Proceedings of the 2nd International Conference on Modern Medicine and Global Health
DOI: 10.54254/2753-8818/29/20240831

Progress in the hemostasis of traumatic liver rupture during interventional embolization

Yi Luo[1, 3], Juntao Liu[1], Yuting Chen[1],Jiaman Li[1, 2, 4]

[1]Department of Trauma Surgery, Zhanjiang Central People's Hospital, Zhanjiang, 524037, China
[2]Corresponding author

[3]116532270@qq.com
[4]984723715@qq.com

Abstract. This paper mainly discusses the progress of hemostasis of traumatic liver rupture in interventional embolization. Traumatic liver rupture is a common intraabdominal traumatic disease in the clinic, and the incidence of right liver injury is generally high. The liver was located under the right diaphragm of the abdominal cavity, deep to both ribs. When subjected to external trauma or acute puncture, it can cause liver rupture and bleeding. If the liver is swollen due to lesions, the chance of liver rupture is relatively large. Severe hemorrhagic shock usually occurs after liver injury, causing bile peritonitis due to bile leakage into the abdominal cavity, and then infection occurs. How to improve the success rate of rescue has always been a difficult problem. This review described the pathological classification, classification and grading of liver rupture and combined with comprehensive studies of hemostatic materials at home and abroad to make a thorough analysis of vascular interventional embolization technique. The purpose of these analyses is to propose that embolization technology has good results for patients with liver rupture and bleeding, which can effectively reduce the disability rate and reduce complications, which is worth advocating clinically. Therefore, with the development of hemostatic materials science, the technology of hemostatic materials and related products has developed greatly, and the vascular interventional embolization technology has been widely improved in the clinical practice of surgery.

Keywords: hepatic rupture, haemostatic, vascular interventional embolization technique, haemostatic materials

1. Preface

Traumatic liver rupture is a high risk and complexity of abdominal injury, which is one of the main culprits of bleeding after abdominal trauma. Hepatic rupture is serious, generally accompanied by shock, biliary bleeding, gallbladder rupture and secondary infection and other related symptoms, clinical complications and mortality rate are extremely high [1]. Patients with more liver function bleeding, blood circulation instability, should be treated with early surgery or intervention in order to save lives. The surgical methods of liver rupture mainly include simple suture repair, omentum filling suture, vascular ligation and liver resection. The principle of the operation is that the hemostasis is rapid, so that the liver tissue is maintained in a normal state, easy drainage [2]. At present, there is no unified indication

DOI: 10.54254/2753-8818/29/20240831

of vascular interventional embolization in patients with liver and splenic rupture. For liver rupture, Hagiara et al. [3] Angiographic (DSA) showed extravasation; Asensio et al. [4]. It is considered that rapid DSA and vascular interventional artery embolization can improve the patient survival rate, especially in patients with grade V liver rupture; Shigeki et al. [5]. If suture repair is difficult with abnormal coagulation function (eg: DIC), which is a high risk, vascular interventional embolization should be performed.

2. Pathological classification of hepatic rupture

The pathological and physiological changes in the initial stage of liver injury mainly show bleeding, hemorrhagic shock, and cyst inflammation. The pathological changes of liver injury vary with the nature of the injury. The tools and shrapnel usually cause insignificant damage to the line and the speed. The damage caused by the high-speed operation of the warhead makes the liver tissue loose and lost. Clinically, there are the following three main types of occlusive liver injury [6].

2.1. Liver subcapsule hematoma

Liver subcapsule hematoma is also known as “broken membrane”. Clinical manifestations are often left upper abdominal pain, enlargement of palpable liver area, left upper abdominal pain, percussion pain; 30% of the patients have aggravation within hours or days, hematoma continues to increase, or due to infection and other factors can cause delayed, sexual complete liver rupture, or even peritonitis and shock. The surface of liver parenchyma breaks, and blood can gather under the liver capsule, sometimes can accommodate 2~4 L blood, if secondary infection, abscess can be formed [7].

2.2. Central liver rupture

Central hepatic rupture is caused by an intact liver capsule, and a parenchymal rupture in the deep liver. Often accompanied by the liver main blood vessels or liver, bile duct injury and other manifestations. The clinical manifestations are similar to the hepatic subcapsule hematoma, but it is easy to cause intra-abdominal infection, and the symptoms of septic shock or toxic shock can appear after several days of injury. The middle part of the liver tissue is damaged, the liver membrane is ruptured, and the superficial liver layer is well preserved. Generally accompanied by the hepatic duct, bile duct rupture, the formation of hematoma. Intrahepatic mass and bile drainage, compression of hepatocyte necrosis, and eventually lead to liver tissue necrosis [6].

2.3. Liver truth rupture

Liver sincere rupture, also known as the complete rupture of the hepatic capsule, is one of the most common liver injury [6]. According to the degree of injury, it can be divided into: ① liver contusion, including simple hepatic contusion; ② liver parenchymal injury; ③ liver parenchymal damage; clinical manifestations is severe abdominal irritation with hemorrhagic shock.

Liver tissue and liver capsule ruptured, and blood bile flowed through the abdominal cavity. However, the degree of injury and pathological changes differ greatly: ① Liver parenchymal contusion: can be a single, normal or irregular tear, simple intrahepatic vascular injury tear; ② liver parenchyma injury injury: distal liver vascular blood flow decline, liver cell ischemia damage, liver tissue loss; ③ liver parenchyma damage: due to severe trauma, the abdominal cavity causes the liver tissue rupture or fall into the abdominal cavity, so that the liver loses its normal form and function. The shed liver necrotic tissue liquefaction forms a blood abscess in the abdominal cavity [6].

3. Classification and grading of hepatic rupture hemorrhage

3.1. Classification of hepatic hemorrhage

According to whether the abdominal wall is damaged, it is divided into two categories: open damage and closed damage.

DOI: 10.54254/2753-8818/29/20240831

Open damage is usually caused by direct penetration through the abdominal wall such as knife or projection. The wounds of sharp objects are generally neat, but of different shades. Low-speed projections, such as through or blind tube wounds of small-caliber bullets, are basically limited to the range of the trajectory. And high-speed bullets or shrapnel, can cause a large range of damage and even damage [6].

Closed liver injury can sometimes cause a hematoma under the liver capsule. But in most cases, it can cause liver contusion and laceration. Shallow liver injury can cause physiological hemostasis by itself, while the rupture of the deep liver center can cause extensive death of liver cells and extensive necrosis of liver tissue. This is usually accompanied by extensive impaired rupture of the hepatic artery, hepatic portal vein, hepatic vein, and bile duct, causing biliary peritonitis. Subperihepatic hematoma can lead to acute abdominal pain (days or more) and abdominal bleeding [6].

3.2. Classification of liver rupture and bleeding

There is no unified standard for the classification of liver injury. The classification of liver trauma proposed by the American Association of Trauma Surgery in 1995 is still the standard cited in European and American countries [8].

Domestic Zhiqiang Huang [9] A more concise and practical classification of liver trauma is proposed: grade I, the depth of liver rupture does not exceed 3 cm; grade, hepatic rupture injury to hepatic artery, hepatic portal vein, hepatobiliary duct grade 2~3 branch; grade or central area injury, hepatic rupture injury to hepatic artery, portal vein, main hepatic duct or its primary branch.

4. Haemostatic materials

Successful hemostasis is often one of the key factors in the success or failure of traumatic liver rupture surgery. If there is a lot of bleeding or incomplete hemostasis during the operation, it may cause serious consequences or even life-threatening [10]. Hemostatic materials refer to various kinds of articles, instruments or drugs used to control or stop bleeding, including gauze, bandages, tourniquet, hemostasis powder, hemostasis gel, etc. Hemostatic materials are widely used in the medical field and field emergency field, which can effectively control bleeding and protect wound healing. Hemostatic materials are also essential tools during surgery.

4.1. Inorganic materials

Most inorganic materials, such as mesoporous silicon, chitosan and polyethylene materials composite into TraumaStat [2], With a porous structure and a large surface area, etc. By absorbing the water in the blood, accelerate the coagulation effect, and realize the mechanism of rapid hemostasis [11].

Inorganic hemostasis is good, and hemostasis can be covered on the surface of liver rupture during exploratory laparotomy [12]. But its disadvantage is that it will stay in the body for a long time, resulting in tissue rejection, thus resulting in toxicity to the body, and the liver should be cleared early after rupture. Therefore, this kind of inorganic hemostatic materials in vivo or organs are not suitable for medical hemostasis, and have extremely high use restrictions [13].

4.2. Polymer materials

4.2.1. Gelatin. Gelatin is a water-insoluble solid, colorless to yellowish solid. But when encountering water, it can absorb 5~10 times of water, and the expansion becomes soft. Due to its biodegradability, good biocompatibility and membranformation, gelatin is also widely used in the pharmaceutical field. Gelatin material is used for clinical vascular interventional embolization technique for hemostasis [14]The risk is low, but because of its high instability, so the red blood ball, white blood ball, blood board and other pull ability is not strong, is also its shortcomings [2].

4.2.2. *A single oxidized cellulose derivative.* Oxidative cellulose derivatives have good water absorption and biological strength [15]. The oxidative reaction of cellulose can be used as an anticoagulant with

DOI: 10.54254/2753-8818/29/20240831

significant affinity for HB. Fe3 + in blood binds into colloidal particles, and microvascular ends are closed, which can play a hemostatic role under vascular interventional embolization technology. At the same time, oxidized cellulose can activate blood coagulation factors and accelerate blood coagulation [16].

4.3. New R & D materials

At present, because the hydrogel expands rapidly in water, it can maintain a large volume of water and not dissolve [17], Has blocks bacteria, prevents wound infection, and allows O_2And H_2O has gradually replaced other materials in clinical practice and become an important hemostatic material. It has the function of interventional surgery and emergency hemostasis, and is an important material for future surgical hemostasis [18].

5. Vascular interventional embolization technique

Vascular interventional embolization technique is safe and effective in treating traumatic liver rupture and hemorrhage. Vascular interventional embolization technology for the technical methods of different target vessels, providing unprecedented superiority than other clinical means. One is the faster time to rescue the patient; the operation difficulty and treatment effect also greatly exceed the abdominal organs of surgery or endoscope. There are two main categories of vascular interventional embolization techniques: radiographic diagnosis and embolization management. Interventional embolization can be used either before, during and after surgery, or combined with separate surgery [19].

5.1. Interventional angiography examination of hepatic rupture

The interventional angiographic examination of liver rupture and bleeding is mainly manifested as [7]: (1) hepatic vascular direction change or extrusion, blood transport change, and spleen filling defect in non-vascular areas; (2) contrast agent overflow of blood vessels, local irregular small spots, or massive high-density shadow, the shadow is concentrated in the vascular rupture mouth. Sometimes only venular shadows with rough edges and indistinct margins are found until the venous phase; (3) unlike the arterial stage and subcapsular hematoma, the vascular movement is significant. The subcapsular peripheral blood vessels cannot reach the abdominal cavity; (4) interrupted hepatic artery branch with or without contrast overflow from the interrupted distal blood vessel; (5) arteriovenous fistula; (6) traumatic aneurysm; (7) organ rupture.

5.2. Diagnosis and treatment plan

Preoperative inclusion and exclusion criteria [20]: (1) Excessive injury should be treated by relevant professional physician to eliminate excessive injury that causes death; (2) patients whose vital signs recovered after blood transfusion, infusion and compression; (3) abdominal CT scan; (4) severe liver vascular injury excluded by abdominal CT scan; (5) no contraindications at the femoral artery puncture site.

5.3. Treatment with hepatic artery interventional embolization (TAE)

The function of anatomical liver is characterized by rich blood supply and strong bile secretion, which determines that there may be obvious blood water overflow during injury, and biliary peritoneal inflammation is more serious. For grade I and grade wounds, only small wounds on the liver capsule surface are generally treated conservatively. However, grade or higher liver damage includes the hepatic lobe (segment) vessels and the intrahepatic biliary tract, which are usually accompanied by damage to other organs. At this point, the functional activity of the abdominal cavity organs in the body is near the physiological limit [21, 22]. Traditional laparotomy includes liver resection, gauze filling, or hepatic artery ligation. The results of general anesthesia and surgery aggravate the instability of the body's physiological function, and even appear the triad of death including coagulation disorder, metabolic acidosis and hypothermia, causing a vicious cycle and endangering the life of patients [23].

DOI: 10.54254/2753-8818/29/20240831

Previously, it was believed that TAEs is mainly applicable to human patients with stable blood circulation, which may have only mild liver injury, while for severe patients with unstable vital signs, effective hemostasis is needed to further stabilize patients' blood pressure and other important signs. —— The next diagnosis and treatment require efficient and time-saving infusion. After the study, it was gradually found that TAE is a less invasive hemostatic measure with less impact on the physiological function of the body, without strict contraindications [24].

The TAE uses the advanced Seldinger technology [25], Cathepuncture of the right leg femoral artery and a 5F-RH or Cobra catheter to the coeliac trunk, to start DSA imaging. From far to near, the tube diameter and blood transport status of different grades of hepatic arteries were gradually monitored, and the injury location of the artery rupture and bleeding site was determined. Based to the findings in the angiography, appropriate embolic drugs were selected. Patients with hepatic artery bleeding, thrombosis with clear tablets; patients with hepatic artery bleeding (in part) underwent gelatin particle embolization with spring winding. The contrast was repeated at least three times without exudation to confirm no bleeding. If the spleen and / or kidneys bleed, embolization should be performed simultaneously [20].

6. Discussion

Traumatic liver rupture with bleeding and unstable blood circulation, early surgery or vascular intervention should be used to save life. Studies have shown that more than half of the patients with traumatic liver insufficiency and bleeding have relatively stable blood flow and can be effectively alleviated by aggressive medical therapy [26]. And for traumatic liver insufficiency accompanied by bleeding and unstable blood circulation, in order to save the patient's life, surgery or vascular intervention should be performed as soon as possible. Melloul [26]A retrospective analysis of the treatment and outcomes of 4946 patients with grade III-V traumatic liver rupture with AASAT (including 12 studies) found that the proportion of vascular intervention varied widely between centers (0 – 72%), and the mean success rate of hepatic artery embolization was 93% (81% – 100%).

The choice of embolic agents is also extremely important. At present, the commonly used clinical embolic agents mainly include gelatin sponge and steel ring, PVA, granule and NBCA glue. Among them, gelatin sponge is vascular recanizable. The steel wire can determine the size and number by the thickness of the blood vessels. PVA, particles and NBCA glue embolization is strong, encountered blood immediately coagulation. The cause of possible rebleeding after embolization may be related to the use of gelatin sponge as an embolic agent [27].

However, the research data show that the hemostasis effect of clinical hemostatic materials on liver rupture needs to be improved, especially in the case of serious damage to liver tissue, which is difficult to attach to the wound display, which plays the role of compression and hemostasis, which is unfavorable to the surgical efficiency of doctors and the postoperative recovery of patients [2]. Therefore, how to produce hemostatic materials under better hemostatic conditions, and have the characteristics of antibacterial, accelerated tissue healing, biological decline, so as to meet the clinical needs, is a topic that should be considered by health materials research and development institutions.

Hepatic artery embolization, as an important means of non-surgical treatment of closed liver trauma, has received more and more attention in the treatment of liver rupture and bleeding. It is mainly suitable for patients with relatively stable circulation and CT enhanced scan indicating active bleeding in the liver area, and then for patients with bleeding after surgical exploration or surgical hemostasis failure. In patients with closed liver trauma, angiography can identify bleeding points and find signs of vascular damage (such as aneurysm, arteriovenous fistula, truncation or clip into blood vessels, etc.); the correct choice of endovascular embolization can instantly control liver rupture and bleeding, and the success rate of surgery can exceed 85% [26]. Since the complications of hepatic embolization treatment mainly lead to hepatic ischemic necrosis, the emphasis is placed on preserving the normal hepatic vascular branches as much as possible and ensuring the intact part of blood circulation in the liver during vascular embolization [6].

DOI: 10.54254/2753-8818/29/20240831

7. Summary

In conclusion, hepatic artery interventional embolization, as a rapid hemostatic measure that requires emergency treatment during traumatic liver rupture, is useful in the diagnosis and treatment of intra-abdominal organ trauma, and has less effect on the patient's body [24]. Only when more hepatic vessel rupture achieves hemostasis, can clinicians have time for further diagnosis and treatment, which is consistent with the control of damage. It is important to control the treatment of the injury, including liver injury bleeding, but it needs to choose the timing with the patient, which requires consistent opinions and guidelines.

References

[1] Perl V J U, Leroux B, Cook M R, et al.Damage-control resuscitation and emergency laparotomy: Findings from the PROPPR study [J].Journal of Trauma & Acute Care Surgery, 2016, 80(4):568.DOI:10.1097/TA.0000000000000960.

[2] Liu Jun, Guo Chunliang. Progress in rapid hemostatic materials for ruptured liver wounds [J]. Continuing Medical Education, 2020,34 (08):

[3] Zhan Shilin, Chen Jianxiong, Peng Linhui, et al. Application of vascular intervention technique in the control of severe liver trauma injury [J]. Lingnan Modern Clinical Surgery, 2012(1):3.DOI:10.3969/j.issn.1009-976X.2012.01.009.

[4] Hagiwara A , Yukioka T , Ohta S ,et al.Nonsurgical management of patients with blunt splenic injury: efficacy of transcatheter arterial embolization. [J].American Journal of Roentgenology , 1997, 167(1):159-166.DOI:10.2214/ajr.167.1.8659363.

[5] Asensio J A , Rold ??N G , Petrone P ,et al.Operative Management and Outcomes in 103 AAST-OIS Grades IV and V Complex Hepatic Injuries: Trauma Surgeons Still Need to Operate, but Angioembolization Helps [J].Journal of Trauma and Acute Care Surgery, 2003, 54(4):647-654.DOI:10.1097/01.ta.0000054647.59217.bb.

[6] Chang Zhongfei, Li Qiang, Liu Fengyong, etc. Endovascular intervention for liver rupture and bleeding [J]. Chinese Electronic Journal of Interventional Radiology, 2015,3 (02):

[7] Lu Qian, Yan Tao, Wang Guangyu, et al. Application of Interventional embolization in the treatment of traumatic splenic rupture [J]. Jiangxi Medicine, 2007,42(7):2.DOI:10.3969/j.issn.1006-2238.2007.07.017.

[8] Moore E E , Cogbill T H, Jurkovich G J, et al.Organ Injury Scaling: Spleen and Liver (1994 Revision) [J].Journal of Trauma and Acute Care Surgery, 1995, 38(3):323-324.

[9] Huang Zhiqiang. Theory and practice of abdominal surgery [M]. Science Press, 2003.100

[10] Chen Qiuxing, Ye Ning, Lu Huadong, and other cases in the treatment of traumatic liver rupture [J]. The Chinese Journal of Trauma, 2015,31(4):2.DOI:10.3760/cma.j.issn.1001-8050. 2015.04.014.

[11] Shang Xiaoqiang. Study on the dynamic interaction between zeolite molecular sieve and plasma proteins and its procoagulation mechanism [D]. Zhejiang University, 2019.

[12] Li Jun; Zhang Hui. Surgical treatment of traumatic liver rupture [J]. Chinese Journal of General Surgery, 2010,19 (07): 834-836.

[13] Blue Guanghui. Development and study of chitosan / gelatin composite hemostasis materials and its properties [D]. Southwest University, 2016.

[14] Liu Shulin; Xu Hao copper. Interventional treatment value of liver trauma and bleeding secondary to liver lesions [J]. Journal of Chengdu Medical College, 2019,14 (02): 207-210 + 270.

[15] Dong Lidan, Wei Changping, Li Zhongtian, and so on. Preparation and properties of nanochitosan composites [J]. China Optics, 2018,11(5):6.DOI: C NKI: SUN: ZGGA.0.2018-05-008.

[16] Wang Lulu, Wang Shaohua. Application status of topical absorbable hemostatic materials and their research progress [J]. Medical Graduate Journal, 2018,31(1):4.DOI:10.16571/ j.cnki.1008-8199.2018.01.023.

[17] Cirillo G , Spataro T , Curcio M ,et al.Tunable thermo-responsive hydrogels: synthesis, structural analysis and drug release studies. [J].Mater Sci Eng C Mater Biol Appl , 2015, 48:499-510.DOI:10.1016/j.msec.2014.12.045.

[18] Jianxia X X S X S L C K J F M Y J .Lyophilized apoptotic vesicle-encapsulated adhesive hydrogel sponge as a rapid hemostat for traumatic hemorrhage in coagulopathy [J].Journal of Nanobiotechnology,2023,21(1):407-407.

[19] Chen Huang, Golden Banner, Zhang Qingxian. Interventional treatment for traumatic liver, spleen, and renal rupture and hemorrhage [J]. Journal of Trauma Surgery, 2020,22 (03):

[20] Duan Jianfeng, Liu Xiaochen, Yang Fan and so on. Application of interventional hepatic artery embolization in the treatment of some grade V traumatic liver rupture [J]. Liver, 2022,27 (07):

[21] Manterola C , Flores P , Otzen T .Floating stoma: An alternative strategy in the context of damage control surgery [J].Journal of Visceral Surgery, 2016:S1878788616300832.DOI:10.1016/j.jviscsurg.2016.06.003.

[22] Roberts D J , Zygun D A , Faris P D ,et al.Opinions of Practicing Surgeons on the Appropriateness of Published Indications for Use of Damage Control Surgery in Trauma Patients: An International Cross-Sectional Survey. [J].Journal of the American College of Surgeons, 2016:515-529.DOI:10.1016/j.jamcollsurg.2016.06.002.

[23] Surgical management of AAST grades III-V hepatic trauma by Damage control surgery with perihepatic packing and Definitive hepatic repair –single centre experience [J].World Journal of Emergency Surgery, 2015, 10(1):1-8.DOI:10.1186/s13017-015-0031-8.

[24] Fei Xianming. Evaluation of postoperative quality of life after liver resection and interventional (TAE) treatment for hepatic hemangioma [D]. Anhui Medical University, 2020.DOI:10.26921/d.cnki.ganyu.2020.000236.2018

[25] Yan Dong's CSCO Guidelines for the Diagnosis and Treatment of Primary Liver Cancer interpreted the —— part of hepatic artery intervention therapy [J]. Electronic Journal of Liver Cancer, 2018,5 (03): 4-7.

[26] Melloul E, Denys A, Demartines N.Management of severe blunt hepatic injury in the era of computed tomography and transarterial embolization: A systematic review and critical appraisal of the literature [J].Journal of Trauma and Acute Care Surgery, 2015, 79(3):e793-e793.DOI:10.1097/TA.0000000000000724.

[27] Niu Haigang, Zhu Fuyi, Li Gang. Effect of vascular interventional embolization technique on hemostatic effect and complications in patients with traumatic hepatosplenic rupture and bleeding [J]. World's Latest Medical Information Abstract, 2016,16 (89):