Chapter

Liver Trauma Management

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Abstract

Liver trauma is responsible for the majority of penetrating abdominal trauma and is the third most common injury caused by firearms. Presenting a 20% mortality rate, it is an organ with wide and complex vascularization, receiving blood from the hepatic veins and portal vein, as well as from the hepatic arteries. The diagnosis is not always simple in polytrauma patients and contains a wide range of exams such as computerized tomography and diagnostic peritoneal lavage. Treatment depends mostly on a few factors such as the patient's hemodynamic stability, the degree of injury according to the AAST classification, the resources available, and the surgeon's expertise. Considering these factors, minor lesions can be treated mostly with a conservative approach in hemodynamically stable patients. Embolization by arteriography has shown good results in major lesions in clinically stable patients as well. On the other hand, more complex lesions associated with hemodynamically unstable patients may indicate damage control surgery applying techniques such as temporary liver packing and clamping the pedicle to restore the hemodynamic status. This chapter aims to describe those techniques and their indications in liver trauma.

Keywords: liver trauma, damage control surgery, hepatic trauma, hepatic surgery, trauma surgery

1. Introduction

1.1 Liver trauma

Trauma is the leading cause of death in people aged 1–44 years, with hemorrhage being the primary cause of preventable death, accounting for 30–40% of fatalities [1]. The liver is the main organ affected in penetrating abdominal trauma in 35–45% of cases, mainly due to its susceptible and relatively superficial location in the right hypochondrium [2], and is the most commonly injured organ in patients suffering blunt abdominal trauma as well [3].

2. Incidence

Data from the National Trauma Data Bank (NTDB) showed that liver injury occurs in almost 40% of victims of blunt abdominal trauma with an overall mortality of 14.9% [4]. Liver trauma can range from minor lacerations or capsular hematomas with minimal morbidity and mortality to hepatic avulsions with high mortality.

Most hepatic injuries are minor and can be graded using the American Association for the Surgery of Trauma Hepatic Injury Scale as described under the "classification" topic ahead [5].

The right lobe of the liver, being the largest portion of the liver parenchyma, constitutes the region most affected during abdominal injury. It is known that it occurs more frequently in males and in young individuals, in the first four decades of life, in the majority of cases. Associated factors include risky behavior, such as alcohol and drug consumption, and more exposure to accidents. The mortality of patients with liver trauma ranges from 14.9–20%. When associated with shotgun lesions, the severity of the injury tends to be higher; therefore, the mortality could be up to 20% [6].

3. Classification

The severity of liver injuries is classified according to the American Association for the Surgery of Trauma (AAST) grading scale. This scale is based on parenchymal level of injury and number of liver segments affected.

To understand the classification of liver trauma, it is essential to master the anatomy of the liver. The division of the liver by the Couinaud segments occurs through the branching of the portal triad, composed of the branch of the portal vein, the hepatic artery, and the bile duct. The ramifications of these vessels cause the portal blood to be mixed with the blood in the hepatic artery in the portal spaces, which drains into the centrilobular vein, subsequently into the sublobular veins, and through the two hepatic veins, which end in the inferior vena cava. **Table 1** shows the classification of liver trauma according to the AAST.

The degree of liver injury and hemodynamic instability are important determinants in the mortality rates of patients with liver trauma as well as to determine the type of treatment to be instituted [2]. The concomitance of intra-abdominal injuries with liver trauma is common in penetrating trauma, and it is also a relevant factor

Grade of liver injury	Type of injury	Description of injury
I	Haematoma	Subcapsular, <10 % surface area
	Laceration	Capsular tear, <1 cm parenchymal depth
II	Haematoma	Subcapsular, 10–50 % surface area
		Intraparenchymal, <10 cm in diameter
	Laceration	1–3 cm parenchymal depth, <10 cm length
III	Haematoma	Subcapsular, >50 % surface area or expanding. Ruptured subcapsular or parenchymal haematoma
		Intraparenchymal haematoma >10 cm or expanding
	Laceration	>3 cm parenchymal depth
IV	Laceration	Parenchymal disruption involving 25–75 % hepatic lobe or 1-3 Couinaud's segments in a single lobe
V	Laceration	Parenchymal disruption involving >75 % of hepatic lobe or >3 Couinaud's segments within a single lobe
	Vascular	Juxtahepatic venous injuries, i.e., retrohepatic vena cava/central major hepatic veins
VI	Vascular	Hepatic avulsion

Table 1.
Classification of hepatic trauma (AAST).

in the management. [6] However, in many cases, there is no correlation between the AAST degree and the patient's physiological state [7].

Most patients have grade I injuries, and the incidence gradually decreases as the degree of injury increases, as shown by a study conducted with 300 patients between 2003 and 2013 at the Department of Surgery and Emergency, in Kartal [2]. It was found that the prognostic factors [2] related to the worst outcome were high levels of AST, ALT, LDH, INR, and creatinine and low levels of platelets and fibrinogen at admission, which were also associated with liver injuries of grades IV and V.

4. Diagnosis

Currently, the most useful complementary exams in the diagnosis of liver trauma are abdominal ultrasound and computed tomography (CT) with intravenous contrast. Abdominal ultrasound is the initial image exam, with a sensitivity of 82–88% and specificity of 99%, to detect intra-abdominal injuries, although it must be taken into account that the accuracy depends on the examiner's experience [8]. Computed tomography is the most sensitive and specific technique for determining the extent and severity of liver trauma and is the imaging test that provides us with more information on polytrauma patients, since it offers an excellent view of the skull, chest, abdomen and pelvis, bone structures, viscera, and soft tissues. The arrival of helical technology has improved the resolution, reduced the duration of the exam, and allowed the three-dimensional reconstruction of the images, which is very useful if there is vascular involvement.

Diagnosis by peritoneal lavage (LPD), with the advent of new imaging techniques, has fewer indications. Although it has an accuracy of 98% to detect intraperitoneal blood, it lacks specificity of the injured organ, which causes many unnecessary laparotomies [8].

In patients with hemodynamic instability, the Focused Assessment with Sonography for Trauma (FAST) is the exam of choice due to its sensibility to detect free fluid in the abdomen, and it can be done faster than CT as an initial exam. **Figures 1, 2**, and **3** show some possible changes in abdominal CT in patients with liver trauma.

Some more recent studies have shown the role of two-dimensional and three-dimensional [15] ultrasonography (US) in the trauma of massive viscera, such as the liver. There is evidence that the regular US is not capable of having high

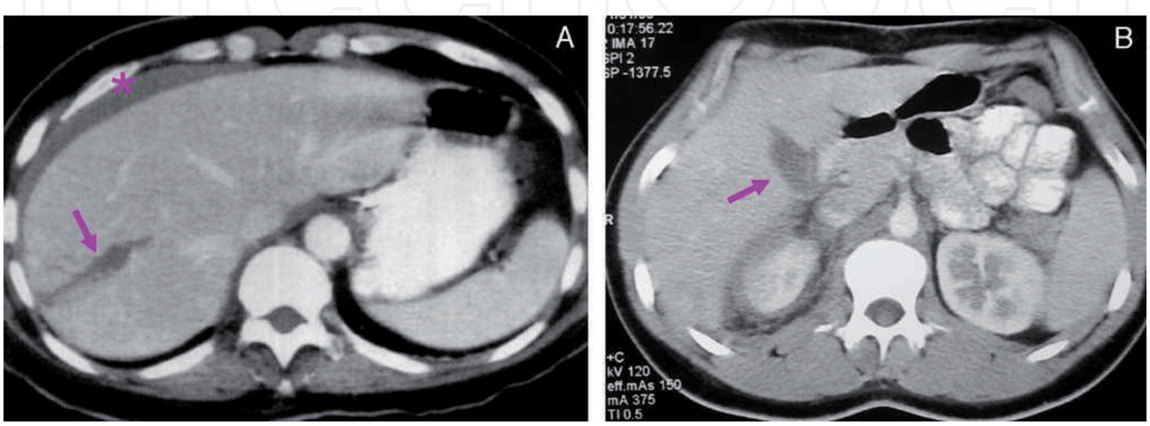

Figure 1.
Hemorrhagic hepatic lacerations (A) in the right hepatic lobe and (B) close to the hilum. Hypodense areas of linear morphology that come into contact with the capsule (arrows). They associate free liquid (asterisks).

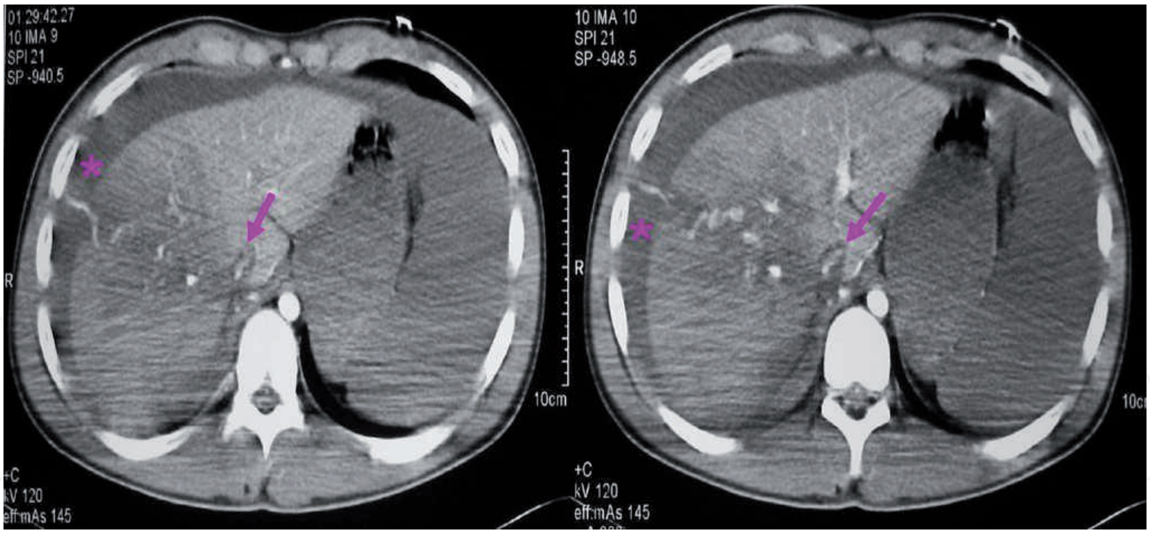

Figure 2.
Extension to the inferior vena cava. There is a large hepatic termination with extension to the inferior vena cava (arrow), which appears to be free of perihepatic primary fluid and active for bleeding (asterisk).

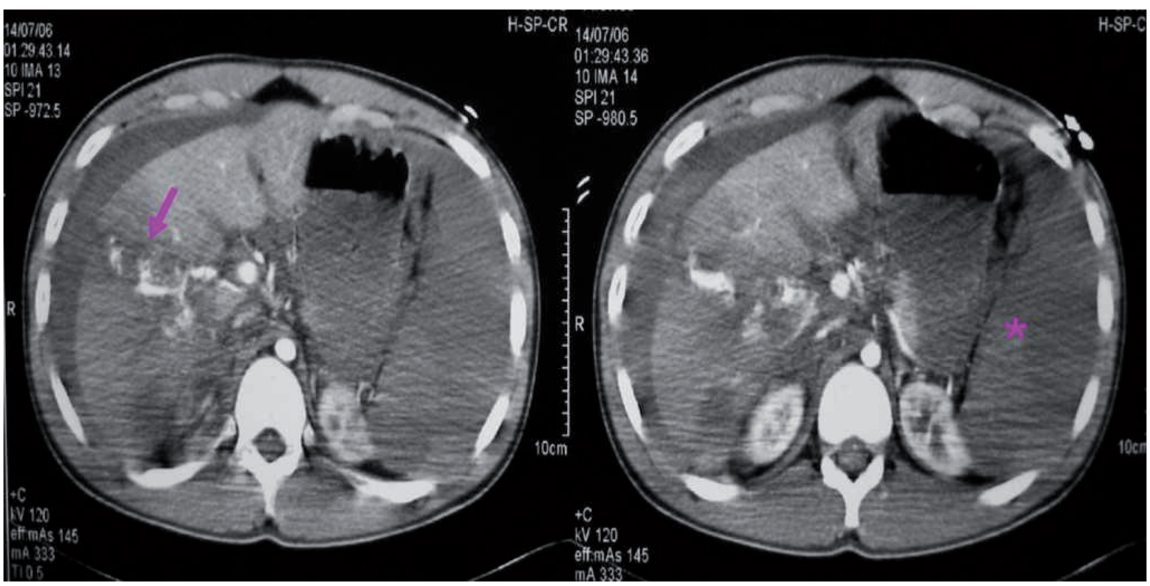

Figure 3.
Active bleeding. Active contrast leakage (arrow) is observed in a patient with severe hepatic trauma. Associated perihepatic fluid (hemoperitoneum). Splenic infarction (*).

sensitivity to detect active bleeding in a solid abdominal organ. In recent years, US using contrast agents could greatly improve the detection of bleeding. Recently, contrast US has mainly depended on two-dimensional ultrasound (2DUS). With the development of imaging technology, three-dimensional static ultrasound (3DSUS) and real-time three-dimensional ultrasound (RT3DUS) can provide more accurate images and additional information in some assessments of abdominal disease. Thus, there are new technologies and possibilities for measuring the degree of hepatic impairment, but these are not always available, and sometimes just the physical examination is possible as a diagnostic tool [8].

5. Treatment

The treatment for liver trauma has been modified over the years, since the beginning of the twentieth century, when aggressive surgical treatment predominated, which gradually changed over the decades to more conservative treatment, especially after the Second World War.

6. Indications

"Miss nothing and fix everything" has long been the dogma for emergency management of visceral trauma, which imposed obligatory emergency laparotomy for any hemoperitoneum. For blunt hepatic trauma, that attitude has been gradually transformed since the 1970s, moving toward avoidance of emergency laparotomy whenever possible [9–11]. Introduction nonoperative management of blunt liver injury has been proven to be an effective treatment option since the late 1990s, regardless of the degree of injury as long as the patient's condition remains stable [12–14].

Currently, nonoperative management is undertaken in 60–80% of blunt traumatic liver injuries, and [15, 16] the success rate is 82–100% [8, 15, 17]. The overall mortality and morbidity of those cases is 5–8 and 14–18%, respectively [15–17]. The overall mortality in surgically managed patients is 9–18%, but in high-grade injuries (grades III–V) the mortality is around 40%, and the overall morbidity in operated patients is 30–40% [15, 17]. Coimbra et al. [18] have reported that nonoperative management reduces the overall mortality of grade III and IV blunt liver injuries [19].

This approach has been supported by not only the contribution of contrast-enhanced CT [9–11] but the endoscopic and radiological adjunctive interventional procedures as well, which have expanded its scope and helped managing postoperative complications [15].

A review of the literature about the indications and effectiveness of liver angioembolization in the context of trauma showed that the main indications for this procedure are the presence of contrast blush on CT scan (the most common) and failure in nonoperative management and control of continued bleeding after damage control surgery. The authors included 11 articles related to the topic, with the rate of effectiveness of hepatic angioembolization being 93%, and the main complications highlighted were the presence of liver necrosis (15%), abscess formation (7.5%), and biliary leakage [20].

7. Surgical treatment

Despite the trend of nonoperative treatment and continued advances in the areas of trauma and critical care, uncontrolled bleeding from major liver injury is still the leading cause of death and continues to frustrate trauma surgeons [12]. Therefore, it is crucial for the surgeon to know when surgery is needed. The two most important criteria for indicating immediate operative treatment to a patient with a hepatic injury are the presence of hemodynamic instability and the existence of peritoneal irritation, regardless of the grade of injury or the volume of hemoperitoneum.

There are several surgical techniques that could be applied depending upon the complexity of the lesion including simple manual compression, Pringle's maneuver (clamping of the hepatoduodenal ligament), hepatorrhaphy, hepatectomy, hepatic artery ligation, and liver resection. Finally, in the direst of circumstances and under specific indications, even a liver transplant can be considered [6]. Regarding the incidence of the surgical techniques employed, hepatorrhaphy is generally the most used procedure in most cases, and the least used are epiplonplasty and left hepatectomy, according to a recently published study, as shown in **Table 2** [6].

Technique*	Patients	%
Hepatorrhaphy	86	80.37
Segmentectomy	2	1.87
Left hepatectomy	1	0.93
Electrocauterization	4	3.74
Topical hemostatic agents	2	1.87
Epiploplasty	1	0.93
Damage Control	7	6.54
No action (liver damage with no active bleeding)	12	11.21
Nontherapeutic laparotomy	4	3.74

Table 2.
Surgical techniques used to treat liver injuries in patients with liver trauma.

8. Damage control surgery

8.1 Background

Besides all advances portrayed, the prognosis of hemodynamically unstable patients with complex (AAST Organ Injury Scale 4 IV–V) liver injury is still poor, as their treatment and decision-making process are extremely challenging for the trauma team [21]. It is known that approximately 10% of the patients in this scenario will present life-threatening injuries and hemodynamic shock and that the primary and ultimate repair of severe traumatic injuries in patients with unstable physiology is detrimental to outcome [1, 22, 23]. A staged management approach known as "damage control surgery" (DCS) has been demonstrated to improve the survival in these cases [1, 22]. The principles of DCS involve abbreviated surgery to control blood loss and contamination in the abdomen with simultaneous resuscitation of physiology. Once the hemodynamic state is restored, the definitive surgical repair is performed [22, 24].

Although the term "damage control surgery" was first described for trauma management by Rotondo et al. [22], the idea of the procedure was already existent for a long time before. The proposal to use this surgery in trauma and emergencies has succeed during the Second World War, in the mid-1940s, when the structure for hospital care was insufficient and the number of victims exceeded the capacity to give support to the injured [25]. There are older reports of the application of this technique with similar purposes in Edwin Smith's Surgical Papyrus, more than 8000 years ago, a conduct used by the absence of other options at the time the idea was conceived [26].

According to a review by Benz and Balogh about damage control surgery, its modern model emerged in the late 1970s from clinical experience with major hepatic trauma [27]. Perihepatic packing consists in manually approximating the liver parenchyma followed by the consecutive placing of dry abdominal packs around the liver and straight over the injury. This technique was firstly incorporated by Pringle [28] in enthusiasm for staged laparotomy. Since then, numerous clinical reviews were conducted in order to study this technique.

Elerding et al. [29] observed that 82% of deaths following liver trauma were due to uncontrolled hemorrhage and progressive coagulopathy, even after primary vascular injuries had been addressed. The whole lethal coagulopathic state apparently was impaired by hypothermia and acidosis, the observation upon which the "lethal triad" term was suggested [23]. In 1981, Feliciano et al. [30] reported on the observed merit of temporary laparotomy pad tamponade for postinjury coagulopathy. Nine out of 10 patients with persistent hepatic parenchymal ooze, despite all attempts at surgical control, survived with intra-abdominal packing and delayed removal. This finding led the authors to advocate the technique as a lifesaving maneuver in select trauma patients with persistent coagulopathy. Two years later, Svoboda et al. [31] reaffirmed the survival benefit of intra-abdominal packing.

Despite being initially organized as an emergency strategy in patients who have suffered severe trauma, the principles of damage control have also been approached in nontraumatic abdominal emergencies, in order to reduce mortality compared to definitive primary surgery [32]. According to the 10th edition of ATLS [33], damage control surgery is an important component of crisis management care, given that in many disasters, hospitals are destroyed and transportation to medical facilities may not be feasible or the environment may be contaminated, so this context is an option for using this technique.

8.2 Intra-abdominal packing

Damage control surgery by intra-abdominal packing has shown to be effective and able to significantly decrease morbidity and mortality, both in trauma and nontraumatic massive intra-abdominal hemorrhage [34]. In the last decades, consensus has been reached about considering the accomplishment of an effective perihepatic packing [35] to be the most effective and quickest way in order to obtain hemorrhage control [21].

This procedure consists in the placement, after fast and complete mobilization of the right liver lobe, of a total number of eight lap pads all around the posterior paracaval surface (avoiding vena cava compression), the lateral right side, the anterior surface, and posteroinferior visceral surface of the liver (avoiding any intrahepatic packing) [36, 45]. The diaphragmatic surface must remain free in order to avoid any respiratory compromise. Reoperation after appropriate resuscitation allows packing removal and definitive repair of liver injuries.

8.3 Indications for damage control surgery

Regarding the indications for damage control surgery, it is known that there is a wide range of conditions in which it can be used, and the decisive moment for the use of these techniques is not preoperative adequacy, but the intraoperative becomes essential for the evaluation [37].

Overall, in the context of severe trauma with hemodynamic instability, the rationale of performing a "shortened laparotomy" is usually based upon the concept of the lethal triad [25], composed of hypothermia (due to inadequate environmental conditions, deficient thermal protection, blood loss, and infusion of unheated liquids), metabolic acidosis (inadequate tissue perfusion, caused by hemorrhage and shock, which predisposes to anaerobic metabolism and metabolic acidosis), and coagulopathy (metabolic acidosis with interference on coagulation factors and volume replacement).

In a practical manner, there are some absolute indications for the procedure, such as estimated blood loss greater than 4 L and the administration of more than 10 red blood cell concentrates [37]. Although there are classic indications for performing damage control surgery, new studies have questioned these indications and proposed other observations to better elucidate the cases eligible for the procedure [37]. Among them, those who presented moderate accuracy were systolic blood pressure (BP) < 90 mmHg or central body temperature < 34°C, and five indications produced major and conclusive changes in the pretest probability of performing damage control surgery during emerging laparotomy: discovery of pancreas, duodenum, or pancreatic-duodenal complex devascularized or completely ruptured;

a. Large abdominal vascular lesions with multiple visceral lesions
b. Diffuse bleeding of a nonmechanical nature
c. Multiple trunk penetrations
d. Blunt trunk trauma, resulting from high-energy impact
e. Operating and resuscitation time greater than 90 minutes
f. Bulky transfusion (>10 red blood cell concentrates)
g. Severe liver damage
h. Ruptured pelvic hematomas
i. Lesions of the retrohepatic vena cava
j. Pancreatic lesions that require resection
k. Significant hemodynamic instability

Table 3.
Traditional indications of damage control surgery.

estimated intraoperative blood loss >4 L; administration of >10 U of concentrate and red blood cells; and systolic BP persistently <90 mmHg or arterial pH persistently <7.2 during the operation [37]. The traditional indications [38] to perform this surgery are explained in **Table 3**. The factors related to almost 100% of mortality [25] are temperature (value <32°C), advanced age (70 years), and drop in pH.

Damage control surgery can be performed in three basic and sequential steps [25], which consist of the following:

a. Performing lifesaving procedures, such as stopping bleeding, controlling evisceration, and avoiding resections and reconstructions.

b. Resuscitation in an intensive care unit (ICU).

c. New surgical approach intended to review the lesions and to attempt definitive treatment.

Although it is often the only option in severe trauma, surgery to control damage should be considered, since it is related to serious complications [39], such as enteric fistulas, readmissions, multiple surgical interventions, and reduced quality of life.

In a study carried out in a trauma center in the city of Sao Paulo, Brazil, from a total of 392 patients, 207 had liver damage, and in cases it was necessary to perform the DCS (6.54%), which showed 100% survival, reaffirming the role of damage control surgery in severely traumatized patients with the lethal triad [6].

9. Liver transplantation in hepatic trauma

Considering that the causes of death following severe hepatic trauma are uncontrollable bleeding due to vascular and liver laceration injury and acute liver failure, it is possible to cogitate liver transplantation as an option, since the procedure could treat both conditions; however, indications are still very restricted [40–42].

The indications for liver transplantation in this scenario described in the literature are uncontrollable continuous bleeding after damage control operation; extensive complex liver lacerations not amenable to surgical correction; extensive lesions of the portal vein, hepatic vein, or bile duct that cannot be repaired by surgery; progressive liver failure due to trauma; and hepatic necrosis [40–42].

It is important to keep in mind that this procedure should only be considered once all other therapies were attempted, making it imperative to adopt damage control measures in order to promote temporary hemostasis until an organ becomes available for transplantation [38–41]. Also, not all patients are candidates for transplant and that the choice should be conducted carefully and individually. Situations such as severe sepsis, multiple organ failure, and other associated serious injuries may contraindicate the transplant [40–43].

There are two types of procedures described in the literature: transplantation in one step and staged transplantation. The first consists in the immediate removal of the native liver with subsequent implantation of a new organ, whereas the latter consists in creating a temporary vascular portocaval shunt to allow the patient to wait for the organ and avoid congestion in mesenteric splanchnic system [40, 42].

It is important to keep in mind that this is the last alternative to serious hepatic lesions. Even when indicated, this treatment presents a low success rate not being a viable alternative to the majority of liver traumas.

10. Complications

Trauma patients, especially those requiring a staged surgical approach, are subjected to multiple operations and prolonged ICU stays and are at high risk of developing complications such as abdominal compartment syndrome (ACS), acute respiratory distress syndrome, and multiple organ failure.

Generally, the incidence of complications is related to the degree of the hepatic trauma and the type of treatment used in the process, being directly proportional to the severity of the trauma presented by the patient, ranging from small changes in the liver parenchyma to vascular and biliary system injuries.

Since the majority of the liver injuries are managed nonoperatively, it is important to bear in mind that approximately a quarter of the patients with blunt hepatic injury managed nonoperatively will manifest complications that impose intervention, infrequently operative [3].

There is evidence that conservative treatment for extensive liver injuries results in a higher incidence of biliovascular complications [44]. In a recent article carried out in Italy with 56 young patients with liver injury AAST III or greater, mostly due to blunt trauma, 17 patients had 21 liver complications: 4 biliary, 12 vascular, and 1 combined biliary and vascular. Liver complications increased with the highest degree of liver trauma, with 3.5% in grade III, 52% in grade IV, and 70% in grade V. One patient with active arterio-portal fistula required urgent angioembolization, while other arterial pseudoaneurysms 7.23 ± 5.14 days after the trauma were detected. Angioembolization was successful in 83% of patients. The work highlighted that the main predictors of biliovascular complications were the requirement for blood transfusion and the degree of injury. Portal vein laceration was a predictor of biliary and nonvascular complications [44].

When considering radiological intervention, as portrayed previously, the main complication of hepatic angioembolization is the presence of massive hepatic necrosis (MHN). In a study carried out with 538 patients who had high-grade traumatic liver injuries [6], 16 patients (22.5%) had grade III injuries, 44 (62%) grade IV injuries, and 11 (15.5%) grade V injuries, with 71 (13%) having undergone therapeutic liver angioembolization, with 8 patients (11.3%) from the latter group dying as a result of liver damage. Complication rates were 18.8%, 65.9%, and 100% in patients with grade III, IV, and V injuries, respectively, for an overall complication rate of

60.6%. Thirty patients (42.2%) developed MHN [45]. Patients who developed MHN were compared with those who did not. It was observed that patients with MHN had higher-grade lesions, significantly needed more transfusions, and had a significantly longer hospital stay (all $p < 0.001$). Patients who developed MHN were more likely to undergo surgical intervention (96.7% vs. 41.5%, $p < 0.001$), with 87% undergoing damage control laparotomy [45].

As for the surgical treatment, many complications can occur depending on the type of procedure. The most frequent postoperative complication is related to infection such as pneumonia, peritonitis, and intra-abdominal abscess, and it represents almost three quarters of all immediate complications. The survival rate in patients with blunt liver trauma (60%) may be lower than the ones with penetrating trauma (87.5%), possibly due to the higher rate of head injuries associated with blunt trauma, as a consequence of severe traumatic brain injury [6].

In a recent study [6] carried out in a university hospital, in Sao Paulo, from 392 trauma patients who underwent laparotomy, 107 had liver injuries, 78.5% with penetrating trauma, in severe firearm injuries. The incidence of postoperative complications was 29.9%, and the most frequent were infections, including pneumonia, peritonitis, and intra-abdominal abscess. The survival rate of patients with blunt trauma was 60% and of penetrating trauma, 87.5% ($p < 0.05$). Another retrospective work carried out at the Department of Hepatobiliary Surgery and Liver Transplantation Unit of A.O.R.N.A. Cardarelli from Naples, Italy, considered 50 patients with liver trauma and assessed the main complications related to the type of trauma and treatment employed [46]. A wide range of complications is observed and is associated with five pathophysiological findings: acute bleeding after packing the cavity with compresses, liver hematoma, arteriovenous fistula, sepsis, biliary fistula, and coleperitoneum [46].

With the implementation of DCS, patients previously considered as beyond help turned capable of surviving their initial injuries, and as they were transferred to ICUs for physiological stabilization prior to surgical reconstruction, they were submitted through a supranormal resuscitation [1]. Later it was observed that this practice resulted in many of these patients receiving excessive volumes of crystalloid and experiencing subsequent problematic tissue edema of the lungs and gut during attempts at physiological restoration [47]. The combination of shock, large volume resuscitation, intestinal edema, and a tightly packed and closed abdomen led to increased intra-abdominal pressures and the development of virtual epidemics of abdominal compartment syndrome [47]. With an initial reported prevalence of more than 30% and mortality rate greater than 60% [48] in the major trauma population, many patients died not from their initial injuries but from lethal respiratory, renal, and cardiac failure due to increased abdominal pressure. Prospective observational studies soon identified the association between abdominal compartment syndrome and traumatic shock resuscitation [1, 49].

The aggravated physiologic derangement caused by intra-abdominal hypertension (IAH) can rapidly result in multiorgan failure in a vicious circle unless interrupted by abdominal decompression [50–52] such as open abdomen management (OA). OA consists of intentionally leaving the abdominal fascial edges of the paired rectus abdominis muscles unapproximated (laparostomy) in order to abbreviate operation, prevent IAH, and facilitate reexploration without damaging the abdominal fascia. Temporary abdominal closure (TAC) refers to the method for providing protection to the abdominal viscera during the time the fascia remains open [50, 52] Patients undergoing OA management are at risk of developing entero-atmospheric fistula (EAF) and a "frozen abdomen," intra-abdominal abscesses, and lower rates of definitive fascial closure [53, 54]. The risk-benefit ratio must be kept in mind, and measures to mitigate complications are necessary. In all patients with an OA, every effort should be exerted to achieve primary fascial closure (i.e., fascia-to-fascia closure of the abdominal wall within the index hospitalization) as soon as the patient can physiologically tolerate it [50].

Through the liberal use of open abdomen surgery and systematic evidence-based modifications to traumatic shock resuscitation techniques, the concept of damage control resuscitation was created. Damage control resuscitation differs from previous resuscitation approaches by attempting an earlier and more aggressive correction of coagulopathy as well as metabolic derangements. It embraces several key concepts, including permissive hypotension, the restriction of isotonic fluid for plasma volume expansion, and the early and rapid administration of component transfusion therapy to support correction of postinjury coagulopathy [1, 55]. Damage control resuscitation restores physiological reserve facilitating more definitive surgical treatment resulting in decreased perioperative complications and improved outcomes [1].

Liver injury management has been changed in recent years with the advancement of technology, newer diagnosis, and therapeutic tools. The indications of nonoperative treatment are increasing with improvement of survival and lower morbidity rates.

11. Conclusion

The liver is the second most common affected organ in abdominal trauma and therefore has a prominent role in all the abdominal traumas. During the past decade, the management presented a significant evolution especially with the growth of interventional radiology. Procedures such as arteriography and arterial embolization helped to manage once difficult lesions with poor prognosis. Nevertheless, when it is possible, the nonoperative management should be preferred since it presents less morbidity.

Hepatic lesions classified as grade IV are a cause for anguish and anxiety for the surgeons, since they present a higher morbidity and mortality. The first concern in severe liver trauma should be the patient stabilization, which can be done through damage control surgery, which consists of executing the crucial and strategically ordered steps (shortened surgery, correction of physiological measurements in intensive care and proposed reoperation) to reduce operational time, correct a loss of death (medicated by acidosis, hypothermia, and coagulopathy), and improve the patient's long-term prognosis.

In the context of trauma, control damage surgery appears as an alternative for severely injured patients, who have multiple injuries to the abdominal viscera.

After clinical stabilization in an intensive care unit, the patient will be reoperated, and less severe injuries will be corrected, with the patient's gradual recovery after correcting the lethal triad.

In the same perspective, this chapter reviewed liver trauma centered on damage control surgery, providing the main content related to the topic, from its causes, trauma mechanism, classification, bibliographic review, therapeutic options, and current statistics to prognosis and the role of damage control surgery in this context. Thus, it is expected that at the end of the chapter, the reader will be able to organize the main topics related to liver trauma and consider making difficult decisions in practice in trauma hospital, always seeking the best prognosis for patients.

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