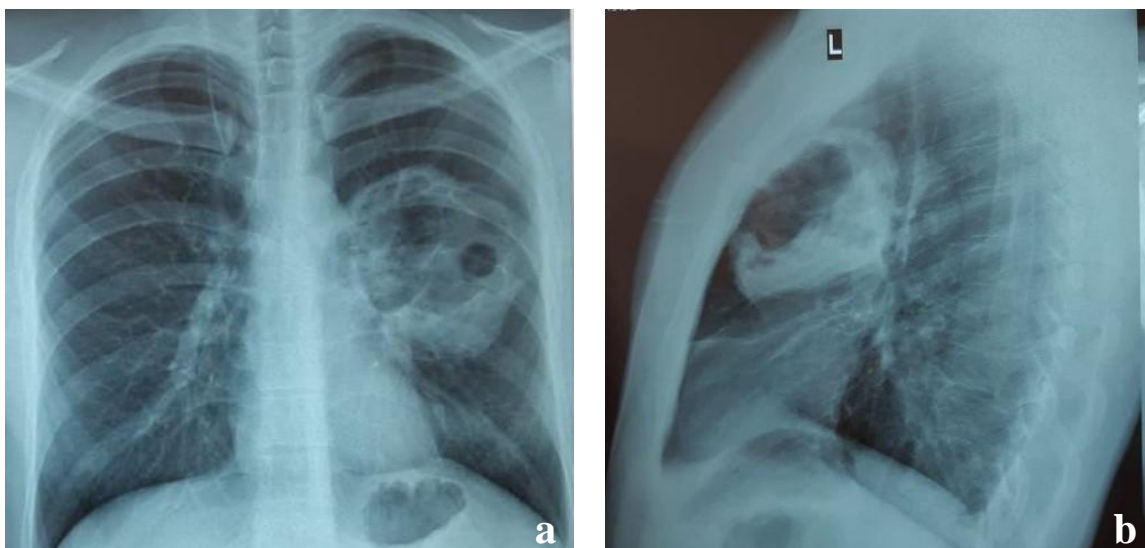


Fig 3. X-ray picture of complications of a bilateral gunshot wound to the chest on the 30<sup>th</sup> day in the form of pneumocele of the upper lobe of the left lung: a - direct projection; b - lateral projection (left side)

The treatment of this pathology was carried out according to the principles, as in the case of penetrating gunshot wounds of the chest, depending on the possibilities of the level of medical care.

Mortality at the prehospital stage after injury was associated with the presence of an injury incompatible with life (the great vessels and heart were damaged) and amounted to 14 ( $70 \pm 0.5$ ) % of cases; on admission to level II - 4 ( $20 \pm 0.2$ ) % cases (there were injuries incompatible with life, but blood loss was slower); at level III - 2 ( $10 \pm 0.2$ ) % cases (associated with severe hemorrhagic shock).

MSCT data of the chest organs, especially the direction of the wound channel, provided complete information about the extent of damage and determined the scope of surgery.

Thus, among patients with bilateral gunshot wounds to the chest, there is a high mortality rate, long-term treatment and complications in 100% of cases.

### **Discussion**

The concept of bilateral gunshot wounds to the chest is absent in the Ukrainian literature, and in the English-language literature there are sporadic data on bilateral gunshot wounds to the chest, which are analyzed based on statistical indicators of long-term hostilities in Iraq and Afghanistan [11, 13]. According to the experience of ATO/OCF, such injuries are also rare.

In bilateral chest injuries, the size of damage to the lungs and mediastinal organs plays an important role. With this pathology, lung damage is always asymmetric, which is associated with the high kinetic energy of the projectile, its uneven distribution and the direction of the wound channel. If the wounded did not die in the first hour, then the prospects for his survival are great, but complications always arise, which leads to long staged treatment. With the transportation of the wounded to each next level of medical care, the quality and possibilities of medical and diagnostic measures increase. Reducing the time of wounded person transportation to level II of medical care can reduce the number of deaths.

The approaches to the treatment of bilateral wounds are the same as for penetrating chest wounds [10, 12], however, the prognosis and the number of complications is many times higher, which requires further study and improvement of treatment methods for this pathology [7, 8]. The mortality rate in the first hours after injury is associated with massive blood loss, severe hemorrhagic shock, respiratory failure as a result of damage to the great vessels, heart, tracheobronchial tree and lungs, in most cases incompatible with life [5, 6].

### **Conclusions**

1. Placing of a bilateral gunshot wound to the chest in a separate nosological unit is etiopathogenetically justified, which is associated with typical manifestations, course and outputs.
2. The severity of bilateral chest gunshot wounds is associated with damage to the respiratory system and mediastinum.
3. Damage by one wounding projectile to the organs of the pleural cavities and mediastinum leads to severe consequences and requires further study and improvement of diagnosis and treatment of this pathology.

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