REVIEW PAPER

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Diagnostic methods and surgical treatment of patients with thoracoabdominal traumas (review of the literature)

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Abstract

Thoracoabdominal traumatism is a topical problem of modern medicine due to its wide prevalence, severe course and unfavorable outcome. This article presents an overview of the epidemiology, diagnosis, and surgical treatment of patients with thoracoabdominal injuries. It showed that the current incidence of thoracoabdominal injuries reaches 13.7–16.4% of all chest and abdominal injuries. Lethality in thoracoabdominal injuries ranges from 3.13% to 20%. In most cases these are patients of working age, with an average age of 27.5–34.8 years, men comprising 71.2%. Nowadays, the number of patients with thoracoabdominal injuries tends to increase in Uzbekistan and other economically developing countries of the world because of increasing transportation, construction and crime. Video-thoracoscopy and video-laparoscopy are among the widespread methods of diagnosis and treatment of thoracoabdominal traumas. According to many authors, the specificity of video-laparoscopy and video-thoracoscopy is 100%, and the sensitivity is 87.5–99.3%.

Key words: thoracotomy, laparotomy, thoracoabdominal injuries, video-laparoscopy, video-thoracoscopy, damage control.

Introduction

Injuries of the chest and abdomen cause severe disorders of the basic vital functions of the body immediately at the time of injury and within minutes after it. The presence in the thoracoabdominal region of the human body of the main vital organs, main vessels, the specificity of the anatomical structure, the proximity of intestinal contents and enzymes in the case of damage lead to massive internal bleeding, shock, cardiorespiratory disorders and purulent-septic complications [1, 2]. Mortality in thoracoabdominal injuries varies from 3.13% to 20% [3]. The main causes of death in thoracoabdominal trauma are acute blood loss, shock, peritonitis, and respiratory distress syndrome [4]. Postoperative complications in thoracoabdominal injuries occur in 14.9–53% of patients [5]. Difficulties in the timely diagnosis of this pathology are due to the polysymptomatic nature of the clinical picture, the severity of the condition of the patients, the absence of specific symptoms of diaphragm damage, and the presence of combined injuries of the organs of the chest and abdominal cavities [4]. As in other traumas, an injury to the thoracoabdominal region requires accurate and rapid diagnosis, thoughtful and adequate surgical tactics, and the ability to predict the dynamics of the development of pathological changes that occur in the parenchymal organs and the gastrointestinal tract. Operations are complex and laborious, outcomes depend on the timing of surgical intervention, and careful management of the patient is needed in the postoperative period. Moreover, monitoring the prevalence of thoracoabdominal injury in the population with an assessment of the dynamics of risk factors, causes of development, diagnosis and approaches of surgical treatment is an urgent problem of modern medicine, which encourages us to study the epidemiological situation in relation to thoracoabdominal injuries and requires continuation of the search for optimal diagnostic measures and the choice of the correct surgical tactics at all stages of treatment.

The purpose of the study is to conduct an analysis of diagnostic methods and surgical treatment of patients with thoracoabdominal injuries and to determine the directions for improving the surgical tactics of this pathology.

Epidemiology of thoracoabdominal traumas

At the moment, the frequency of thoracoabdominal injuries is 13.7–16.4% of the total number of traumas of the chest and abdomen [6]. Mortality of patients from thoracoabdominal injuries is 4.5 times higher than from other types of traumas. With this type of injury, 52.3% of deaths occur at the scene of an accident, up to 38.8% occur in a hospital, 6% in emergency rooms, and 2.5% during transportation of patients [2]. Thoracoabdominal injury, depending on the mechanism of injuries, is divided into

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open and closed. Open injuries are represented mainly by stab and gunshot wounds. According to Gao *et al*. [7], the frequency of open injuries of the chest and abdomen in the structure of peacetime injuries has increased by 2.5–3 times over the past 10 years. Men represented 61.5–92.6% of cases of thoracoabdominal injury among all the patients [8]. In most cases, these are patients of working age, on average 27.5–34.8 years. The main causes of thoracoabdominal injury are traumatic impacts: motor vehicle accidents, penetrating wounds from a sharp object, gunshot wounds, sports injuries, falls from a height and accidents at work [9]. According to the information published by the World Health Organization (WHO) in 2020, about 29% of thoracoabdominal injuries were caused by road traffic accidents, 12.6% by falls and 9.16% by individual crashes in 2019 [10]. These data may differ depending on the country and region [11]. In addition, road traffic accidents are more common among men. High mortality (from 11% to 77.6%) in the first hours after the injury is due to both the severity of injuries and often errors in the provision of care at the prehospital stage, in diagnosis and surgical tactics in a hospital setting [12]. While penetrating situations such as traffic accidents, violence and self-harm are the main causes of injury in people between the ages of 25 and 35, this declines after age 45, and blunt injury mechanisms such as domestic accidents and falling predominate, especially after 45 years [5]. In recent years, the number of patients with thoracoabdominal trauma has tended to increase in the Republic of Uzbekistan and other economically developing countries of the world.

Characteristics of clinical pictures of thoracoabdominal traumas

It is possible to distinguish three types of symptom complexes in thoracoabdominal traumas: 1) injuries with a predominance of symptoms of damage to the organs of the chest cavity, 2) injuries with a predominance of symptoms of damage to the organs of the abdominal cavity, 3) injuries with evenly expressed symptoms of damage to the organs of the chest and abdominal cavities [3]. The percentage of patients with a predominance of symptoms of damage to the chest organs in thoracoabdominal wounds ranges from 25% to 32%. They usually develop syndromes of acute cardiovascular and/or acute respiratory failure associated with intrapleural bleeding, cardiac tamponade, pulmonary collapse and contusion, and upper airway obstruction. Most often, the lungs are damaged (up to 80% of cases), in 10–15% the pericardium, heart, and large vessels, in 5% the trachea and/or esophagus [13]. With such injuries, open or intense pneumothorax, hemothorax, contusion of the lung and/or heart, injury and cardiac tamponade, subcutaneous and mediastinal emphysema, and violations of bronchial patency may occur. The general condition of patients is severe, and many have signs of II–III degree shock. The second group is characterized by trauma in the abdominal organs; according to various authors, the percentage of them ranges from 35% to 62% [14]. In the clinical picture, the classic signs of injury to parenchymal or hollow organs, blood loss and shock come to the fore. The absolute local clinical signs of a penetrating wound of the abdomen are the loss of a strand of the greater omentum or intestinal loop from the wound, as well as the release of small intestine, feces, bile or urine [15]. Damage of the internal organs of the abdomen, the syndrome of intra-abdominal bleeding (hemorrhagic) and the syndrome of perforation of a hollow organ (peritoneal) develop and prevail already at the prehospital stage. In addition, if the pancreas is damaged, a pancreatogenic syndrome can gradually develop, associated with general (endotoxemia) and local (including enzymatic peritonitis, retroperitoneal phlegmon) manifestations of traumatic pancreatitis [2]. The third group occurs in 20–40% of patients with thoracoabdominal traumas, characterized by the same severity of symptoms in the chest and abdominal cavities [16]. Patients usually present in a serious or extremely serious condition with severe respiratory and cardiovascular disorders against the background of signs of massive blood loss, peritonitis and shock. Clinical manifestations, especially when the abdominal organs move into the pleural cavity, are quite pronounced, and therefore diagnosis, as a rule, does not cause any particular difficulties. An example of a thoracoabdominal injury without damage of internal organs is a pleural sinus injury with a penetrating wound to the diaphragm. The clinical picture that occurs when the diaphragm itself is damaged develops with relatively rare isolated wounds. However, in these cases, the symptoms of diaphragm damage in some patients may be completely absent, and the wound of the diaphragm remains, as a rule, unrecognized [4]. Pain in the area of the xiphoid process is considered a characteristic sign of a diaphragm injury. At the same time, pain in the abdomen, tension in the abdominal muscles, and a positive Blumberg sign do not always indicate damage to the diaphragm in thoracic injury, since they can often occur in a reflex way. The same applies to the phrenicus sign and hiccups, since they can manifest themselves when the diaphragmatic pleura is irritated by outflowing blood [7, 11].

Special and non-specialized diagnostic methods

Laboratory methods

In thoracoabdominal injuries, laboratory methods are used primarily to assess the amount of total blood loss, the state of the coagulation, anticoagulation and fibrinolytic systems, proteins, electrolytes, gas composition and acid-base state of the blood, liver and kidney function, the severity of endotoxemia, the general resistance of the body (immunogram) and microbial contamination of wounds and cavities (bacteriological diagnostics). Physical and laboratory methods of examination do not always allow one to accurately establish the diagnosis and determine the nature of the injuries received.

Instrumental methods

Emergency radiation diagnostics may include traditional ultrasound examination, X-ray examination (fluoroscopy, radiography, etc.), X-ray computed tomography, magnetic

resonance imaging, angiography, and radionuclide studies. Each of the methods has its own advantages and disadvantages, the consideration of which determines the possibility and necessity of their use. The task of urgent radiological examination in thoracoabdominal wounds is early recognition and determination of the nature of all injuries, without which it is impossible to provide adequate therapeutic measures.

Ultrasonography

Emergency ultrasound is the basic method in deciding the order of surgical intervention on the organs of the chest and abdomen in the combined variant of their injury [3]. At the same time, even small (50 ml) accumulations of free fluid (blood) are visualized in typical places – the hepatic-renal fossa, near the liver and gallbladder, between the loops of the intestines, in the lateral canals of the abdomen, or in the small pelvis. In addition, the ultrasonic method of investigation makes it possible to reliably detect injuries of parenchymal organs [2]. This method of research makes it possible to obtain certain information about the morphological changes in the internal organs and determine the amount of fluid in the free abdominal cavity. It is a non-invasive and fast diagnostic method. The main object of the pathology detected by ultrasound is the blood that has poured into the abdominal cavity in the zones ("acoustic windows") adjacent to the internal organs with a relatively dense surface (kidneys, spleen, filled bladder). Separation of the parietal and visceral layers of the peritoneum in sloping areas of the abdomen is a sign of the presence of free fluid in the abdominal cavity [13]. The use of ultrasound makes it possible to monitor the state of these parenchymal organs in dynamics and set indications for surgical treatment in time with an increase in the size of an intra-organ hematoma with the threat of a breakthrough. Also, the Doppler method makes it possible to establish the presence or absence of blood flow in these formations, which is crucial for determining surgical tactics [2]. Plain X-ray is sufficient to detect gas in the abdominal cavity. Free gas in the abdominal cavity is located in the highest located compartments [6]. When examining the victim in a vertical position, free gas is determined under the diaphragm. Free fluid (blood) in the abdomen can also be seen on plain radiographs.

Computed tomography

This method makes it possible to detect pathological contents in the pleural cavity with a high degree of reliability, measure the density of the detected pathological formations and evaluate its nature, and detect fragmentation of the blood clotting [7]. In this regard, computed tomography is a mandatory and most accurate method for diagnosing clotted hemothorax and late complications of chest trauma, such as fragmented pleurisy and pleural empyema, traumatic pulmonitis, intrapulmonary hematomas, pulmonary atelectasis, and post-traumatic pneumonia. Magnetic resonance imaging in the identification of damage to the parenchymal organs of the abdomen and lungs has no advantages over X-ray computed tomography, and in the presence of metallic foreign bodies in the body it is generally contraindicated.

Video-thoracoscopy and video-laparoscopy

Widespread use of video-thoracoscopy and video-laparoscopy in the hospital allows almost complete elimination of diagnostic errors. The specificity of video-laparoscopy and video-thoracoscopy is 100%, the sensitivity is 87.5–99.3%, and the predictive efficiency is 96.8% [13]. Thoracoscopy can reveal damage to the organs of the chest cavity even in the absence of obvious clinical and radiological symptoms, especially if the wound of the chest wall is located in the anatomically dangerous "cardiac" and "thoracoabdominal" zones. During the examination, even in the absence of hemothorax and pneumothorax, a pericardial wound or hemopericardium can be detected [2, 17]. On the basis of literature data and our own clinical experience, we found that the most optimal indications for video-thoracoscopy in chest injuries and thoracoabdominal injuries, including those accompanied by shock, are: medium and large hemothorax, ongoing intrapleural bleeding with drainage from the pleural cavity of blood in an amount of less than 500 ml/hour, penetrating wounds of the chest in the projection of the heart and large vessels (in the "cardiac" zone), in the absence of convincing signs of cardiac tamponade and intense mediastinal hematoma, penetrating wounds of the chest in the "thoracoabdominal" zone, growing and intense emphysema of the mediastinum, intractable tension pneumothorax, persistent, not stopped within 3 days after injury and recurrent pneumothorax, clotted hemothorax, foreign bodies in the pleural cavity, lung and mediastinum. For six indications, thoracoscopy is performed on an emergency basis, and for the rest, it is performed urgently (during the first day after the injury) and delayed (scheduled) order [14]. Results of surgical treatment: to reduce mortality by 4.7%, the number of complications by 2.9 times and completely avoid unjustified "diagnostic" thoracotomies. Emergency video-laparoscopy is carried out according to the generally accepted method for the timely diagnosis of the nature of the injury of the abdominal organs in patients with thoracoabdominal injuries. Indications for emergency laparoscopy are: 1) the absence of reliable signs of damage to the organs of the abdominal cavity; 2) indirect signs of damage to the diaphragm; 3) the presence of a penetrating wound of the chest in the "zone of thoracoabdominal wounds" [2, 6]. According Koganti the role of minimally invasive surgery in trauma, in particularly diagnostic laparoscopy, has become increasingly essential and utilized for both blunt and penetrating injuries. Diagnostic laparoscopy can avoid potential negative or non-therapeutic laparotomies [18]. In the case of thoracoabdominal injuries or their suspicion, video-laparoscopy is performed only after video-thoracoscopy, suturing of the diaphragm wound and adequate drainage of the pleural cavities. If these conditions are not met, "laparoscopy in

case of rupture or injury of the diaphragm is accompanied by the development of tension pneumothorax in 100% of the patients. Possible complications of this are a decrease in saturation, mixing of the mediastinum with a turn of the heart around its axis, heart rhythm disturbance, up to ventricular fibrillation and asystole. Preliminary drainage of the pleural cavity and temporary obturation of the diaphragm wound with a strand of omentum during laparoscopy saves the patient from the development of these complications" [15]. The patients undergoing video assisted thoracoscopic surgery for retained hemothorax have significant morbidity and prolonged length of stay. In fact, the optimal time to videothoracoscopy was identified as 3.9 days and was the only modifiable risk factor associated with decreased pulmonary morbidity [19].

Surgical tactics in thoracoabdominal traumas

Currently, the vast majority of surgeons believe that endovideosurgical methods occupy an important place in the diagnosis and treatment of this pathology. Based on the analysis of literature data, indications and contraindications for video-thoracoscopy and video-laparoscopy in thoracoabdominal injuries, data indicating their high diagnostic significance and the need for widespread use for performing minimally invasive medical manipulations as a reasonable alternative to open operations, indications for emergency and urgent thoracotomy and laparotomy, some new methods of operative surgical technique are proposed. Surgical tactics in thoracoabdominal injuries, based on the results of a multifactorial assessment of the severity and outcomes of traumatic shock, make it possible to identify patients who are indicated not only for resuscitation, but also for corrective operations [20]. This contributes to the early activation of the patients and reduces the frequency of various complications. The survival rate of patients with polytrauma has increased in the last decade due to the development of a system of emergency specialized medical care. This was influenced by the creation in the 1980s in the United States, and then in Western Europe, of the "damage control" system, which received comprehensive approval at the 37th World Congress of Surgeons in 1997. "Damage control" involves programmed multi-stage surgical treatment of patients admitted to the hospital in critical condition, in whom the use of traditional approaches is invariably associated with an unfavorable outcome [21].

Scales used in traumas

To date, many systems have been developed to assess the severity of injury according to various criteria. The following scales were built according to the anatomical principle: Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), New Injury Severity Score (NISS), Polytrauma Score (Hannover) (PTS), Organ Injury Scale (OIS), International Classification Injury Severity Score (ICISS), VPH-P (MT), VPH-P (OR), VPH-P (R); according to functional – a) sorting: Trauma Score (TS), Revised Trauma Score (RTS), Glasgow Coma Scale (GCS), VPH-Sort; b) dynamic evaluation: Evaluation (Apache II, Apache III), SOFA, VPH-SP, VPH-SG, VPH-SS; and combined – Trauma and Injury Severity Score (TRISS), TRISSAN, A Severity Characterization Trauma (ASCOT), MODS. The implementation of the modern doctrine of treatment of thoracoabdominal injuries is complemented by the tactics of programmed multi-stage surgical treatment.

Damage control in thoracoabdominal traumas

Bleeding is the main cause of death. The management of the severely injured trauma patient in the emergency department requires a multidisciplinary team that performs damage control maneuvers aimed at rapidly controlling bleeding, hemostatic resuscitation, and/or prompt transfer to the operating room, if required [22]. Therapeutic tactics for "damage control" are divided into three phases [7]. According to their ideas, the first stage includes an emergency, as soon as possible, surgical intervention in order to stop ongoing bleeding and prevent contamination of the abdominal cavity with microbial agents, using packing of the abdominal cavity and its subsequent temporary closure without tension in order to prevent the development of intra-abdominal hypertension syndrome (abdominal compartment syndrome). The second stage of the Damage Control concept includes complex intensive anti-shock therapy in the conditions of the intensive care unit, which consists in correcting water and electrolyte disorders, hypoxia, hypothermia, hemocoagulation disorders, etc. The third stage, the beginning of which corresponds to the period of 24–36 hours after the injury, implies exhaustive surgical aid consisting, as a rule, of removing hemostatic tampons, performing reconstructive and restorative interventions in the required volume and subsequent suturing of the abdominal wall.

Dilemma: laparotomy or thoracotomy

The volume and type of surgical intervention for injuries of the thoracoabdominal region depend on the severity of the injury, organ damage and blood loss. The sequence of intervention is dictated by the nature of the existing injuries. If profuse bleeding into the pleural cavity is expected, then thoracotomy is performed first. In the case of profuse bleeding into the abdominal cavity, the intervention begins with laparotomy. It is preferable to perform separate thoracotomy and laparotomy as the least traumatic [7]. According to Zhestkov *et al.* [6], absolute indications for thoracotomy should be considered reliable signs of damage to the heart and main vessels: large and total hemothorax, hemopericardium and cardiac tamponade, hemomediastinum with compression of the airways and main blood vessels. With reliable clinical and radiological signs of rupture of the trachea and large bronchi, an emergency thoracotomy is also necessary. Clinical experience shows that laparotomy is indicated for all patients with a predominance of symptoms of abdominal injury, as well as a significant proportion of patients with severe symptoms of injuries in both cavities. In typical cases, laparotomy involves the

removal of pathological exudate from the abdominal cavity, identification of the source of bleeding and peritonitis, stopping intra-abdominal bleeding, suturing wounds of hollow and parenchymal organs, draining the small intestine (according to indications), sanitizing the abdominal cavity and taking measures to ensure its prolonged perfusion in the postoperative period [5]. Quite often, during thoracotomy for diaphragmatic rupture, the need for revision of the abdominal organs is revealed due to various findings that were not diagnosed before the operation. Altyev *et al.* [1] offer a differentiated approach to choosing the type of operation in the presence of hemoperitoneum: with hemoperitoneum of more than 400 ml and multiple thoracoabdominal injuries, they recommend performing laparotomy, and in patients with single thoracoabdominal injuries, with hemoperitoneum of less than 400 ml, they recommend performing laparoscopy. Kukushkin *et al.* [13] believe that in thoracoscopic visualization of a diaphragm injury and sonographic signs of fluid in the abdominal cavity, the criterion for choosing between laparoscopy and laparotomy is the stability of hemodynamics. With stable hemodynamics, laparoscopy should be performed, and with unstable, laparotomy. Wang considered that laparoscopic surgery can be a practical alternative to laparotomy for appropriate patients. Decisions to perform laparoscopy should be based on the experiences of the surgeon and the resources available [23]. Kones *et al.* [4] identified two indications for the choice of laparotomy for thoracoabdominal injuries – hemodynamic instability and peritonitis. In other cases, the authors recommend laparoscopy. Kukushkin [13] makes the choice of intra-abdominal intervention based on the data of diagnostic laparocentesis, which he performed in 98 patients with thoracoabdominal injury. In 86 (87.8%) cases, he found an admixture of blood or the contents of the hollow organs of the abdominal cavity. He considered the discovery of the contents of hollow organs as an indication for laparotomy, and the detection of blood impurities as an indication for laparoscopy. According to Mukhin *et al*. [3], criteria for the conversion of laparoscopy to laparotomy are hemoperitoneum more than 500 ml, and ongoing bleeding with an unvisualized source. Kukushkin [13] considers damage to the hollow organs of the abdominal cavity as an indication for conversion. At the same time, a number of researchers seek to suture wounds of hollow organs during laparoscopy. In rare cases, researchers report the use of thoracophrenolaparotomy for injuries in the area of the caval gate of the liver in patients with thoracoabdominal injury. However, other authors consider laparotomy and thoracotomy less traumatic for such injuries [20]. Most authors use the combination of thoracotomy and laparotomy occasionally, in specific clinical situations. For example, in cases of heavy bleeding in both anatomical cavities, investigators perform simultaneous thoracotomy and laparotomy with two surgical teams. If there is only one team, Ermolov *et al*. [2] recommends starting surgical treatment with thoracotomy.

Using angiography in thoracoabdominal traumas

Angiography began to be used for injuries and wounds long before the appearance of the term and specialty "X-ray endovascular surgery". Until now, in some areas, angiography remains the gold standard for diagnosing vascular lesions. In the case of damage to the chest and abdomen, as a rule, a femoral puncture access is performed for angiography. The transition from diagnostic angiography directly to therapeutic intervention according to indications is optimal. Increasingly, CT angiography is performed for the purpose of diagnosis, and if damage is detected, therapeutic endovascular intervention is immediately performed [11, 12]. Despite this, often the quality of the obtained tomogram does not allow one to make a tactical decision, which requires angiography. Often, the extremely serious condition of the victim does not allow the patient to be transported to the CT department. In this case, angiography performed on the C-arm in the anti-shock operating room may be useful.

Conclusions

Thus, the above indicates that the improvements of surgical approaches to patients with thoracoabdominal traumas are not yet completed. Researchers continue to search for optimal combinations of classical and minimally invasive operations in relation to a variety of clinical situations that arise during the treatment of patients with thoracoabdominal traumas.

Disclosure

The authors report no conflict of interest.

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