

# Traumatic Injuries of the Spleen, New Methods of Diagnosis and Treatment

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**Abstract** This review of domestic and foreign presents statistical data on spleen injuries, briefly describes the evolution of the development of surgery of spleen injuries. The main part of the review is devoted to the results of traditional and minimally invasive surgical interventions for spleen injuries, various methods of intraoperative hemostasis. Analyzing the literature data and debatable views to solve this problem, the authors point out that the use of minimally invasive interventions give better clinical results.

**Keywords** Spleen injury, Diagnosis, Choice of treatment tactics, Surgical operations, Hemostasis

## 1. Introduction

Traumatic injuries of the spleen account for 10-50% of all abdominal injuries, with damage to internal organs – 1,5-5%. The occurrence of traumatic injuries of the spleen is associated with the anatomical structure of this organ and the existing features: low mobility, the presence of a thin capsule, fullness of the organ, while traumatic injuries of parenchymal organs occupy the second place in the composition of injuries of the abdominal cavity, the spleen - the third, of which about 2% of observations are intraoperative, in which mortality is 5-27%, the severity of the condition in the event of injuries is determined by the multiplicity of lesions and the presence of combined damage to parenchymal organs, the volume and intensity of blood loss.

According to the mechanism of damage to the spleen, closed abdominal injuries are most common – 85%, slightly less injuries – 15%, isolated injuries – 15-40% [13,16,20,32, 54,59].

Traumatic injuries of the spleen in most cases occur among people of working age, more often in men – up to 70%, which determines the relevance and need to improve existing methods of diagnosis and treatment that contribute to the preservation of patients' lives and ensure its decent quality [12,41]. According to forecasts, spleen injuries tend to increase, mortality remains at the level of 6-7%, this determines the urgency of the problem and the search for ways to solve it optimally.

Treatment of spleen injuries is mainly surgical – splenectomy, organ-preserving methods of surgical intervention, conservative is also used, which consists in monitoring the patient in dynamics, possibly with embolization of the splenic artery

[1]. The choice of treatment methods for spleen injuries depends on the degree of its damage, while conservative therapy can be carried out mainly at the initial stages (I and II degrees). To date, the issues of surgical or conservative management of patients as a result of traumatic lesions of the spleen remain open. Splenectomy remains one of the interventions that are the simplest and most reliable way to achieve hemostasis in ruptures and hematomas.

With the development of video laparoscopic technology, interventions using video endosurgery have been widely introduced. For the first time, this type of intervention was performed in 1991 by V.Delaitre and V. Maignien [25,26].

## 2. The Spleen and Its Physiological Functions

The spleen is an organ of the immune system that plays an important role in its regulation. Anatomically, it consists of 3-7 segments with their own (segmental) blood supply separated by non-vascular planes. Morphological structure: the spleen is represented by red and white pulp, reticuloendothelial and connective tissue, white – in its composition contains 25% of all lymphocytes, while the lymphoid tissue includes more than 70% of B-lymphocytes and 25-40% of T-lymphocytes [2,7,23], which explains its role in providing immune protection.

Normally, the size of the spleen is – 12x7x3cm, weight 150-250gr, topographically localized in the left hypochondrium, behind the IX, X, XI – ribs. Main functions: filtration, immunological control, deposition and hematopoiesis of stem cells, in one minute it passes 150-200 ml of blood, accounting for 5% of cardiac output [36,50].

The splenic artery originates from the ventral trunk, followed by the division of branches into upper (large) and lower (smaller) with their further division into segmental

arteries that provide blood supply to the parenchyma of the spleen. This should be taken into account, since understanding segmental blood supply plays an important role in solving the issue in order to perform organ preservation, ruptures parallel to segmental vessels cause minimal blood loss, and perpendicular ones cause significant bleeding.

The filtration capacity of the spleen is also due to the anatomical features of its blood supply system, since arterioles are opened by capillaries in the tissue of the red pulp, in which the processes of immunological recognition and phagocytosis, pathological inclusions and cells that have completed their life cycle occur with the help of macrophages.

The spleen, being an organ of the reticuloendothelial system, participates in stimulating the activity of neutrophils, macrophages, enhancing the processes of hematopoiesis in the bone marrow, has antitumor activity. The presence of a large number of cells producing antibodies, the spleen is responsible for the synthesis of immunoglobulins, while most of the lymphocytes are localized in the lymphatic follicles, which are located together with the arteries and arterioles. The follicles have a periarterial zone in structure, the center of reproduction of antibody-forming cells (B- lymphoblasts, plasmocytes), the mantle zone - immunocompetent cells are located in it; the marginal zone is the transition and the border between the white and red pulp.

The features of the structure and blood supply of the spleen must be taken into account during surgical interventions, since the complexity of the vascular structure causes difficulties in hemostasis, limiting the radicality of the interventions, since in addition to the central blood supply, the spleen has developed a system of collaterals penetrating into the thickness of the organ, which require mandatory alloying of the splenic artery. At rest, the spleen can contain up to 500 ml of blood, which is not included in the general circulation system. This function (blood depot) is associated with the ability to contract the organ, which leads to an increase in the number of shaped elements of peripheral blood [34,42,61], since the spleen forms a splenic platelet pool, 30-40% of platelets are localized in it. Hematopoiesis processes in the spleen are minimal and begin at 4 months of intrauterine development.

As the literature sources show, of all the reticuloendothelial tissues, only the splenic one has the ability to phagocytic clearance of antigenic particles [37].

As can be seen from the above, the spleen is one of the organs of the immune system, consisting of immune-competent cells with a complex morphological, histological and anatomical structure that ensures the performance and regulation of important and necessary functions of the body. The presence of these facts shows the need for a certain approach to the choice of surgical intervention, as well as its implementation, proving the need for maximum preservation of this organ.

The implementation of organ-preserving methods of treatment requires the best way to assess the severity of damage to the spleen. A significant breakthrough in this

direction was the development of a classification system for spleen injuries, which was carried out in 1989 by representatives of the American Association of Traumatological Surgery (AAST). The improvement of surgical approaches contributed to subsequent revisions of this system, in which it was recommended to increase the first degree of injury to the third in the presence of an additional internal organ injury in the patient, grade I-II spleen injuries are considered low, and IV-V high. Another version of the classification is proposed by Marmery, for the characterization of spleen injuries with the presence of vascular anomalies, which are visualized using computed tomography. According to this classification system, bleeding is differentiated into: intraparenchymatous and subcapsular, with the presence of pseudoaneurysm or arteriovenous fistula, the presence of active intraperitoneal bleeding. Knowledge of the degree of damage makes it possible to improve the selection of patients who need angioembolization or other type of intervention.

Taking into account the functional peculiarity and importance of the spleen as an organ, in recent decades the issue of organ-preserving treatment of spleen injuries, especially among children, has become acute. First of all, this is due to the presence of immunological function and the development of a high risk of functional disorders of this system during splenectomy. Spleen injuries, unlike liver injuries, can contribute to the occurrence of a fatal outcome as a result of delayed emergency care, as well as rupture of subcapsular hematoma or pseudoaneurysm, another risk factor is the development of various infectious processes as a result of the lack of immunological function of the spleen. The numerous causal factors that are not in favor of splenectomy dictate the need and standardization of recommendations with the development of an algorithm for diagnostic approaches and the choice of treatment methods.

### 3. Diagnosis of Spleen Injuries

Clinical manifestations in spleen injuries are associated with the degree of rupture and are characterized by signs of intraperitoneal bleeding. Pain syndrome may manifest immediately after injury, but it may also be delayed, due to the appearance of signs of shock. The main symptoms are - the presence of pain on the left in the hypochondrium with a spread to the lumbar region. With severe pain, the patient can take a forced position – lying on his left side with his legs drawn to his stomach, while attention is drawn to the impossibility of taking a position - lying on his back with a return to the forced position. This symptom was first described by B.S. Rozanov [6], upon careful examination of the patient, it is possible to detect soreness in the left shoulder, which is a pathognomonic sign in spleen injuries, which is caused by damage to nerve endings – a symptom of Kher, the pain increases when the patient is brought into a horizontal position [4]. It should be borne in mind that, in case of violation or absence of consciousness of the patient, combined injuries with a significant area of damage, the clinical picture may be erased and veiled, in this regard, in

case of traumatic lesions of the abdominal cavity, it is necessary to carry out instrumental methods of examination with subsequent observation in dynamics.

Laboratory diagnostic methods – a general blood test is significant, while it is necessary to pay attention to a decrease in the number of red blood cells, hemoglobin, hematocrit, which are associated with massive blood loss; with the development of inflammatory processes, pronounced leukocytosis is noted on the hemogram. It should be noted that all changes in blood parameters are observed a few hours after the traumatic injury. With traumatization and involvement of the kidneys in general urine tests, hematuria may be observed without other biochemical shifts in the analysis.

When conducting an overview radiography, abdominal X-ray, it is possible to determine the presence of free gas in the sub-diaphragmatic space, possibly an effusion in the pleural cavity, fluid in the abdominal cavity with volumes of more than 500-700ml, sometimes gas bubbles in the retroperitoneal tissue can be detected in the intestine. To diagnose possible perforation of the stomach or intestines, an X-ray contrast diagnosis is performed, in which it is possible to detect contrast leakage into the abdominal cavity and retroperitoneal space [5,11]. Computed tomography is also considered a highly effective method of diagnosing spleen damage, which allows you to determine the patient's management plan – conservatively or operationally with sensitivity up to 100%. The only limitation of its use is the transportation of the patient for the study, its duration, which limits the use in severe injuries and patient conditions when urgent decisions need to be made.

Angiography is necessary to confirm the traumatic injury, with the determination of its level in the spleen used after CT. This method is also applicable as a therapeutic method for vascular embolization. This method can be recommended both diagnostically and therapeutically, as it allows you to identify the presence of vascular pathology and at the same time carry out a complete embolization of the vessel, which allows you to save the lives of patients [11].

Currently, despite the evidence in favor of angiography for spleen injuries with a high degree of severity, the full implementation and adoption of these protocols remains controversial. Most AVAST members believe that mandatory angiographic studies are necessary for IV-V degree spleen injuries [11,53]. These opinions are related to the results obtained after the treatment of patients who underwent angiography, the main drawbacks of this method were that despite selective angioembolization of the spleen, it can bleed, i.e. this procedure does not provide a complete stop, it may miss the presence of a vascular anomaly detected on CT, thereby complicating selective angioembolization [46,66].

In numerous studies, the authors come to the conclusion that without a randomized, controlled study of the process of managing patients with spleen injuries, disputes over the choice of therapeutic tactics will continue.

Diagnostic peritoneal lavage is an invasive technique, the advantage is that it allows you to diagnose the presence of hemoperitoneum with a high probability, but it is impossible

to determine the source, therefore this technique and its application are somewhat limited in diagnostic terms [11,67].

One of the most effective methods of diagnosis and treatment is performing diagnostic video laparoscopy. Since 1980, laparoscopy has been widely introduced into surgical practice, making it possible to achieve satisfactory results in reducing surgical trauma, recovery time and hospitalization. The introduction of this method into the surgical practice of emergency care began later, since patients admitted for emergency operations are characterized by the presence of unstable hemodynamics. In recent years, due to the increase in video laparoscopic interventions, the improvement of technologies, as well as the improvement of surgical techniques by surgeons, the use of these techniques in emergency care has found wide application and increased, both for diagnostic and therapeutic purposes [11].

## 4. Treatment Tactics

Closed and open abdominal injuries are a rather complex and global surgical problem. This is due to the existing features of vital organs localized in the abdominal cavity, their anatomy, vascular architectonics, innervation, as well as the functional activity of each of them, this causes the development of massive bleeding with the development of hemoperitoneum, followed by the transition to peritonitis and the formation of multiple organ failure, death. Depending on the injuries received, they differ in the severity of clinical manifestations by the presence or absence of internal bleeding, the shock reaction of which directly affects the measures necessary for carrying out, the outcomes of treatment, the complexity and urgency of surgical interventions, the tactics of the postoperative period [5].

According to the nature of injuries in the structure, there are road transport; falling from a height; various man-made disasters; natural disasters; recently, gunshot and mine-explosive injuries have become widespread.

The outcome of the volume of injuries they differ: 1) isolated abdominal injuries – in the absence of other injuries in the patient, the mortality rate is 5-20%, while they can be either single or multiple (knife wounds); 2) combined – in the presence of other injuries in patients in combination with abdominal trauma (craniocerebral, musculoskeletal injuries chest injuries), mortality is quite high – 50-90%; 3) thoraco-abdominal trauma – with damage to the diaphragm. According to the nature of injuries, there are closed (blunt abdominal injuries) and open (wounds).

Clinical manifestations of abdominal wall injuries are accompanied by pain syndrome, pronounced muscle tension, forced position of the patient on his back/sideways with bent legs, while the abdominal wall may not participate in the act of breathing, there are symptoms of irritation of the peritoneum. When the abdominal wall is damaged, the symptoms of internal organ damage are characteristic, which can lead to diagnostic errors and laparotomy. The spleen is damaged in 20-25% of victims with abdominal trauma, it may be a consequence of impact, compression, displacement

of organs, sometimes there is damage to the spleen by rib fragments. There are also one-stage (85%) and two-stage (when there is a rupture of a subcapsular hematoma, 3-7 days) ruptures with spleen injuries. With penetrating abdominal wounds accompanied by spleen injuries, surgical intervention is indicated, only sometimes conservative treatment is carried out with closed injuries (stable hemodynamics after infusion therapy, confirmation of the absence of damage to other abdominal organs, preservation of consciousness, age younger than 55 years).

An indication for emergency surgery is a lesion of the spleen with signs of ongoing bleeding. Absolute indications for splenectomy are: extensive wounds (splenosis of the spleen, its separation from the vascular pedicle); inability to perform reconstructive surgery due to the severity of the patient's condition; lack of hemostasis [5].

The performance of organ-preserving operations for spleen injuries is recommended only by some authors, while they emphasize the historical performance of splenorrhaphy, which was performed by Tiffany in 1894 [8,14,48]. According to research [3,12,15,18], in order to perform organ-preserving operations, suturing, coagulation of traumatic wounds with infrared radiation, their tamponade with an omentum, laparoscopic application of clips to the splenic artery are used. In the research of foreign authors [28,47], the existing methods of selection of organ-preserving interventions are indicated, which are carried out depending on the morphotypes of emerging violations of the integrity of the spleen. In the first type, there is a rupture of the capsule with the preserved parenchyma of the spleen; in the second, the rupture of the capsule is combined with a violation of the integrity of the parenchyma; in the third, the rupture reaches the gate of the spleen; in the fourth, complete destruction of the spleen. Based on the types of violations, at the first, the authors recommend suturing of absorbable material; use applications of biological glue or powdered collagen. In the second case, it is necessary to excise the damaged tissues with the imposition of deep seams and the addition of strengthening them with an oil seal on the leg. The third type requires resection of the spleen, while the wound surface is strengthened with an omentum, followed by the application of biological glue or collagen. In the fourth case, splenectomy is necessary. The inability to perform organ-preserving operations is massive intraperitoneal bleeding, which is stopped using embolization, with superficial injuries - with the help of intra-arterial administration of pharmaceuticals [17,43].

With a double rupture of the spleen into parts without damaging the blood supply to the organ, coagulation methods with a mesh or a hemostatic sponge are used, which are fixed with mattress seams [27,44], horizontal-mattress; mattress; octagonal; ordinary, using chrome-plated catgut and mesh. There are many works on the possibility of using fibrin film in the presence of parenchymal bleeding, while suturing the spleen is minimized, accelerating rapid healing and its recovery.

In foreign literature sources there is material on the active use of natural hemostatics – collagen, fibrillar cream, gelatin sponges, the effectiveness of which ranges from 18-53%, but

the possibility of their use is limited to isolated injuries [30,58].

The main contraindications to the preservation of the spleen are severe traumatic shock, unstable hemodynamics, significant damage to the parenchyma, separation of the spleen from the vascular pedicle [45].

Splenectomy as an operative method was used until its immunological function was studied. Since the 60s, an increase in the level of knowledge about the functional features of the spleen as an organ involved in the immune response, recognition and control of infectious agents has allowed a new look at this problem [35,60] and consider the possibility of saving it. Achievements in the field of radiological technologies, improvement of CT and ultrasound diagnostics, interventional radiology, with the help of which the nature of the lesion of the spleen in trauma was determined, as well as the possibility of conservative treatment, played an important role in solving this problem [63].

The correct assessment of the possible risks of failures after organ-preserving operations depends on the exact determination of the degree of damage and severity of injuries, which are important prognostic factors. In 2001, Ren et al. [51], published data on the results of intervention in traumatic damage to the spleen using manual laparoscopy, i.e. post-traumatic splenectomy using laparoscopic technique. Over time, such interventions increased, which made it possible to expand the indications for them. Currently, considerable experience has been accumulated in performing interventions on the spleen using laparoscopic endovideosurgery, which suggests that splenectomy performed using it is an alternative to open surgery, when performed by an experienced surgeon.

To choose a treatment method and use any of them, it is necessary to take into account: the severity of the injury, the degree of damage to the spleen, the Glasgow coma scale and the volume of the hemoperitoneum. There are reports from foreign colleagues [62,64] about splenectomy due to ongoing bleeding, due to ineffective endovascular embolization, or an abscess arising after it.

In recent years, a comparative assessment of open and laparoscopic surgery for traumatic injuries of the spleen has been most often carried out in the literature sources. According to the conclusions of the majority of authors [31,57] indications for laparoscopic splenectomy are the failure of conservative treatment methods and embolization of splenic arteries.

Thus, laparoscopic surgery expands its range of use in abdominal injuries. Summarizing the literature data, it can be concluded that these interventions are indicated for hemodynamic stability of patients, in the absence of results from conservative methods of stopping bleeding, which is judged by the level of hemoglobin and the amount of transfused fluid to maintain normal vital signs. Immediate splenectomy according to WSES recommendations [22] it should be carried out with damage to the spleen with the presence of unstable hemodynamics, or with combined damage to the abdominal organs.

Angioembolization of the splenic artery is one of the

minimally invasive methods of treatment, which is carried out in case of spleen injury. Historically, this procedure was first performed by S.J.Sclafani in 1981 [56]. Researchers note a fairly high efficiency of using embolization when diagnosing grade I-II damage in patients, since the risk of using splenectomy increases with increasing degree. There are proximal and distal embolization.

The development of interventional radiology has played an important role in terms of evaluating and making decisions about treatment tactics, managing patients with traumatic injuries [21,49]. The development of angiography, the search for the introduction of new embolic agents into clinical practice made it possible to stop dangerous bleeding using endovascular embolization. This method allows you to get rid of invasive operations, which subsequently lead to the risk of high mortality among patients with traumatic injuries [33,38,40,65,66]. When assessing the condition of patients with injuries, it is necessary to carefully select them for the use of angiography. In the presence of acute bleeding in patients, small-caliber clamped arteries are characteristic, this is a systemic reaction of the body to a decrease in intravascular volumes of circulating blood, kidney hypoperfusion and intravascular exhaustion may occur. Impaired hemostasis, hemodynamics, high cardiac output, contrast rate may contribute to an increase in the volume and speed of contrast movement during angiography. The possibility of coagulopathy in injuries of internal organs can affect and have an effect on the effectiveness of embolizing agents, causing the development of vascular thrombosis [8,40,65].

Embolization is a long procedure that can be carried out for more than half an hour, depending on the patient's condition and hemodynamic instability. This makes it necessary to have a trained team of doctors - interventional radiologists, surgeons, resuscitators, as well as nurses, on whom the success of the treatment of patients with acute trauma depends [19,39,52,55]. The main complication in them is: violation of the integrity of the arteries, which may be one of the primary causes of death. This indicates the need to take emergency measures in terms of timely diagnosis and implementation of the correct treatment tactics.

Increasing knowledge and expanding new approaches to endovideosurgical interventions for spleen injuries will allow surgeons to make an accurate prediction of conservative treatment failures, while laparoscopic surgery may become the method of choice among patients with a high risk of conservative treatment failures.

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