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## Review article

# Treatment strategy for hepatic trauma

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## ABSTRACT

Liver is one of the organs with the highest injury rate, and in recent decades, the guidelines for the treatment of liver trauma have changed considerably. Now, there is a growing consensus that the most important step is diagnosis and depending upon the degree of severity, non-operative therapy is the main treatment method for hepatic trauma if conditions permit. For serious hepatic trauma patients such as those with hemodynamic instability, they should be operated upon as soon as possible. Regardless of the surgical options, doctors should control damage to patients and try to prevent complications. New therapies such as hepatic artery embolization and liver transplantation have been more and more used for the treatment of serious hepatic damage in clinics.

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## Introduction

Liver is a solid organ with the highest injury rate in abdominal injury.<sup>1</sup> Approximately 15%–20% of abdominal injuries refer to hepatic trauma. Hepatic injury takes the third place in abdominal injury and 80%–90% of hepatic injuries are blunt ones.<sup>2</sup> In 2013, a study using ultrasonography to evaluate the intraperitoneal trauma showed that liver was the mostly affected organ and younger people were more vulnerable to hepatic and pancreatic injury.<sup>3</sup>

In 1994, American Association for Surgery of Trauma (AAST) proposed the standard classification of hepatic trauma. According to the classification, level I–II hepatic trauma is called minor hepatic trauma, accounting for 80%–90% of all hepatic trauma. The hepatic trauma of level III and above is called serious hepatic trauma, with the mortality of 10%, and if patients have multiple injuries, the mortality may be elevated to as high as 25%.<sup>4</sup> Serious hepatic trauma is always combined with parahepatic vena cava injury, with the mortality of above 50%.<sup>5</sup> The treatment strategies of serious hepatic trauma have been advanced for decades.<sup>6</sup> The clinical experience shows that early diagnosis, accurate assessment, active resistance to shock, optimal treatment plan and the organ function

preservation are protective factors to reduce the mortality and enhance the treatment.

## Diagnosis of hepatic trauma

It is easy to diagnose hepatic trauma. Patients usually have a history of liver injury, blunt trauma or penetrating trauma. Patients have some typical clinical manifestations such as right upper abdominal pain (sometimes with radiating pain to the right shoulder), nausea and vomiting, thirst, peritonitis, and hypovolemic shock. Imaging examination is widely used for the diagnosis of hepatic trauma. Abdominal ultrasound can quickly assess intra-abdominal hemorrhage, suitable for hemodynamically instable patients, but limited by weak sensitivity and a high rate of misdiagnosis. Therefore, abdominal ultrasound is usually used for the patients who could not tolerate CT scanning. CT is the most commonly used method for the diagnosis of intra-abdominal solid organ injury.<sup>7</sup> For small occult liver damage, enhanced CT scan can reveal the wound and assess the bleeding.<sup>8</sup> Enhanced CT combined with ultrasound is regarded as the most valuable method to evaluate abdominal trauma.<sup>9,10</sup> Thanks for the development of modern imaging techniques, CT scanning can provide adequate information for definite diagnosis of liver injury or intra-abdominal hemorrhage.<sup>11,12</sup>

The most difficult and important aspect is the preliminary evaluation and early rescue. For hemodynamically instable patients, we should promptly determine the order of severity of hepatic trauma, and proceed with timely exploratory laparotomy and treatment.

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### Non-operative therapy for hepatic trauma

In the past, most scholars thought that non-operative therapy was only appropriate for level I–II liver traumas, which were hemodynamically stable without signs of peritoneal irritation or other organ injuries. Nowadays, the concept of hepatic trauma treatment has changed substantially. Karkiner et al<sup>13</sup> summarized the indications of non-surgical treatment in 2005. A study showed that non-operative therapy is effective for isolated liver trauma.<sup>14</sup>

With the development of conservative treatment in medical field, non-operative therapy has been more and more used.<sup>15</sup> Asfar et al<sup>16</sup> revealed that about 80% of blunt hepatic injuries can be treated by non-operative therapy, especially the hemodynamically stable patients. In China, non-operative strategy is widely used in clinic, especially for minor blunt hepatic trauma and liver capsule bleeding. The reasons for this change lie in the following aspects: (1) in about half of blunt liver trauma patients, the bleeding has been stopped before exploratory laparotomy; (2) liver has the great capability of auto-hemostasis after injury; (3) CT has been improved and minimally invasive surgery has been developed; (4) medical treatment in intensive care unit is given.

The study of about 40 000 liver injured patients from 405 trauma centers showed that the probability of operative therapy for successfully treated complicated liver trauma is lower than 40%, regardless of whether or not other organs are injured. This data indicated that non-operative therapy for complicated liver trauma is more successful than operative therapy, and the success rate of non-operative therapy is increasing. In cases of serious liver trauma (levels III and IV), non-operative therapy reduced the mortality to 23.5%.<sup>6</sup>

Based on clinical experience, a substantial amount of evidences suggest that non-operative therapy has a great curative effect. Norrman et al<sup>17</sup> reported that the curative ratio for non-operative therapy was 89%. Besides the adults, non-operative therapy also presents beneficial outcome for children.<sup>18</sup>

For perforating liver injury, operation is the first choice; for multiple organ injury, exploratory laparotomy could find the occult trauma. For blunt trauma patients who are hemodynamically stable, non-operative therapy could be adopted, with monitoring vital signs.

In the absence of complicating factors, abdominal laparotomy is not dependent on the severity of hepatic trauma, as the success rate of non-operative therapy is 90%.<sup>19</sup>

For hepatic trauma patients, the doctors should pay close attention to the hemodynamic status. Hemodynamic stability is the basis of non-operative therapy, i.e., non-operative therapy depends upon the premise that the patients have no other injured organs, especially no intestinal damage.

The monitoring system, angiography and endoscopic retrograde cholangiography are very important for hepatic trauma patients. Doctors should be experienced in order to closely observe the patients and prepare for emergent operation in time. In the early stage, the doctors should accurately judge the severity of injury, monitor the patients' vital signs and ensure hemodynamic changes timely. Moreover, symptomatic treatment, nutritional support, and the maintenance of the patient's water and electrolyte balance are necessary to promote the healing of viscus organs, meanwhile the doctors should also pay attention to the protection of viscus function.

### Operative therapy of hepatic trauma

In China, it is believed that non-operative therapy applied for level III hepatic trauma should be very prudent. Due to a lack of

advanced medical techniques, most primary hospitals do not have adequate monitoring capacity, good ICU guardianship or liver specialists in medical team, and follow-up treatment options, especially after non-operative therapy fails. Therefore, for liver trauma, especially for serious and complicated liver trauma, surgeons should select the optimal treatment method according to the patient's condition and the medical conditions of the hospital and in the end, if possible, they should broaden the indication criteria for operative therapy as required. If the patients are hemodynamic unstable, they should be operated upon promptly.<sup>20</sup>

For perforating liver wounds, operative therapy is the first choice, and for multiple organ damage, exploratory laparotomy can locate and repair occult trauma. For blunt trauma patients, who are hemodynamic stable, non-operative therapy may be suitable, with close monitoring and appropriate preparation for operation.

The aim of operation is to ascertain the traumatic condition, stop any bleeding, prevent bile leakage, remove the devitalized tissues and give adequate drainage. For the patients who need surgical treatment, timing is important. It is reported in literature that about 6.1% of deaths occurred in "mors in tabula" or during the first 24 h after injury and 6.9% of deaths occurred during the hospitalization.<sup>21</sup> If the patients have absolute surgical indications, the surgery should be performed as soon as possible. The principle of surgical treatment is rapid hemostasis, thorough debridement and adequate drainage. Stopping bleeding is the key to treat hepatic trauma because it can influence the mortality of the hepatic trauma patients. In addition, thorough debridement and adequate drainage could reduce the decomposition products of necrotic tissue and prevent the formation of abdominal abscesses.

Surgeons should choose the most appropriate scheme according the result of surgical exploration and the wound condition. Operation methods include single pure suture, deep mattress suture, debridement, anatomical hepatectomy, hepatic arterial ligation, gauze packing, liver coated mesh method, etc. Surgeons should choose the optimal one.<sup>22</sup> Damage control is the principle for operative treatment since it may save time, which is beneficial for those patients transferred to other trauma centers, or requiring further treatment.<sup>4</sup>

Minor liver wounds can be treated by single pure suture. Deep mattress suture is appropriate for contusion and laceration of the liver in which the cleft is deep, including the placement of hemostatic gauze and omentum majus into the liver tissue defect. This is suitable for level III injury, and even some cases of level IV injury. Debridement should be performed based on the anatomical structure of the liver, in order to completely remove any necrotic tissues, ligature the damaged vessels and bile ducts, and retain the normal liver tissue to the greatest extent. This is routinely performed because debridement is focused upon the injured part of the liver, unlike anatomical hepatectomy.<sup>23</sup> The anatomical hepatectomy requires excellent technical skill and a prolonged operation time, and is thus rarely used clinically.

The peripheral hepatic gauze is effective to control bleeding for level III liver trauma, even for levels IV and V liver trauma. This technique is practical for primary hospitals. Nicol et al<sup>24</sup> found that the increased tamponade time was not associated with increased the morbidity of complications such as sepsis and bile leakage. The secondary operation should be performed 48 h after the condition becomes stable and the hypotension, hypothermia, acidosis and blood coagulation disorders should be corrected. The early performance of second surgery could lead to postoperative bleeding.<sup>25</sup> In addition, surgeons should pay attention to excessive filling of the vena cava or renal vein caused by tamponade, which may lead to abdominal compartment syndrome. The filling parts could get effective drainage in order to reduce the risk of infection.

Many surgeons usually use mesh wrapping for hepatic trauma. Mesh wrapping is to use absorbable synthetic mesh to pack the damaged area of the liver or the entire organ, to achieve hemostasis by compression. This method is suitable for extensive damage to the liver parenchyma or star-shaped liver laceration, which has vitality and is connected with hepatic pedicle.

Normally continuous hemorrhage results from the rupture of liver parenchyma or the damage of major blood vessels. To treat serious hepatic trauma such as levels III and IV injuries, the operation is still a challenge. If the patients present no hemodynamic instability, acidosis or blood coagulation disorders, stage I operation is advisable.

During the operation, surgeons should expose operation vision quickly and achieve hemostasis, and the key to treat the complicated liver trauma is to control hemorrhage. When the surgeon is unable to find the exact origin of bleeding, he should avoid suturing hemostasis or hepatic lobectomy blindly. Instead the surgeon could use “Pringle’s maneuver” to stop bleeding temporarily. If the tip is still bleeding, it suggests that the bleeding comes from the main hepatic vein or inferior vena cava. These liver traumas are very intractable and the mortality is very high. In theory, surgeons could dissociate and control the inferior vena cava and repair the venous directly, but in fact it is very difficult to get enough time to dissociate the blood vessel. Therefore, it is advisable to control bleeding with gauze and stabilize the conditions for the secondary phase of treatment. This method can improve the clinical outcomes in patients with complicated hepatic trauma.

### Novel techniques for hepatic trauma

In recent years, surgeons have developed new surgical methods to treat hepatic trauma, such as laparoscopic exploration, hepatic artery embolization and liver transplantation. The laparoscopic exploration is widely used for hepatic trauma patients, with advantages of damage control, clear vision, simple operation and high safety. With the development of interventional surgery, hepatic artery embolization is found to be an effective way to treat hepatic trauma patients, both adults and children, regardless of hemodynamic stability.<sup>26–28</sup> Some surgeons used transarterial microchip embolization to treat children who suffered from liver artery injury, and obtained beneficial results.<sup>29</sup> Transcutaneous contrast-enhanced ultrasound-guided injection of hemostatic agents was compared with traditional surgery treatment for liver, spleen and kidney trauma, presenting better outcomes.<sup>30</sup>

For the patients with large-area comminuted liver damage and some cases of levels III and IV hepatic trauma, liver transplant is their last resort, however, because of the lack of liver source for transplantation and high cost, it has not been widely applied.<sup>31</sup>

### Damage control of hepatic trauma

In 1983, Stone et al<sup>32</sup> proposed a theory of damage control surgery. In 1993, Rotendo et al<sup>33</sup> formalized the concept and the treatment specification of damage control surgery. Operative treatment may bring damages to patients, if combined with primary trauma, it may lead to a double-attack.<sup>4</sup> The focus of damage control surgery is the reduction of the adverse impact on patients. At present, damage control surgery is widely recognized, but it has strict indications: firstly, surgeons should act according to the traumatic condition of patients; secondly, the patients with serious combined injuries are preferred; thirdly, the patients present with hemodynamic instability, clotting disorders and low temperature. The most important purpose of damage control surgery is to rapidly control the hemorrhage, shorten operation time and avoid complex surgery. Before effective resuscitation, the surgeons should repair

liver vasculature to avoid the risk of low blood pressure, acidosis and clotting disorders. For a large area of comminuted liver rupture with uncontrollable bleeding, surgeons should stop the bleeding by stuffing gauzes around the liver and clear necrotic tissues as soon as possible. After hypothermia, acidosis and blood coagulation are corrected, surgeons can proceed to the operative stages. A majority of scholars, both in China and abroad, believe that the second phase of surgery should be 36–72 h after the patient becomes medically stable.<sup>10,34</sup> Concurrently, surgeons should be aware that this procedure may bring high risk of complications such as wound infection, abdominal abscess, wound dehiscence, even abdominal compartment syndrome.

### Postoperative complications of hepatic trauma

Due to severe hepatic trauma caused by extensive damage to the liver tissues, ischemic necrosis may cause a few complications such as bleeding, biliary fistula, abdominal abscess cyst formation.<sup>35</sup> These complications are dependent upon the severity of liver trauma. The drainage is necessary in such cases, i.e., the surgeons routinely set double tubes around the liver section and under the diaphragm area. Active postoperative observation, early detection and treatment are effective to prevent these complications. After operation, sustained low pressure suction for 48 h is suggested, together with washing if necessary, to guarantee unobstructed drainage and prevent postoperative wound infection.

Patients with postoperative bleeding or hemodynamic instability should undergo prompt reoperation. If the patient suffers from late-onset bleeding with hemodynamic stability, vascular embolization should be performed to pinpoint the vascular damage and embolize the artery. This can decrease the amount of blood transfusion required, and improve the outcome. If it fails, the surgeons should consider surgical treatment.<sup>9</sup> Postoperative cholestasis or peripheral hepatic abscess can be treated by percutaneous puncture drainage, either under the ultrasound or CT-guided. The patients with large cysts usually have clinical manifestations including right upper distension, dull pain, fever and increased bilirubin level, but WBC count shows no obvious change.<sup>36</sup> Biliary fistula can be treated by endoscopic retrograde cholangiopancreatography and endoscopic sphincterotomy, achieving satisfactory results.<sup>37</sup> Batur et al<sup>38</sup> reported a possibility of hepatic artery pseudoaneurysm, which should be paid attention to in clinic.

### Conclusion

At present, hepatic trauma is mainly managed by non-operative therapy in clinic. Serious hepatic trauma patients whose effective liquid recovery is still accompanied by hemodynamic instability require surgical intervention. The basic principle of operation is to control the trauma and choose the optimal operative method according to the general condition informed by surgical exploration. Meanwhile, surgeons' experiences and technical skill have great influence on the prognosis of the patients.

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