

Experimental Study of Action Different Kinetic Energy on the Colon

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Abstract. *The purpose of the study.* To increase the effectiveness of surgical care for the wounded with combat trauma of the colon by studying of ballistic, morphological and functional features of the gunshot wounds. *Patients and methods.* A study of surgical treatment of 83 wounded with combat injuries of the colon, received in the area of anti-terrorist operation in the period from 2014–2018. For comparative analysis of treatment results, two clinical groups were formed: comparison and main. The comparison group included 42 wounded who were treated from April 2014 to February 2015 (the first and second periods of ATO), who used traditional surgical tactics. The main group included 41 wounded who were treated from March 2015 to 2018. *Results.* Analysis of the distribution of wounded with combat trauma by type of wound / injury revealed that the vast majority of them in both groups had shrapnel wounds – 49 (59.1%). There were 30 (36.1%) victims with bullet wounds, and 4 (4.8%) with closed injuries. The wounded patients with the battle trauma of the thick bowel by type of injury had missile wounds as a rule – 49 (59.1%). There were 30 (36.1%) patients with bullet wounds, and 4 (4.8%) with closed injuries. Most of the injuries were combined – 58 (69.9%), and with only abdominal injuries – 25 (30.1%), mostly multiple – 21 (25.3%). The great majority of the thick bowel injuries belonged to sigmoid – 32 (38.6%) and transverse colon – 21 (25.3%), which is explained by relatively large size of these parts of the intestine. *Conclusions.* The choice of surgical tactics and scope of surgical interventions on damaged organs and structures took into account the results of experimental study of mechanogenesis and pathomorphology of gunshot wounds of the colon, obtained in bench studies by modeling gunshot wounds on “thoracoabdominal ballistic material”.

Key words: battle trauma, colon gunshot wounds, kinetic energy.

Introduction

Combat surgical trauma is the most pressing problem of military field surgery. The number of wounded as a result of hostilities is 29–31 thousand and killed 13–13.2 thousand people in Ukraine [1]. The proportion of combat abdominal trauma in the structure of sanitary losses of the surgical profile is relatively small and ranged from 4.0 to 7.3% [2, 3], but it is one of the most severe combat injuries. According to the antiterrorist

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operation, colon injuries occur in 19–21% of wounded with penetrating abdominal trauma, and the number of postoperative complications reaches 65%, and mortality is 12–31% [4, 5].

Surgical treatment of colon injuries is a difficult issue in providing surgical care to the wounded. At the same time, the classical methods of colorectal surgery must be adapted to the morphological and functional features of gunshot wounds, taking into account their multiple and combined nature and the organization of surgical care in war.

Ballistic, morphological and functional factors are problematic issues of surgical treatment of gunshot wounds of the colon. Gunshot wounds can be caused by low or high energy bullets and fragments of explosive devices, which cause a temporary pulsating cavity.

The purpose of the study

To increase the effectiveness of surgical care for the wounded with combat trauma of the colon by studying of ballistic, morphological and functional features of the gunshot wounds.

Materials and methods of research

A study of surgical treatment of 83 wounded with combat injuries of the colon, received in the area of anti-terrorist operation in the period from 2014–2018. For comparative analysis of treatment results, two clinical groups were formed: comparison and main. The comparison group included 42 wounded who were treated from April 2014 to February 2015 (the first and second periods of ATO), who used traditional surgical tactics. The main group included 41 wounded who were treated from March 2015 to 2018, in which surgical treatment was differentiated and based on the application of a selective approach to the choice of surgical paraoperative tactics namely: determining the sequence and scope of execution surgery on various parts of the body according to the FAST protocol, assessment of the severity of the wounded according to the perfusion index (PI), the use of damage control surgery (DCS) in the wounded with extremely severe trauma. At the III–IV levels of medical care, a differential approach was used to perform operations of the third phase of DCS tactics, “second look” and treatment of postoperative complications.

Research results and their discussion

Analysis of the distribution of wounded with combat trauma by type of wound / injury revealed that the vast majority of them in both groups had shrapnel wounds – 49 (59.1%). There were 30 (36.1%) victims with bullet wounds, and 4 (4.8%) with closed injuries.

The wounded patients with the battle trauma of the thick bowel by type of injury had missile wounds as a rule – 49 (59.1%). There were 30 (36.1%) patients with bullet wounds, and 4 (4.8%) with closed injuries. Most of the injuries were combined – 58 (69.9%), and with only abdominal injuries – 25 (30.1%), mostly multiple – 21 (25.3%). The great majority of the thick bowel injuries belonged to sigmoid – 32 (38.6%) and transverse colon – 21 (25.3%), which is explained by relatively large size of these parts of the intestine.

The results of experimental study of the pathomorphology of gunshot wounds of the thick bowel during simulation of gunshot wound on the “Thoracoabdominal Ballistic Simulator” were taken into account during the choice of surgical approach and the extent of surgical interventions. The experiment evaluated the macro- and microscopic consequences of damage when using firearms of different kinetic energy.

We have developed practical recommendations for surgical tactics, features of intraoperative revision, surgical manipulations and postoperative monitoring of the clinical course of the wound process (Table 1).

Recommendations for surgical treatment of gunshot wounds to the colon with shells with different ballistic characteristics.

Table 1. Recommendations for surgical tactics, features of intraoperative revision, surgical manipulations and postoperative monitoring of the clinical course of the wound process

Projectile / recommendation	High-speed high-caliber stable in flight	High-speed small-caliber unstable in flight	Low speed
Risk of remote contusion injuries	high	high	low
Mechanical ability of sutures of wound edges	up to 24 hours	up to 24 hours	up to 72 hours
Biological capacity of sutures of wound edges	is absent	is absent	possible
Deviation from the edge of the lesion during resection	up to 20 cm in both directions	up to 15 cm in both directions	up to 5 cm in both directions
Imposition of the primary anastomosis	high risk of insolvency, requires SL	moderate risk of insolvency, requires SL	low insolvency, SL not required
The need for SL to control contusion foci	+	+/-	-

As a result of the clinical and organizational measures, the number of patients with postoperative abdominal complications in the main group – 19 (48.7%) decreased as compared to the comparison group – 28 (75.7%) – ($p = 0.0156$), which we associated with repeated exploration, additional surgical manipulations aimed at improving the surgical outcome during the second operation with DCS and second look management.

Lethality rate in the study group was 11 (26.2%) cases in the comparison group and 4 (9.8%) in the main group ($p < 0.049$; Fisher's exact test).

Conclusions

The choice of surgical tactics and scope of surgical interventions on damaged organs and structures took into account the results of experimental study of mechanogenesis and pathomorphology of gunshot wounds of the colon, obtained in bench studies by modeling gunshot wounds on “thoracoabdominal ballistic material”. The experiment evaluated the macro- and microscopic consequences of damage when using firearms with different kinetic energy. Wounds of the colon reached a diameter of 25–30 mm and at the same distance from the edge of the wound on the intestinal wall spread areas of exfoliation of the mucous membrane, and the color change spread to 100 mm from the edge of the wound, which can endanger acute trophic disorders in the intestinal wall.

When the hollow organs were wounded by the projectile with high kinetic energy, the edges of the wound at a great distance (up to 20 cm) were devitalized or at the state of traumatic parabiosis. As the final method of surgical treatment in this case, extensive resection of the damaged segment of the intestine with the application of a primary anastomosis or stoma exteriorization is shown. The risk of failure of the anastomosis remains high, which necessitates exploration operations such as second look (SL).

When the hollow organs are damaged by projectiles with low kinetic energy – the areas of primary traumatic necrosis and contusion of the organ wall are small, which allows to apply the primary suture to the wound after excision of its edges or to perform a limited resection of the intestinal segment. The risk of suture failure and remote contusion necrosis is small.

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