Evolution of Hemostasis Methods in Damage Parenchymatous Organs (Literature Review)

Babadzhanov A.Kh	Republican Specialized Scientific and Practical Medical Center for Surgery named after acad. V. Vakhidova, Andijan State Medical Institute
Abdullazhanov B.R.,	Republican Specialized Scientific and Practical Medical Center for Surgery named after acad. V. Vakhidova, Andijan State Medical Institute
Sadikov R.A	Republican Specialized Scientific and Practical Medical Center for Surgery named after acad. V. Vakhidova, Andijan State Medical Institute
Kuchkarov M.Yu.	Republican Specialized Scientific and Practical Medical Center for Surgery named after acad. V. Vakhidova, Andijan State Medical Institute

ABSTRACT

The article presents historical facts on the improvement of hemostasis over the past 100 years. A review of the classifications of liver and spleen injuries with prognosis and options for surgical interventions was carried out. The authors identified the range of unresolved problems, the existing positive and negative aspects of physical and chemical methods of local hemostasis, outlined ways to improve surgical methods for stopping parenchymal bleeding.

Keywords: surgery, parenchymal organs, bleeding, hemostasis, hemostatic coatings

In peacetime, with penetrating wounds of the abdomen, liver damage is observed in 37%, and with a closed abdominal injury - in 16% of the victims. Spleen injuries occur in 3.5-9% of victims with penetrating abdominal injuries and in 16-30% with blunt trauma, and with combined abdominal trauma, this figure reaches 40% [3,7]. Mortality in open liver injuries is 6-12%, in closed injuries - 28-72% [15,21].

Of the total number of patients with severe liver injury, 40% die at the hospital stage, 60% survive, of which only 70% return to work, and 30% become disabled [19]. Postoperative mortality in blunt abdominal trauma with liver damage is 30.4%, in stab-cut wounds of the organ - 4-10.5%, in combined trauma 39.3% of victims die [16].

The characteristic features of modern abdominal trauma are the multiplicity and severity of injuries, accompanied by gross violations of homeostasis and disorders of the vital functions of the body, which leads to a high mortality rate that does not tend to decrease - 25-70% and a high incidence of postoperative complications - 35-83% [6]

Types Of Liver Damage

F. Christopher (1938) greatly simplifies the classification of liver damage, dividing them into: 1) rupture of the liver tissue and capsule; 2) crushing of the liver tissue without rupture of the capsule; 3) central ruptures of the liver.

A.T. Lidsky (1963) proposed dividing liver damage with crushing of parenchyma into 2 subgroups: a) with the remaining tissue in direct connection with the organ and b) with complete detachment of individual fragments of the organ. K.D. Mikeladze, E. I. Kuzanov (1965) all liver injuries are divided into 2 main groups: 1) ruptures of the parenchyma and liver capsule; 2) subcapsular ruptures and central hematomas. According to the authors, such a classification is convenient because each of these 2 groups has its own most characteristic clinical picture. A.J. Donovan, F.L. Turrill, F.L. Facey (1968) all liver damage is divided into 3 main groups: 1) peripheral; 2) central and 3) damage in the area of the gate of the organ. In turn, vascular damage or damage to the bile ducts can be observed in these groups.

However, this classification is not without drawbacks inherent in those previously proposed by other surgeons. J. Wasowski (1968) divides closed liver injuries into: rupture of the liver and its capsule; subcapsular hematomas and intrahepatic ruptures. In 1994, a classification of injuries of parenchymal organs was proposed, adopted by the American Association for the Surgery of Trauma (AAST), supplemented by the Abbreviated Injury Scale (A1S), developed earlier (in 1971) as a method for quantifying and comparison of various types of damage to parenchymal organs [33].

Currently, the classification of liver injuries, revised and approved by the American Association for Trauma Surgery in 2018, is used [30]

American Association of Trauma Surgery Liver Injury Scale (2018)

Grade	Type of trauma	Description of trauma
I	Hematoma	Subcapsular, < 10% surface area
	Gap	Capsule rupture <1 cm, parenchymal depth
II	Hematoma	Subcapsular, 10-50% surface area, intraparenchymal, <10 cm
	Gap	Capsule rupture, parenchyma depth 1–3 cm, diameter <10 cm
III	Hematoma	Subcapsular, >50% area of ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma >10 cm
	Gap	>3 cm parenchymal depth
IV	Gap	Parenchymal destruction with 25 to 75% involvement
B	Gap	Parenchymal destruction involving > 75% of the liver lobe
	Vascular	Juxtagepatic venous lesions (retrohepatic vena cava/central large hepatic veins)

The number of surgical interventions on one of the largest parenchymal organs of the human body - the liver, according to various authors, ranges from 10 to 45% [22,32,36].

It should be taken into account that such a high level of surgical interventions includes not only planned, but also urgent manipulations. In the process of performing any operation, hemostasis and prevention of infectious complications are carried out. Over the long historical period of abdominal surgery, a huge number of ways to stop parenchymal bleeding have been developed: hemostatic sutures M.M. Kuznetsov and Yu.R. Pensky (1894), mattress sutures by V.A. Opel (1906), A.N. Lubbock, G.A. Orlov (1936), B.I. Alperovich's block-like suture (1955), etc., however, the suture material cuts through the tissue of parenchymal organs, increases bleeding, and deeply applied repeated sutures can cause ischemia of an organ or part of it, followed by dysfunction and even necrosis. In addition, suturing does not quickly stop bleeding [11,24].

In modern surgery, preference is given to electrocoagulation. It is known that the development and implementation of new devices for ensuring hemostasis of biological tissues has been carried out since the middle of the 19th century, when electrocoagulation was invented.

Almost unrecoverable side effects of this method were quickly established, the main of which are large areas of tissue damage in the area of application, namely the formation of a burn eschar (necrosis) with a depth of about 5 mm with its possible exfoliation and the development of re-bleeding. Currents conducted through the return electrode can cause internal burns, damage to blood vessels and nerve endings From the second half of the 19th century. Cryosurgery is actively developing, while solid carbon dioxide, freons and liquid nitrogen are used as a refrigerant in cryoapparatuses. An invaluable contribution to the development and development of cryosurgery of parenchymal organs, namely the liver, was made by Professor B.I. Alperovich with students and colleagues since the 1970s. One of the most relevant developments of this team was a cryoultrasonic scalpel created by B.I. Alperovich, JI.M. Paramonova and employees of the Siberian Institute of Physics and Technology (Tomsk).

The cryoultrasonic scalpel provided hemostasis at the capillary level, but had a number of disadvantages. Further introduction of new techniques made it possible to create a cryovibroscalpel (authors B.I. Alperovich, JI.M. Paramonova, A.I. Paramonov).

In the 1960s-1970s. to ensure hemostasis during tissue dissection, plasma flows and laser radiation began to be used. Plasma scalpels and coagulators, using various working fluids (argon, helium, hydrogen), provide dissection and coagulation of tissues by achieving a very high temperature of the plasma flow and laser beam. It has been established that plasma flows are most appropriate to use in surgery of parenchymal organs, primarily in liver surgery [2]. However, the use of complexes based on plasma flows has its drawbacks: the complexity of the operation of the complex, the need to cool the plasma torch with running water with a high degree of purification, the need for power supply from a 380 V network, filling cylinders with a scarce working fluid (argon or helium).

Currently, laser radiation generated by various types of laser scalpels - CO, YAG-neodymium, etc. is widely used in surgery to ensure tissue hemostasis. [4]. Their undoubted advantages include simultaneous dissection and coagulation of blood and lymphatic vessels by a laser beam; relatively small zone of thermal tissue damage, non-contact of the instrument. The disadvantages include the high cost of equipment, as well as the presence of a thermal burn, which slows down the process of tissue regeneration.

Types Of Damage To The Spleen

According to the literature, with blunt abdominal trauma, traumatic injuries of the spleen occur in 57.9-95.0% of cases, while splenectomy is performed in 83.6-89.0% of cases, and various types are performed in I.0-26.3%. organ-preserving operations, associated with a much lower number of postoperative complications [17,31]. According to P.L. Chalya et al. [23], complications after splenectomy are recorded in 30.5% of cases. Hospital mortality, according to Chalya et al. [23], - 19.5%. The main stage of the operation in case of damage to parenchymal organs is the achievement of reliable final hemostasis.

Manipulations aimed at stopping parenchymal bleeding sometimes take 75% of the operating time. The performance of organ-preserving operations on the spleen is limited by its peculiar anatomical and morphological structure, a characteristic loose structure with a small content of connective tissue and a dense network of blood vessels, which determines the exceptional difficulties in solving this problem. The development of secondary parenchymal bleeding and subsequent relaparotomy often increase hospital mortality to 23.6-71.2% [5].

Surgery for splenic injuries has gone through several stages. Splenectomy was performed in China in the 2nd century AD, but it was first described in the medical literature in 1549 [28]. In 1581, Viard removed part of the spleen that had fallen out through a stab wound in the abdominal wall. In both cases there was a recovery. Until the 1980s, splenectomy was the only operation for trauma to the spleen. So, in the manual on operative surgery it is written: "In connection with this circumstance, which characterizes the parenchymal organ, except for splenectomy, that is, the complete removal of the spleen, no other interventions on it are recommended" [13]. Deepening knowledge about the numerous functions of the spleen, including the immune one, has led to the development of organ-preserving operations [18].

As is known, the clearance of splenic filtration from the systemic circulation through macrophage phagocytosis is 10–15% [34]. In 1952, the message of N. King, N.V. Shumaker about fatal post-splenectomy sepsis for the first time called into question the generally accepted doctrine of splenectomy [29]. Of 100 patients who underwent splenectomy, bacteremia in the postoperative period is recorded in 2.3 people [26]. Against the background of generalization of infection and an increase in postsplenectomy immune deficiency, 5.7% of patients develop syndrome of aggravated postsplenectomy infections (OPSI-syndrome) [27] with concomitant changes in the rheological properties of blood [8,10], thromboembolic complications [14], a high probability of developing a chronic disseminated intravascular coagulation syndrome. In a study by D. Demetriades et al. [25], taking into account the data of multivariate analysis, splenectomy was determined as an independent risk factor for the development of infectious complications in the early postoperative period. Accordingly, an acute question arises about the maximum preservation of the organ (spleen) during bleeding.

The spleen injury grading system proposed by the American Association of Trauma Surgeons [35]: I degree of spleen injury: Hematoma - Subcapsular, <10% of the surface area Rupture - Rupture of the capsule, <1 cm in the depth of the parenchyma.

II degree of damage to the spleen: Hematoma - Subcapsular, 1 0-50% of the surface area, <5 cm in diameter Rupture - 1-3 cm in the depth of the parenchyma, without involvement of grabecular vessels.

III degree of damage to the spleen: Hematoma - Subcapsular,> 50% of the surface area or growing; ruptured subcapsular or narenchymal hematoma. Intraparenchymal hematoma >5 cm or progressive Rupture >3 cm deep into the parenchyma or involving trabecular vessels.

IV degree of damage to the spleen: Rupture - Rupture, including segmental vessels or vessels of the gate, with an extensive area of devascularization (> 25% of the spleen).

V degree of damage to the spleen: Rupture - Complete destruction of the spleen Vessels - Damage to the vessels of the esophagus with devascularization of the spleen.

The modern literature describes many methods to stop parenchymal bleeding, allowing to save the damaged spleen. The existing techniques are divided into four groups: mechanical, biological, physical and chemical. Biological methods of hemostasis, in turn, are divided into groups depending on the type of materials used: the body's own biological tissues, blood products and its fractions, processed animal tissues, preparations based on substances contained in plants, and combined preparations. Each of the methods has its own advantages and disadvantages, which generally determine its effectiveness and prevalence. The latter largely depends on economic accessibility, especially when it comes to high-tech devices and materials.

One of the most common ways to mechanically stop parenchymal bleeding during surgical interventions on the spleen is the imposition of hemostatic sutures on its parenchyma - splenorrhaphy. Due to the weakness of the connective tissue skeleton of the spleen, the low efficiency of the method is due to the impossibility of creating high pressure using hemostatic sutures, which stops bleeding from vessels with an intraluminal pressure of more than 30-40 mm Hg. Art. [1]. The disadvantages of the method are partially eliminated by the use of plastic materials, through which, after strengthening the injury site, the parenchyma of the organ is stitched through. The use of these materials reduces the risk of tissue necrosis distal to the applied sutures by creating a more uniform compression of the parenchyma and less trauma to the organ.

Of the biological tissues for plastic purposes, it is proposed to use the preserved peritoneum, pericardial graft, serous-muscular flap of the greater curvature of the stomach, diaphragmatic flap, free peritoneal-poneurotic flap, autodermal flap. Most of the listed materials for various reasons have not found wide application in clinical practice, and at present, surgical techniques using them are of historical importance.

Of the physical methods of hemostasis in surgery of parenchymal organs, electrocoagulation, argon, microwave, laser and radiofrequency coagulation, contact infrared radiation, ultrasonic, harmonic, jet scalpels, plasma flows, radiofrequency ablation are used. Achieving a hemostatic effect by physical methods of influencing the wound surface and bleeding vessels of the parenchyma is rational mainly for its shallow and superficial injuries [17]. To stop bleeding from parenchyma vessels with a diameter of more than 1.0 mm, an increase in exposure and power of energy exposure is required, which inevitably leads to damage to the stromal elements of the organ and increases the area of parenchyma necrosis to a depth of 4-8 mm, and the resulting coagulation eschar often serves as a substrate for infection and rebleeding. Physical methods of hemostasis during operations on parenchymal organs do not meet the requirements of the “ideal method”, which should be accompanied by minimal or no blood loss, minimal parenchymal necrosis, and reduced surgery time [17].

Every year, the demand from medical institutions for the use of hemostatic sponges is progressively growing. For example, the volume of purchases of hemostatic local agents in Russia relative to all other hemostatics of various mechanisms of action in 2017 amounted to 38% [12].

One of the open questions remains about specific indications for the local use of hemostatics in abdominal, cardiovascular, and thoracic surgery. An analysis of the literature suggests that, although in the 21st century we have undeniable progress in the development of new technologies, including 3D printing, bioengineering, nanotechnology, the production of new synthetic materials and biological products, we have to admit that there is still no “ideal” hemostatic implant. Further multicenter studies are needed to evaluate the effectiveness of local hemostatics, taking into account different localization and degree of damage. In this regard, clinical and experimental studies of a domestic hemostatic agent with an assessment of its effectiveness is an important area for research.

References

1. Alekseev B.C. Clinical and anatomical justification of organ-preserving operations in case of damage to the spleen: Abstract of the dissertation candidate of medical sciences. - Saransk, 1997. - 18 p.
2. Andreev A.L., Rybin E.P., Ochvatkin V.G. et al. The first experience of the use of plasma scalpel in laparoscopic operations // Abstracts of the 8th All-Russian Congress of Surgeons. Krasnodar, 1995. - p. 322-323.
3. Bazaev A.V., Aleinikov A.V., Korolev S.K. and other damage to the liver and spleen in the victims with a combined road injury // Medial. -2014. -No. 1 (11)) .- p. 17-19.
4. Vishnevsky V.A. Liver operations: guide for surgeons. - M.: Miklosh, 2003 .-- 164 p
5. Grigoryev S.G., Petrov V.A., Grigoryeva T.S. Relaparotomy. Terminology issues // Surgery. - 2003. - No. 6. - S. 60-63.
6. Ermolov A.S., Blashvestnov D.A. and other damage to the parenchymal organs of the abdominal cavity for abdominal injury: a training manual. - M.: State Budgetary Educational Institution of Additional Professional Education of the Russian Medical Academy of Postgraduate Education, 2015. - 138 p.
7. Earth A.B. Local hemostasis is a fluid active hemostatic matrix // Surgery.

Journal. them. N.I. Pirogov. - 2019.- No. 5.- P. 104-115.

8. Kirichuk V.F., Maslyakov V.V., Barsukov V.G. Changes in the rheological properties of blood after splenectomy in the near postoperative period // Annals Hir. - 2007. - No. 1. - p. 36-38.
9. Kolyshev I.Yu. Features of the application of laser radiation during liver resection (experimental research): dissertation of the candidate of medical sciences. -M “2015. - 149 p.
10. Maksimova N.E., Mochulskaya N.N., Emelyanov V.V. Fundamentals of immunoanalysis: textbook. manual. - Yekaterinburg: Publishing House of the Ural University, 2021. - 148 p.
11. Marchenko V.T., Shkurupiy V.A., Rassadovsky M.V. et al. Features of the connection of tissues and hemostasis when using the adhesive composition "Sulfacrylate" of the new generation // Siberian consultation. - 2003. - No. 2. - S. 50-54.
12. Review of the tender procurement market for hemostatic agents according to the results of 2019. Moscow: [Electronic resource]. URL: https://www.hwcompany.ru/blog/expert/obzor_rinka_gemostati4eskikh_sredstv (date of circulation 09/17/2020).
13. Operational surgery: under. Ed. I. Littmann. - Budapest: Publishing House of Hungary, 1981
14. Romantsov M.N., Chertonikov E.F., Danilenko V.I. et al. Morphological characteristics of the processes of reparation of modeled bleeding defects of the stomach in the treatment of yellow -pushed and diovin // Journal of anatomy and histopathology. - 2017. - T. 6, No. 1. - p. 81-86.
15. Severinov D.A. The experimental justification of the use of local hemostatic agents based on sodium salt of carboxymethyl cellulose with the addition of transhasamic acid with liver damage: dissertation of a candidate of medical sciences. - Kursk, 2021. - 135 p.
16. Severinov D.A., Bondarev G.A., Lipatov V.A. et al. Intraoperative tactics of local surgical hemostasis for injuries and planned operations on the parenchymal organs of the abdominal cavity // Bulletin of the examination and clinical surgery - 2020. -T. 13, No. 2-3.-p. 268-278.
17. Semichev E.V., Baykov A.N., Bushlanov P.S. et al. Comparative analysis of the coagulation of “cold plasma” and the overlap of hemostatic seams on the liver structure in the early stages after atypical resection // Bulletin of Siberian Medicine - 2015. - T. 14, No. 1. -p. 92-101.
18. Smolya A.N. Closed abdominal injury. Damage to the spleen. Part 2 // Surgery. Magazine named after N.I. Pirogov. - 2016. - No. 2. - p. 4-10.
19. Feskov A.E., Sokolov A.S., Soloshenko S.V. A new hemostatic bandage based on a natural biopolymerachitosan // Medicine of emergency conditions. - 2017. - No. 2 (81). - p. 95-98.
20. Tsyrkunov V.M., Prokopchik N.I., Andreev V.P., Kravchuk R.I. Clinical morphology of the liver: necrosis // Journal of the Grodno State Medical University.-2017,-No. 5.-p. 557-568.
21. Shaimardanov R.Sh., Gubaev R.F., Sharafiev S.Z. Surgical tactics for traumatic damage to the liver // Bulletin of modern clinical medicine.-2015. -No. 8 (Appendix 1) .- p. 104-108.
22. Brillantino A., Iacobellis F., Festa P. et al. Nonoperative management of blunt liver trauma: safety, efficacy and complications of a standardized treatment protocol // Bull. Emerg. Trauma. - 2019. - Vol. 7. - P. 49-54.
23. Chalya P.L., Mabula J.B., Giiti G. et al. Splenic injuries at Bugando Medical Centre in northwestern Tanzania: a tertiary hospital experience // BMC Res Notes.-2012.-Vol. 23.-P. 55-59.
24. Chiara O., Cimbanassi S., Bellanova G. et al. A systematic review on the use of topical hemostats in trauma and

emergency surgery // BMC Surg. - 2018.-Vol. 18, №1,-P. 68.
25. Demetriades D., Scalea T.M., Degiannis E. et al. Blunt splenic trauma: splenectomy increases early infectious complications: a prospective multicenter study // J. Trauma Acute Care Surg. - 2012. - Vol. 72, №1,-P. 229-234.
26. Ejstrud P., Kristensen B., Hansen J.B. et al. Risk and patterns of bacteraemia after splenectomy: a populationbased study // Scand J Infect Dis. - 2000. - Vol. 32, №5.-P. 521-525.
27. El-Alfy M. S., El-Sayed M.H. Overwhelming postsplenectomy infection: is quality of patient knowledge enough for prevention? // Hematol J. - 2004.-Vol. 5, №1,-P. 77-80.
28. Fioravanti L. II tesorodella vita humana. - Venice: Valgrisi; 1673.
29. Japanese Classification of Gastric Cancer - 2nd Engl. Edit. Japanese Gastric Cancer Association //Gastr. Cancer. - 1998. - № 1. - P. 10-24.
30. Kozar R.A., Crandall M., Shanmuganathan K. et al. Organ injury scaling 2018 update: spleen, liver, and kidney // J. Trauma Acute Care Surg. - 2018. - Vol. 85.-P. 1119-1122.
31. Mufti T.S., Akbar I., Ahmed S. Experience with splenic trauma in Ayub Teaching Hospital,
Abbottabad // J. Ayub. Med. Coll. Abbottabad. - 2007.-V. 19, №3,-P. 3-5.
32. O'Neill S.B., Hamid S., Nicolaou S„ Qamar S.R. Changes in approach to solid organ injury: what the radiologist needs to know // Canad. Assoc. Radiol. J.-2020.-Vol. 71.-P. 352-361.