Chapter 5

Hepatic Trauma

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Additional information is available at the end of the chapter

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Abstract

Liver is the second most common solid organ frequently injured by blunt trauma and could be the commonest organ injured by penetrating trauma. The injury can be mild and goes undetected or detected and treated conservatively. It can be severe where the liver wounds can bleed until death. Once the patients with liver injury are resuscitated, the degree of liver injury can be evaluated using ultrasound scan and computed tomography imaging. If the patient is stable, diagnostic peritoneal lavage is very helpful when the imaging facilities are not available. Non-operative treatment of liver trauma has been proven to be valuable in 80% of patients with grade I, II, III and IV (grade I—mild injury; grade II—moderate injury; grade III and IV—severe liver injury). Laparotomy is mandatory if the patient's condition is unstable. By using the explorative laparotomy technique, the grade of liver injury is assessed, and accordingly the procedure is performed including suturing, ligation of the bleeding vessel, segmental resection, perihepatic packing, and so on. Morbidity and mortality of liver injury can be minimized with early diagnosis and appropriate management.

Keywords: liver injury, non-operative treatment, grading of liver injury, perihepatic packing

1. Introduction to surgical anatomy of liver

The liver is situated at the right upper quadrant of the abdomen, extending from the 5th intercostal space at the mid-clavicular line to the 10th costal margin, with a length of about 13 cm which is called the liver span. It weighs 1500 g and is the largest intra-abdominal organ, receiving 1.5 L of blood flow per minute. It is surrounded by a membrane called Glisson's capsule. It has two lobes—right and left—separated by falciform ligament, two fissures anteriorly where the ligamentum teres is attached, posterior fissure where the ligamentum venosum is attached and the third fissure on the right lobe called porta hepatis where the hepatic triad enters the liver.

1.1. Surfaces of the liver

The liver has diaphragmatic surface which is related to chest cage. Visceral surfaces are related to the following structures: right kidney, right adrenal gland, gall bladder, duodenum and hepatic flexure.

Its surface is attached to the diaphragm by a falciform ligament, right and left triangular ligament and coronary ligament.

The liver is composed of eight segments. Each lobe is composed of four segments. Each segment has its own artery, vein and duct and can be resected separately without interfering with the other segments.

Cantlie line is an imaginary line that goes from the gall bladder fossa to inferior vena cava.

The liver is composed of hepatic plates. Each plate is composed of hepatocytes, sinusoids and Kupffer cells.

1.2. Vascular supply of liver

Hepatic artery comes from the coeliac axis and divides into the right and left. It supplies 25% of blood to the liver, and portal vein supplies 75% of blood to the liver tissues. The portal vein is formed by superior mesenteric vein and splenic vein behind the neck of the pancreas.

1.2.1. Hepatic veins

There are three large hepatic veins, which drain the hepatic parenchyma of the liver lobes into the inferior vena cava.

1.2.2. Nerve supply

Parasympathetic nerve from the right vagus via coelic plexus, left vagus to porta hepatis, and sympathetic nerve along the blood vessels.

Function of the liver:

1. Bile production and secretion.
2. Detoxification of toxins.
3. Protein synthesis.
4. Production of heparin, bile pigments.
5. Storage of glycogen.
6. Erythropoiesis in infants.

Epidemiology of liver trauma:

Liver is the second most common abdominal organ that can get injured by blunt trauma [1, 26] and is the most common cause of death in abdominal trauma—100% mortality if untreated

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or missed from examination. Blunt abdominal trauma is more fatal than penetrating trauma. Before 1993, all liver injuries were treated through surgery. From 1998 onwards, non-operative treatment was introduced as the standard method of treatment for liver trauma with 80% of adult liver trauma treated conservatively and 97% of children also treated non-operatively [25].

Liver injury can be mild when the trauma affects less than 25% of one lobe, moderate when the trauma affects between 25 and 50% of the lobe, and severe when the trauma affects more than 50% of the lobe.

Why liver is prone to trauma?

The liver is prone to trauma for the following reasons:

1. Fixed position of the liver: The liver is an organ which is huge and fixed at the right upper quadrant of the abdomen.
2. Liver is an organ with friable parenchyma.
3. Liver has a thin capsule.

Liver trauma can be the following:

Subcapsular haematoma, laceration, contusion, liver avulsion, bile duct injury, and gall bladder injury. Eighty percent of liver trauma involves segments 6, 7 and 8.

2. Etiology of liver trauma

The liver can be injured commonly by the following:

1. Blunt trauma commonly due to road traffic accident and can follow fall down from height. Blunt liver trauma is 10 times more fatal than penetrating trauma [7]. Blunt abdominal trauma can sustain up to 1–8% of liver injury. Hepatic trauma forms 15–20% of abdominal trauma and 80% of blunt trauma.
2. Penetrating trauma caused by a bullet or by stabbing with a sharp instrument.
3. Iatrogenic trauma is very rare during surgery or during performance of percutaneous transhepatic cholangiography (PTC). Hepatic vein injury can occur during insertion of (transjugular portosystemic shunt (TIPS).

2.1. Diagnosis of liver trauma

2.1.1. A: Clinical picture of liver trauma

1. Liver injury can be obvious.
2. Liver injury can be easily predicted.
3. Liver injury can be difficult to predict.

Obvious liver trauma:

Liver injury can be positively diagnosed where the following points are clearly established:

1. The patient is in a state of shock where he or she was involved in a road traffic accident or hit by a bullet at the right upper quadrant of the abdomen.
2. The patient is with hypotension and pain at the right upper quadrant of the abdomen after a road traffic accident.
3. Hypotensive patient shows tenderness over the right side of chest with fractured ribs after the trauma.
4. Hypotensive patient with bruises at the right upper quadrant.

Liver trauma can be easily predicted with the following points borne in mind:

1. Drop in blood pressure in a patient with road traffic accident and with guarding and tenderness at the right side of the upper abdomen.
2. Penetrating wound at the right upper quadrant of the abdomen.

Liver trauma is difficult to predict:

1. Normal blood pressure with right upper abdominal pain with guarding and tenderness at the right upper quadrant

Clinical presentation of liver trauma:

1. Pain at the right upper quadrant.
2. Fracture of right lower ribs.
3. Shock

Grading of liver trauma: **American association of trauma**

Grade I: Subcapsular haematoma less than 10% of the surface area. Laceration less than 1 cm.

Grade II: Haematoma more than 10–50% surface area. Laceration from 1 to 3 cm.

Grade III: Haematoma more than 50%. Laceration more than 3 cm.

Grade IV: Ruptured haematoma and bleeding. Laceration of the liver from 25 to 75% of the lobe.

Grade V: More than 75% of liver laceration, retrohepatic vena cava injury or hepatic vein injuries.

Grade VI: Hepatic avulsion.

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2.1.2. B: Investigations

2.1.2.1. Routine investigations

Routine examination includes full blood count, electrolytes, blood sugar, urea, hemoglobin may be normal where the injury is simple, or there may be low hemoglobin indicating blood loss where the injury is severe.

Liver function tests were not done at the admission time and may not be needed if the injury is simple; it could be done if the case showed severe liver trauma. Liver function includes bilirubin, and liver enzymes include glutamic pyruvate transaminase (GPT), glutamic oxaloacetate transainase (GOT) and alkaline phosphatase (ALK) phos.

Blood group is done routinely in all patients with hepatic trauma.

2.1.2.2. Imaging investigations

Ultrasound scan for liver trauma has 99% of specificity and 88% of sensitivity [19–21]. Fast ultrasound replaced peritoneal lavage. Looking to Morrison space if there is fluid in the space indicating bleeding. The use of contrast with ultrasound scan is more beneficial in liver trauma.

CT scan: This is done on a stable patient with oral and intravenous contrast. CT scan for liver injury has more than 90% of sensitivity and specificity (**Figure 1**). Useful for diagnosis of liver injury and follow-up of liver trauma, for any hemorrhage, bile accumulation or sepsis.

X-ray: X-ray chest may show fractured ribs at the site of the liver from 7th to 9th rib but is not specific and not done to look for liver injury.

DPL Diagnostic peritoneal lavage: This is an invasive procedure done on patients with trauma when there is intraperitoneal bleeding. It is useful and produces good results when performed by expert, but nowadays, it is replaced by ultrasound scan.

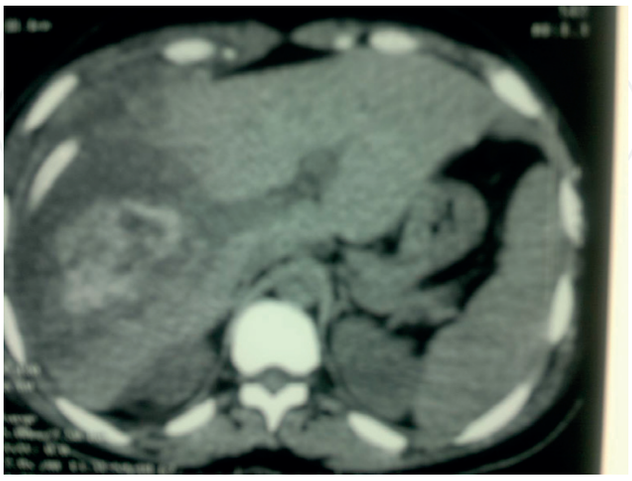

Figure 1. CT scan for a patient with massive liver trauma.

2.2. Treatment of liver trauma

Table 1 shows the number and types of liver trauma treated using different treatments in a busy general hospital.

Eighty percent of adults with liver trauma were treated conservatively, and 97% of those were children who were treated conservatively.

Healing of liver trauma: The liver has good capacity of healing once it is traumatized.

Mild liver trauma: Less than 25% of lobe damage takes 3 months to heal.

Moderate liver trauma: Between 25 and 50% takes 6 months to heal.

Severe injury: Liver injury, which encompasses more than 50% of lobe injured, takes 9 months to heal or more.

Patients with liver trauma blunt or penetrating, mild or severe once diagnosed or suspected should undergo resuscitation as usual traumatized patients, which include caring of respiration, putting good venous access for the fluids, treating emergency killing conditions like tension pneumothorax, fixing urinary catheter to know the output. After patient resuscitation, the grading of liver trauma is evaluated clinically and by imaging and the mode of treatment is planned which will include either [8–10].

1. Non-operative treatment.
2. Operative treatment.
3. Interventional radiology treatment of liver trauma.

Mode	Number of patients	Lobe	Grade	Procedure	Outcome
RTA	94	Left lobe and right lobe	Range from grade I to VI	1. Conservative treatment: 35 cases 2. Diagnostic laparoscopy: 12 suturing and insertion of drain 3. Laparotomy: 47 3-A. Repair of liver wounds: 30 3-B. Packing: 14 perihepatic packing 3-C. Resection: Three had segmental liver resection	13 died
Bullet	124	Left lobe Right lobe	Grade I and II had few patients, and most were grade III, IV	All underwent laparotomy, debridement, repair, omental packing, eight patients had perihepatic packing	18 died
Stab	13	Left lobe and right lobe	I and II	Conservative management	Nil

Table 1. Different types of hepatic trauma patients who were treated at Zliten teaching hospital.

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2.2.1. Conservative treatment of liver trauma

Blunt liver trauma can be mild, moderate or severe. Mild and moderate liver trauma can be managed conservatively without surgery [3, 11, 15, 18].

Conservative treatment includes the following:

1. Full assessment of patients.
2. Full assessment of the grade of liver injury by ultrasound and CT scan.
3. Correction of blood loss by giving blood.
4. Daily monitoring of patient.
5. Discharge of patient once he is fully stable and active.
6. Post-discharge follow-up by clinical assessment and imaging.

2.2.2. Non-operative treatment of liver injury

Non operative management was firstly conducted in children than started in adult, it is not indicated in elderly patients, choosing of the patients for non-operative management (NOM) depends on clinical condition of the patients and associated injury, less on grade of the liver of injury [2, 16].

2.2.3. Advantages of NOM

1. Less hospital stay.
2. Avoidance of unnecessary laparotomy.

An unstable patient can be defined as follows:

1. Systolic blood pressure less than 90 mmhg.
2. Pulse rate more than 120 beats per minute.
3. Altered consciousness level.
4. Altered breathing.
5. Cold clammy skin.

About 80% of blunt liver trauma can be treated conservatively, provided the patient is haemodynamically stable. It can be utilized even in grade IV.

Non-operative treatment can be performed for the following reasons:

1. Patients who are haemodynamically stable with no signs of peritonism.
2. Operative management should be available when needed.

3. Imaging facilities should be available to follow the treatments, which can lead to 100% success rate.

Liver trauma at Zliten University Hospital over a period of 9 years from 2009 to 2017—Patients: 231, deaths: 31, patients who underwent conservative treatment: 48 (**Table 1**).

Most of our patients with liver trauma during war, the time where the weapon is scattered in many regions of the country; none of our patients with hepatic trauma having had gun shot wounds left for conservative treatment, and all patients underwent surgery. This number affected our conservative management in hepatic trauma. Our rate of conservative treatment for patients with hepatic trauma was approximately 50%.

2.2.4. Complications of NOM

Complications of NOM can be diagnosed by clinical examination including blood tests, ultrasound scan and CT scan. Complications may reach up to 7% in grade III and V.

1. Bile collection may reach up to 20%—biliary peritonitis. Haemobilia: Bile leak is treated with endoscopic retrograde cholangiopancreatography most of our patients with liver trauma were during war. If fluid collection is significant, it can be drained percutaneously, laparoscopically or open surgery. **Figure 2** shows the CT of a child with hepatic trauma managed conservatively with the development of bilioma). **Figure 3** shows bilioma collection that was treated by laparotomy.

   Nagano-classified bile leak:

   Type A: Minor bile leak, small radicle from the liver surface—resolved spontaneously.

   Type B: Bile leak from a major duct on the liver surface not tied.

   Type C: Injury of duct branch from the main duct at the hilum.

   Type D: Main bile duct transected.
2. Infection and abscess formation may reach 7% and can be treated conservatively when clinical manifestation is significant.
3. Liver necrosis can be diagnosed clinically with raised liver enzymes, coagulation abnormalities or bile leak.
4. Bleeding: Hepatic artery pseudo-aneurysm accounts to about 1–2% and can be either extrahepatic or intrahepatic—more cases of extrahepatic nature. Liver compartment syndrome due to compression of the liver by huge subcapsular haematoma may result in liver failure.

2.2.5. Surgical treatment of liver injury

1. Surgery is indicated in a patient who is unstable.
2. Surgical treatment is indicated if the patient was on conservative treatment and showed signs of deterioration, [8, 27–29].

Surgical procedures (**Figure 4** shows different repair of liver trauma).

1. Simple suturing of liver tear.
2. Debridment of unhealthy liver tissue and suturing.
3. Resection of severely damaged segment.
4. Liver lobectomy or hepatectomy for severely damaged lobe.

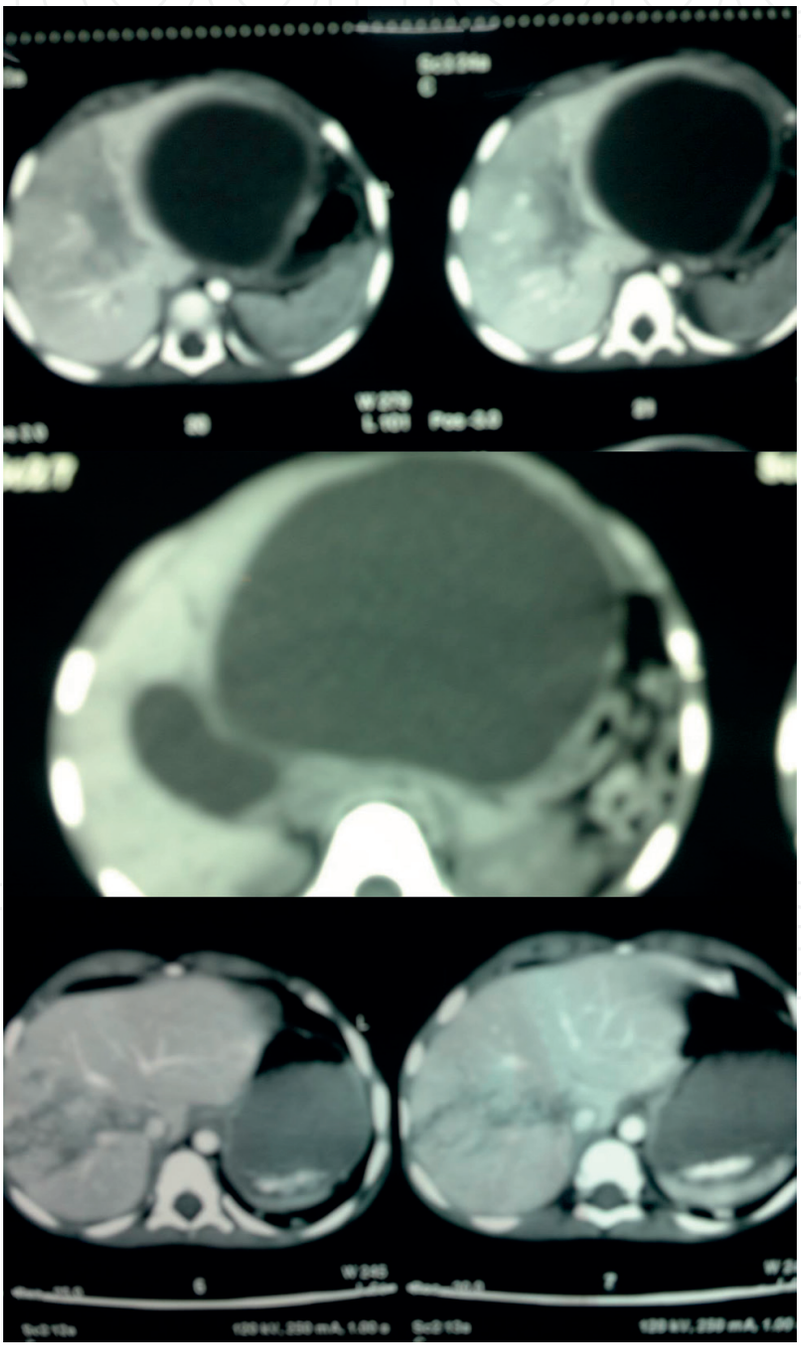

Figure 2. CT abdomen of a child who had liver trauma and was treated conservatively developed bile collection as a complication of hepatic trauma management.

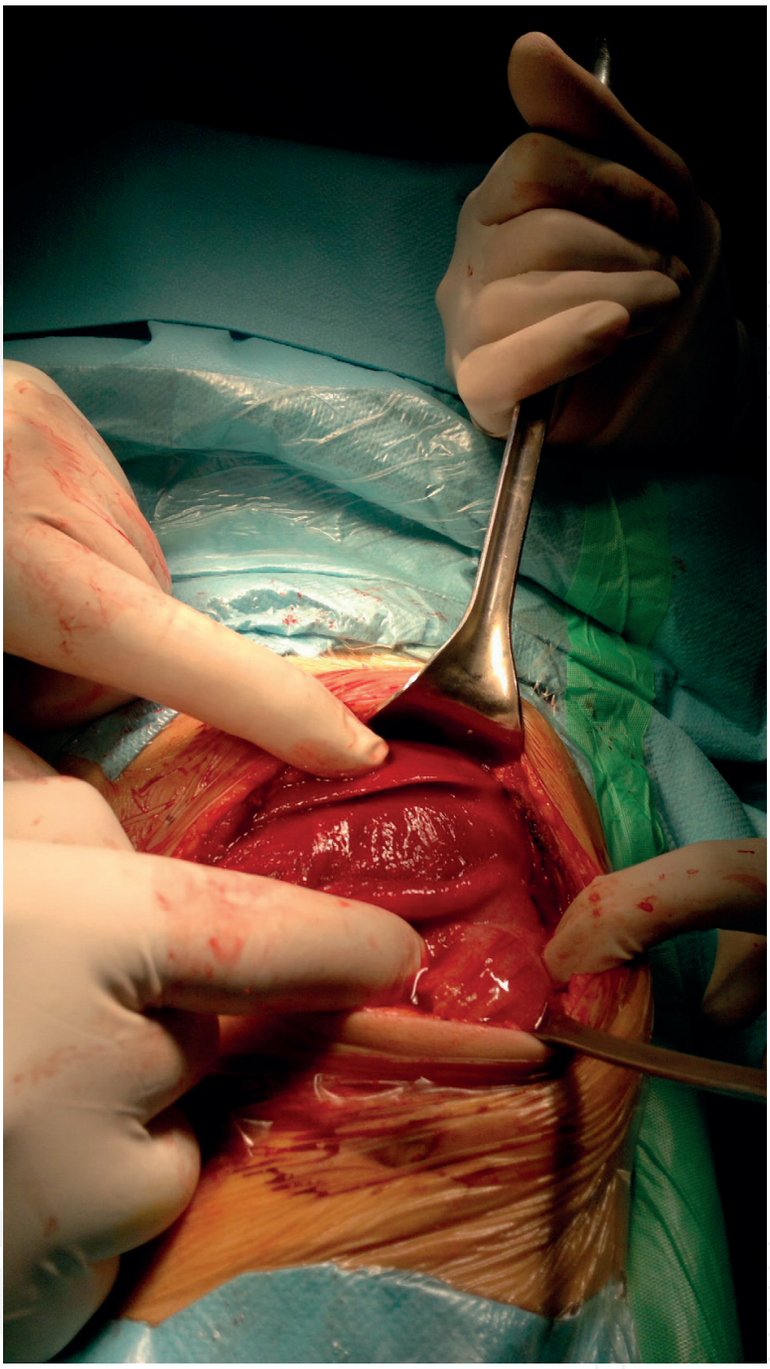

Figure 3. Child who had liver trauma managed conservatively and complicated by bile leak, presented with encysted bilioma. The child underwent laparotomy.[13].

5. Perihepatic packing for uncontrolled bleeding in unstable patients.
6. Arterial embolization which can be performed as the first option in patients who are planned for non-operative treatment or for those patient who developed bleeding after surgery [17].

Damage control in liver trauma:

Damage control is of three phases:

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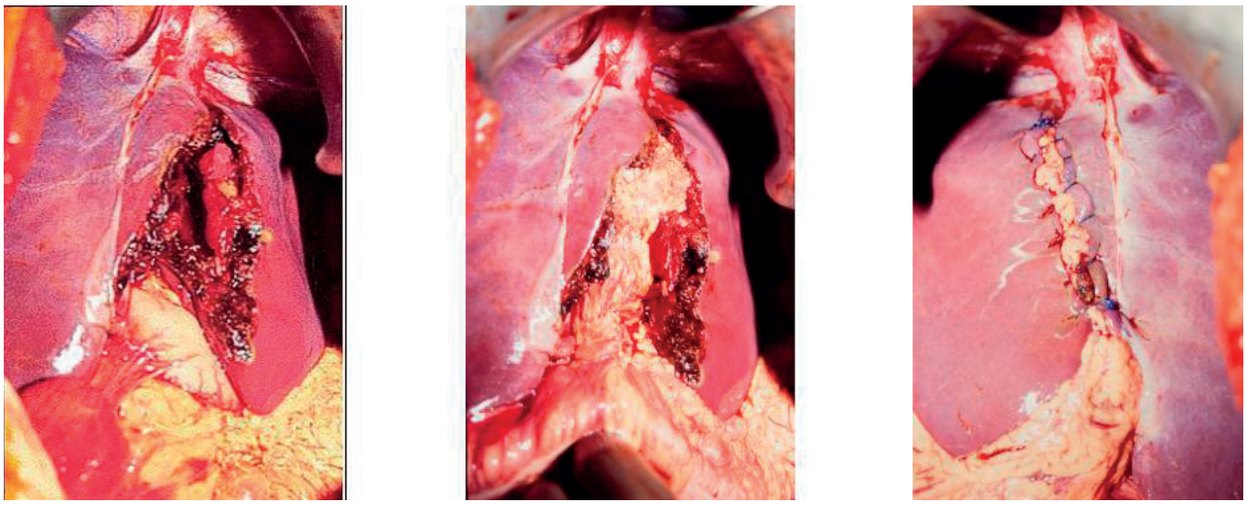

Figure 4. Liver trauma repaired and the wound packed with omentum (taken with permission from Prof. Ronald M. Stewart).

Phase I: Control of bleeding, closure of the abdomen.

Phase II: Intensive care unit resuscitation and overcome on acidosis, hypothermia, hypercoagulability.

Phase III: Re-exploration of the abdomen.

In 1983, Stone et al. proposed damage control for trauma patient [6, 14, 22–24]. Once patient had severe liver trauma, where the condition of the patient is deteriorating during surgery and the bleeding is continuous from the damaged liver, either the damage at the posterior aspect or whole of the liver, damage control is utilized in the form of packing the liver with abdominal gauze pack which are wrapped around the liver [4–6]. This technique is useful in the management of controlling the bleeding that occurs during surgery and liver resection. Packing is also useful to avoid the three killers of the patient during surgery which includes acidosis, hypercoagulability and hypothermia, which can cause cardiac arrest. To avoid the occurrence of these bad incidents, we should change to damage control. Usually six packs are placed around the liver to stop the bleeding. The abdomen left either open or closed depending on the patient's condition with the use of Bogota bag. Packing the liver with gauze packs can be complicated when patients need to go through full resuscitation in the ICU. For the correction of the three killers including acidosis, hyperthermia, hypercoagulability, usually it needs time for our patients 48–72 h to control sepsis with the use of antibiotics.

Complication of perihepatic packing:

The complication of perihepatic packing includes the following:

1. Compartment syndrome.
2. Respiratory embarrassment due to compression on the right dome of the diaphragm.
3. Abdominal sepsis if the packs were left longer than 3 days.

Other surgical procedure for liver trauma include

1. Laparoscopic assessment of liver trauma and suturing of liver tear [12].
2. Liver transplantation for severely damaged liver is difficult to perform because of availability of the liver and the experienced team.
3. Liver exclusion and extracorporeal circulation is seldom done for severe liver trauma.

Controlling of liver bleeding: Bleeding from the liver is controlled by the following procedures

1. Simple suturing.
2. Hepatorrhaphy and control of the arterial bleeding.
3. Use of omental pack and mattress sutures.
4. Selective hepatic artery ligation may control the bleeding.
5. Non-anatomical resection, anatomical resection, venovenous shunt, atriocaval shunts.

Mortality of blunt trauma is 27% and of penetrating trauma is 11%.

Overall, mortality of liver trauma is 10%, Grade III and IV mortality is 10% and V and VI are 75%.

There are many haemostatic materials used for liver trauma are very helpful for controlling the bleeding, which includes the following:

1. Surgical.
2. Spongostan.
3. Tacoceil.
4. Fibrin glue.

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