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DIAGNOSIS AND TREATMENT OF COMBAT INJURIES OF THE HEART AND GREAT VESSELS. Review

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Relevance. According to the modern realities of hostilities in the East of Ukraine, the medical community has grown a request for information about the nature of the most dangerous defeats of the participants of the Joint Forces Operation (JFO) in Donbass.

Objective: analysis and generalization of the nature of heart injuries received during the hostilities in the East of Ukraine, the stages of medical support of such wounded.

Materials and methods. Analysis of scientific publications in scientific journals of Ukraine by keywords for the period 2014-2018.

Results. The nature of injuries among participants in the JFO has been analyzed. The first place is occupied by injuries of blood vessels with bleeding (60%), 2 - pneumothorax (34%), and 3 - airway obstruction (6%). All this can be combined and supplemented by damage to the nervous system and other organs. In the conditions of the modern war in Donbass, shrapnel injuries (50.5%), bullet wounds (25.3%) and closed injury (20.3%) are considered frequent types of injuries. The classification of heart injuries, clinical symptoms, the levels of support for such a wounded are described: first aid at the prehospital stage («golden minutes») on the battlefield, qualified medical assistance («golden hour»), specialized medical care in a hospital. Post-traumatic stress disorders have been described that last from one to 6 months and require complex treatment.

Conclusion. According to NATO's new military medical doctrine, «an effective and reliable medical support system contributes to maintaining the trust of the military and the general public in the army and its political leadership.»

Key words: combat trauma, injury to the heart and blood vessels, stages of medical support, treatment of the wounded.

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MATERIALS AND METHODS

Analysis of scientific publications in scientific journals of Ukraine by keywords for the period 2014-2018.

RESULTS

Heart injury is an injury to an organ caused by mechanical forces (a blow with a blunt or sharp object, an explosive wave, building materials, a fall from a height, a car accident, and a variety of weapons during hostilities).

In peacetime, injuries to the heart and great vessels are very rare, but in wartime, their number increases significantly [6]. Such injuries are extremely life-threatening and require immediate and qualified surgical care. Among the most dangerous lesions of the participants of the Joint Forces Operation (JFO) in Donbas, blood

vessel injuries with bleeding are in the first place (60%), pneumothorax is in the second place (34%) and airway obstruction is in the third place (6%) [3]. All this can be combined and supplemented by damage to the nervous system and other organs [10].

Terminology

In the conditions of modern war in Donbass the most frequent types of injuries are considered shrapnel lesions (50.5%), bullet wounds (25.3%), and closed injuries (20.3%) [5]. Closed heart injury is damage to the heart by a traumatic object that can occur under the action of various solids on the chest (fist, stone, wood, building materials, moving vehicles, earth or asphalt when falling from a height, steering wheel in a car accident) without significant skin damage covers. Blunt trauma leads to a heart attack, regardless of whether the skin is damaged. The slightest damage to the heart in blunt trauma is manifested only by molecular changes and is defined as a *cardiac commotio*.

Severe blunt trauma to the heart can have consequences similar to an acute myocardial infarction or be accompanied by a heart rupture. Blunt heart injury accounts for 70% of all injuries to this organ [9].

At *contusion* owing to the action of a traumatic subject, there are hemorrhages in a myocardium, under

Term	Definition
Closed heart injury: <ul style="list-style-type: none"> • cardiac commotio • contusion • cardiorrhesis 	heart damage caused by a blunt object on the heart (compression, shock, fall from a height, car injury, blast wave) damage to heart structures at the molecular level accompanied by partial tears and hematomas in the myocardium penetrating damage to the outer walls of the heart, heart septa or valves
Open heart injury: <ul style="list-style-type: none"> • damaged by a bladed weapon • damaged by a firearm (gunshot wound to the heart) 	heart damage caused by bladed weapon or firearms stabbed or cut heart wound (knife, finch, bayonet, bayonet, sharpener, etc.) heart damage resulting from the action of firearms (bullet, fragment, shot)
Combined heart injury	Simultaneous damage to the heart and other organs (stomach, lungs, liver)
Polytrauma	Simultaneous traumatic injury to several body systems
Penetrating heart wound	Penetrates the heart cavity: a) blunt wound, having only an input channel, b) perforated wound, having an entrance and an exit
Nonpenetrating heart wound	Does not penetrate the heart cavity, but can injure the pericardium and myocardium

an epicardium or subendocardial. There may be ruptures of muscle fibers, bleeding from damaged coronary vessels. Hematoma can constrict the coronary artery with the development of acute myocardial infarction (up to 6%). Sometimes the intima of the coronary artery is damaged and local thrombosis occurs. Cardialgia of varying severity and arrhythmia may occur. The most severe closed heart injuries are accompanied by rupture of external or internal structures of the heart and account for up to 31% of all closed heart injuries [1]. With closed heart injuries, there is an underestimation of the severity of the lesion.

Penetrating heart injuries

When the heart is injured by a *bladed weapon* (knife, bayonet, bayonet, etc.) there is a stab or cut wound on the skin of the chest or abdomen, but the size of the external injury does not correlate with the severity of the heart itself. At heavy penetrating damages of heart and great vessels, there is bleeding into a pericardial cavity. This causes cardiac tamponade with the risk of developing acute heart failure (with a hemopericardium volume of 150-200 ml) or cardiac arrest (with a hemopericardium of 450-500 ml). In the presence of a wide source of blood from the pericardial cavity, there is a rapid massive blood loss with a clinical picture of internal bleeding and hemorrhagic shock.

A *gunshot wound* has either only an entrance or an entrance and exit hole on the outer skin. The absence of an exit hole indicates a blind injury to the body, but for the heart, it can be both blind and penetrating.

At the *combined trauma* of the heart, the lungs are most often damaged. Traumatic injury to other organs can greatly change the clinical picture of heart injury due to additional sources of bleeding, pneumothorax, increased traumatic shock. When several or all organs are damaged, *polytrauma* occurs, which is most common when falling from a height, or auto trauma, barotrauma by an explosive wave. In such cases, there

is also a risk of underestimation of damage to the heart and great vessels.

70% of battle casualty have bleeding limb blood vessels and need an immediate apply a tourniquet (*«golden minute»*). For example, when a femoral artery ruptures, uncontrolled blood loss leads to hemorrhagic shock in 25 seconds. The peculiarities of the wounds in the modern war in eastern Ukraine are that among the wounded, mine, and explosion damage by spalls predominates simultaneously in many parts of the body. Because the victim may be unconscious and in the *«under the gun zone»*, first aid can be catastrophically delayed and this leads to dangerous blood loss.

Classification of heart injuries

Heart damage is divided into injuries and closed trauma (commotio, contusion, and rupture). Heart injuries are penetrated and non penetrable, blind and through, knife and gunshot wounds, isolated and combined [3].

Bullet wound forms a wound canal, a zone of tissue necrosis, and a zone of molecular shock. A bullet (shard) can pull pieces of clothing into the wound canal. The entrance of a gunshot wound on a body sometimes happens considerably distant from a site of heart that does not promote early diagnosis.

In penetrating stab wounds to the heart, the entrance can also be distant from the projection of the heart. The cut edges of the wound fall off and adapt well, so there is almost no external bleeding.

Heart contusion is the result of a blunt object, so the external signs of injury may not correspond to the severity of heart damage and only after electrocardiographic examination can detect signs of acute myocardial infarction.

Occasionally, a blunt trauma, especially due to sudden braking of the car in a car accident, causes a rupture of the descending thoracic aorta at the site of its anatomical fixation by an arterial ligament. Damage to the main arteries and veins can accompany any heart injury.

The traumatic heart injury can include such damages:

- 1) outer walls of the heart;
- 2) septa of the heart (ventricular and atrial);
- 3) coronary vessels;
- 4) valvular apparatus of the heart;
- 5) conduction system of the heart;
- 6) great arteries and veins.

Clinical symptoms

With a heart injury, the patient's condition is severe or critical, so there is little time for examination, diagnosis, and first aid. The wounded may be conscious or unconscious. He has tachycardia, arrhythmia, and drops in blood pressure (weak pulse).

First aid

According to modern military medical doctrine, medical care is provided on a multilevel basis, which distinguishes pre-hospital and hospital stages [2,8].

The *pre-hospital stage* has a basic level, which includes first aid and pre-medical care, which in some cases is provided in the form of self- and mutual aid. This is the «golden moment» on which the life of the wounded may depend. On the battlefield, a certain sequence should be followed in the actions of fighters in the event of injuries:

- the first priority is to help the wounded,
- the second priority is to prevent new injuries,
- the third priority is to complete the combat mission.

Since the soldier may be in the area «under fire», the victim should be moved to the «zone of relative safety», which is not directly shot, and after first aid (tourniquet, bandage, hemostatic agent, analgesic, immobilization by improvised means) ensure immediate evacuation from the battlefield to a nearby battalion medical center or stabilization point for first aid by emergency specialists. This assistance may include transport immobilization with regular tires, administration of plasma substitutes, injection of an antibiotic to prevent early infection, and subcutaneous administration of tetanus toxoid (1.0 ml). The wounded with prolonged bleeding and critical blood loss are separated from others and evacuated to a military hospital first. For each victim get «Primary patient card (form 100/0)». Control and additional correction of these measures are continued during the immediate evacuation of the victim to the nearest hospital (inspection of the tourniquet and bandage, removal of foreign bodies from the upper respiratory tract, drainage of intense pneumothorax, anti-shock measures).

According to the head of the medical service of the Ministry of Defense of Ukraine Andriy Verba, in the first period of the anti-terrorist operation, there was a lack of equipment for the evacuation of the wounded and low quality individual first aid kit, which included an obsolete tourniquet, naflubin, and a bandage. The new first-aid kit (first level IFAK) includes 15 positions, among which there is a hemostatic (Cellos), a CAT or SOFT turnstile, a nasopharyngeal tube (the size of a fighter), a HALO occlusive dressing, a decompression needle to relieve

intense pneumothorax, a set of tablets (75 diclofenac mg, paracetamol 500 mg, ceftriaxone 500 mg), anti-burn hydrogel bandage, and also tactical scissors [2].

According to modern military medical doctrine, a «golden hour» is allocated, during which the wounded must be given first aid by a doctor or paramedic, and within 4-6 hours - qualified or highly specialized care. For patients with heart injuries, such care is almost always delayed.

Qualified doctor's assistance

In the conditions of hostilities in the East of Ukraine, qualified assistance in most cases is provided by the doctors of the medical company of the brigade. The severity of the patient's condition is explained by the presence of traumatic shock, acute internal bleeding, sometimes with cardiac tamponade, acute heart failure due to injury of the valve apparatus, heart rhythm disorders, as well as possible damage to neighboring organs, for example, lungs, liver, great arteries and veins, middle caliber (intercostal and internal mammary arteries). With a simultaneous injury to the lung, tense pneumothorax and severe breathing disorders can develop very quickly.

If the doctor examines the victim immediately after being wounded in the chest, then the first question to which he must answer himself - does the patient have a heart injury? To answer this question, one should be guided by Beck's triad: a wound in the projection of the heart, cardiac tamponade, internal bleeding. The clinical symptoms of this triad can be confirmed by examining the patient:

- 1) hypotension and tachycardia with a paroxysmal pulse, which becomes weak or disappears upon inhalation;
- 2) cyanosis and swelling of the cervical veins, if there is no hypovolemic syndrome (central venous pressure of about 150 mm Hg. Art.)
- 3) a large heart (percussion), weakened tones (auscultatory).

If a heart injury is suspected, it is necessary to organize careful, but rather, transportation of the victim to the nearest surgical department, and in combat conditions - to a deployed military mobile hospital, or a district (city) hospital, where reinforcement groups from among military surgeons take part in the treatment. This is the second level of qualified medical care, which should be carried out within 60 minutes after injury («golden hour»).

In the medical company of the brigade, or in local hospitals, triage and evacuation of casualties is a priority. Among them are the wounded with signs of external bleeding and the wounded with signs of internal bleeding, who are evacuated in the first place. The long-term effect of the tourniquet may result in irreversible ischemia of the limb; in such cases, it is forbidden to remove the tourniquet, even temporarily. These victims are evacuated secondarily, or a limb is amputated on the spot.

Specialized medical care

This is the third level of surgical care that is now provided in one of three frontline multidisciplinary hospitals:

- 1) Military Medical Clinical Center of the Northern Region (Kharkov).
- 2) a military hospital in Dnipro,
- 3) Regional Clinical Hospital. I.I. Mechnikov (metro station Dnipro).

In these multidisciplinary hospitals and hospitals, the wounded are allocated, in need of previous intensive care, and who are given surgical care after stabilization. The wounded, who undergo surgery on urgent grounds, are sent to the operating room. Another group consists of those wounded who can be operated on for delayed indications: pulsating hematomas, arteriovenous fistulas, amputation of dead limbs. If possible, one should strive for early restorative methods of vascular treatment (end-to-end anastomosis).

If a patient is taken to a hospital or appropriate hospital with suspected heart injury, then he should be immediately submitted to the operating room, especially if there are symptoms of internal bleeding, cardiac tamponade and tension pneumothorax.

The necessary diagnostic procedures, such as: history, examination of the patient, determination of blood group and Rh belonging, laboratory tests, ECG and echocardiography should be performed without delaying surgical intervention. In the absence of a critical condition of the patient and doubts about the diagnosis, preoperative examination may include chest x-ray, ultrasound, abbreviated blood count, and ECG.

Anamnesis. Determine the mechanism of injury and localization of wounds, the period of time that has passed after the injury, external blood loss, the presence of hemoptysis, crying of the patient.

Examination. Find out the state of consciousness (fear, agitation, stupor, coma), the general condition of the patient (satisfactory, severe, agonal), skin color (pale, cyanosis), respiratory rate and the presence of hemoptysis, pulse rate and blood pressure level, intensity of heart sounds, splash blood in the pericardium, wheezing in the lungs. Palpate to check for subcutaneous emphysema (pneumothorax), percussion tympanitis, or dullness over the lungs (hemothorax). Significant enlargement of the liver may indicate severe heart failure or cardiac tamponade.

Instrumental diagnostic methods

The best of them should be considered ultrasound, which is atraumatic and gives maximum information in the shortest time. In patients with blunt trauma to the heart, electrocardiography can be of significant value. Chest radiography is also desirable, but in the horizontal position of the patient its value decreases.

Diagnostic puncture can be performed to diagnose hemopericardium, hemothorax and pneumothorax, if it does not delay the operation. Partial aspiration of blood

from the pericardium and air from the pleural cavity may temporarily improve hemodynamics. Liquid blood should not be aspirated from the pleural cavity, as this will increase bleeding, and during surgery this blood can be used for reinfusion without the need for group and rhesus affiliation.

Bronchoscopy and laparoscopy can be performed after cessation of bleeding from the heart and main vessels, or with symptoms of asphyxia.

Thoracoscopy for heart injuries is impractical, as it takes a long time and does not provide benefits in treatment.

Laboratory tests provide important information about the amount of blood loss (hemoglobin, hematocrit, blood protein), the state of its coagulation, blood type and rhesus affiliation.

Treatment

At injuries of heart and main arteries surgical treatment according to vital indications is always shown. 60-70% of deaths among OOS fighters were due to bleeding. In cases of heart attack due to blunt trauma, the victim is transported and treated according to the principles of acute myocardial infarction. The wounded man is intubated in the heart and transferred to artificial respiration. If necessary, support hemodynamics with sympathomimetics (dopamine, dobutamine), but do not raise blood pressure above the minimum allowable, so as not to increase bleeding. If in doubt about the choice of surgical access, it is best to use a left thoracotomy in the IV-V intercostal space. If necessary, this access can be extended to the right with a cross section of the sternum (branded access). Extended transverse access allows you to control all four chambers of the heart, the main vessels, both lungs and their pleural cavities.

Reaching the pericardial sac, the surgeon opens it wide along the phrenic nerve, sucks the liquid blood into a sterile vessel with an anticoagulant for reinfusion, which is performed by an anesthesiologist. Having established the location of the heart wound, the surgeon covers it with the finger of his left hand and stops further bleeding. When this is successful, further surgical action can be not forced, but give the anesthesiologist some time to stabilize hemodynamics and respiration. The surgeon applies sutures with his right hand (preferably with an atraumatic needle) and is tied by an assistant. Next, control other sources of bleeding (intercostal and internal thoracic arteries), detect and suture lung wounds, perform a sequential audit of all available tissues, remove blood clots. The wound is washed and drainage tubes are installed in each of the open pleural cavities and in the pericardium. The surgical wound is closed in layers. Intensive care and surgical treatment of concomitant lesions, reposition of bone fragments. If necessary, resort to re-surgical treatment of the wound to eliminate complications: hematomas, purulent swellings.

Almost all gunshot wounds end in suppuration, severe pain, osteomyelitis, vascular and nerve damage.

An untreated wound with a bullet or splinter, starting at six o'clock, causes purulent complications and sepsis. All combat wounds should be drained.

Combat injuries of the heart and blood vessels can be complicated by hemorrhagic shock, disseminated intravascular coagulation syndrome, general intoxication, renal and hepatic failure, acute cardiovascular failure, generalization of the infection with the transition to sepsis, the spread of infection to the vessel.

Post-traumatic stress disorder (PTSD)

The consequence of a favorable option for the treatment of wounded and injured during hostilities may be PTSD [4]. This is a delayed and prolonged reaction to an extreme traumatic event that is threatening or catastrophic. Constant companions of PTSD – depression and anxiety. In addition, psychologists pay attention to the following manifestations:

- flash backs – obsessive re-memories of extreme events that cause difficult emotional experiences, repeated nightmares about past events;
- avoidance of thoughts, conversations, places, events and people related to the injury;
- hyperactivity with sleep disorders, irritability, outbursts of anger, difficulty concentrating, constant expectation of a threat, excessive timidity;
- violation of social and professional adaptation.

Therefore, a patient with PTSD should be referred to a psychiatrist by a family or other physician. Also pay attention to the presence of tachycardia and shortness of breath. PTSD is a serious mental condition that occurs as a result of traumatic situations (participation in hostilities, violence or death). Not only the military but also members of their families, temporarily displaced persons and those forced to remain in a zone of military conflict are vulnerable to PTSD. Symptoms of PTSD can be manifested not only in the wounded, but also in other participants in hostilities, as a result of psychological stress.

PTSD lasts from one to 6 months and requires *comprehensive treatment*. Beta-blockers provide rapid anti-anxiety and vegetative-stabilizing effect without sedative effect. It is best to use bisoprolol, which has the highest beta-1 selectivity and no adverse effects on the respiratory system, peripheral circulation. Bisoprolol is soluble in both water and fats. It can be combined with antidepressants and statins [7]. Sertraline, paroxetine and psychotherapy are also effective.

In some cases, PTSD becomes chronic over several years with periods of wavy exacerbation [7]. Such patients become isolated and professionally incompetent, in communication with relatives they are capricious and dissatisfied, but easily come into contact with other participants in similar events. For qualified treatment of PTSD patients are referred to special rehabilitation centers.

CONCLUSION

According to NATO's new military medical doctrine, «an effective and reliable medical care system helps to maintain the confidence of the military and the general public in the military and its political leadership».

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ДІАГНОСТИКА ТА ЛІКУВАННЯ БОЙОВИХ УШКОДЖЕНЬ СЕРЦЯ І МАГІСТРАЛЬНИХ СУДИН

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Актуальність. Відповідно до сучасних реалій бойових дій на Сході України, у медичній спільноті виріс запит на інформацію про характер найбільш небезпечних уражень учасників операції Об'єднаних сил (ООС) на Донбасі.

Мета: аналіз і узагальнення характеру травм серця, отриманих в умовах бойових дій на Сході України, етапів медичного супроводу таких поранених.

Матеріали та методи. Аналіз наукових публікацій в наукових фахових журналах України за ключовими словами за період 2014-2018рр.

Результати. Проаналізовано характер травм у учасників ООС. На 1 місці стоять поранення кровоносних судин з кровотечею (60%), на 2 — пневмоторакс (34%) і на 3 — порушення прохідності дихальних шляхів (6%). Все це може комбінуватись і доповнюватись ушкодженням нервової системи та інших органів. В умовах сучасної війни на Донбасі найчастішими видами травм вважають осколкові ураження (50,5%), кульові поранення (25,3%) та закриту травму (20,3%). Наведена класифікація травм серця, клінічна симптоматика, описані рівні супроводу такого пораненого: перша допомога на догоспітальному етапі («золота хвилина») на полі бою, кваліфікована допомога лікаря («золота година»), спеціалізована медична допомога в умовах лікарні. Описані посттравматичні стресові розлади, які тривають від одного до 6 місяців і потребують комплексного лікування.

Висновки. Згідно з новою військово-медичною доктриною НАТО, «ефективна і надійна система медичного забезпечення сприяє підтримці довіри військовослужбовців та широкої громадськості до армії та її політичного керівництва».

Ключові слова: бойова травма, поранення серця і судин, етапи медичного супроводу, лікування поранених.

ДИАГНОСТИКА И ЛЕЧЕНИЕ БОЕВЫХ ПОВРЕЖДЕНИЙ СЕРДЦА И МАГИСТРАЛЬНЫХ СОСУДОВ

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Актуальность. Согласно современным реалиям боевых действий на Востоке Украины, в медицинском сообществе вырос запрос на информацию о характере наиболее опасных поражений участников операции Объединенных сил (ООС) в Донбассе.

Цель: анализ и обобщение характера травм сердца, полученных в условиях боевых действий на Востоке Украины, этапов медицинского сопровождения таких раненых.

Материалы и методы. Анализ научных публикаций в научных журналах Украины по ключевым словам за период 2014-2018 гг.

Результаты. Проанализирован характер травм у участников ООС. На 1 месте стоят ранения кровеносных сосудов с кровотечением (60%), на 2 — пневмоторакс (34%) и на 3 — нарушение проходимости дыхательных путей (6%). Все это может комбинироваться и дополняться повреждением нервной системы и других органов. В условиях современной войны на Донбассе частыми видами травм считают осколочные поражения (50,5%), пулевые ранения (25,3%) и закрытую травму (20,3%). Приведена классификация травм сердца, клиническая симптоматика, описаны уровни сопровождения такого раненого: первая помощь на догоспитальном этапе («золотые минуты») на поле боя, квалифицированная помощь врача («золотой час»), специализированная медицинская помощь в условиях больницы. Описаны посттравматические стрессовые расстройства, которые длятся от одного до 6 месяцев и требуют комплексного лечения.

Вывод. Согласно новой военно-медицинской доктрине НАТО, «эффективная и надежная система медицинского обеспечения способствует поддержке доверия военнослужащих и широкой общественности к армии и ее политическому руководству».

Ключевые слова: боевая травма, ранение сердца и сосудов, этапы медицинского сопровождения, лечение раненых