Management of Liver Trauma

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ABSTRACT
In the last 30 years, the management of liver injury has evolved significantly. The advancement of imaging studies has played an important role in the conservative approach for management. A shift from operative to nonoperative management for most hemodynamically stable patients with hepatic injury has been prompted by speed and sensitivity of diagnostic imaging and by advances in critical care monitoring. In this review article, the up-to-date recommendation on the management approach of liver trauma will be discussed.

Key words: Diagnostic peritoneal lavage, hepatic embolization, liver packing, liver trauma, nonoperative management

INTRODUCTION
Trauma is the second largest cause of hospital admission, representing 16% of the global burden of all health costs. As per the World Health Organization, by the year 2020, trauma will be the first or second leading cause of years of productive life lost for the entire world population.[1] Approximately, 31% of patients of polytrauma have abdominal injuries. Almost 13% and 16% of cases have spleen and liver injuries, respectively.[2,3] Liver trauma is the leading cause of death in abdominal injuries. Nevertheless, nowadays, it is recognized that between 50% and 80% of liver injuries cease bleeding spontaneously. In addition, better diagnostic and intensive care management have led progressively to the acceptance of nonoperative management (NOM), resulting in decreased mortality rates.[4,5]

MECHANISM OF INJURY
Motor vehicle accidents are the most common cause of blunt liver injury. However, even in penetrating abdominal trauma, the liver is the second most commonly injured organ.[6] These injuries can range from simple parenchymal injuries to serious and major vascular lacerations.[7,8] In general, liver trauma may result in subcapsular/intrahepatic hematomas, lacerations, contusions, hepatic vascular and bile duct injury.[9-11]

ASSESSMENT AND DIAGNOSIS OF LIVER TRAUMA
Most commonly, the initial resuscitation, diagnostic evaluation and management of the trauma patient are...
based on the protocols from the Advanced Trauma Life Support program. Accordingly, hemodynamically unstable (HDUS) trauma patients need emergency exploratory laparotomy for better lifesaving evaluation and management. If the clinical setting allows, a Focused Assessment with Sonography for Trauma (FAST) examination, diagnostic peritoneal lavage (DPL) or computed tomography (CT) may be performed. Plain films obtained during the trauma evaluation are generally nonspecific but may demonstrate right-sided rib fractures, which increase the suspicion for liver injury. In approximately 80% of patients, other concurrent injuries can be present, which can include lower rib fractures, pelvic fracture, spinal cord injury or a combination of injuries. Such concurrent injuries can lead to the rupture of vena cava, colon, diaphragm, right lung, duodenum, kidney and extrahepatic portal structures.

Imaging, especially CT scan, confirms the injury and helps in defining the grade of injury. It is also useful in identifying concurrent intra-abdominal and chest injuries. FAST reveals the presence of blood and bleeding (hemoperitoneum and hemopericardium) but not the degree of organ injury. A recent Cochrane review has put a question mark on the reliability of ultrasonography for early diagnostic investigations in patients with suspected blunt abdominal trauma. Magnetic resonance imaging may be useful in a subset of hemodynamically stable (HDS) patients who cannot undergo CT scan (e.g., intravenous [IV] contrast allergy) and patients with suspected bile ductal injury. Arteriography is generally reserved for patients who have indications for hepatic embolization (HE) to manage intrahepatic arterial hemorrhage. Koca et al. found that liver transaminases can predict the hepatic injury with higher accuracy as the grade rises, and it can be superior to FAST in terms of determining the need for laparotomy. The main drawbacks of CT scan are its cost, low sensitivity in detecting bowel injuries and in its use in HDUS patients.

The most widely accepted liver injury grading scale is the American Association for the Surgery of Trauma classification system. In 2008, a study on solid organ injuries, using the National Trauma Data Bank, showed that approximately 67% of hepatic injuries are Grade I, II or III. The NOM is observed to have a higher successful outcome in low-grade injuries (Grades II, III and I). Patients with Grade VI injuries are universally HDUS, and surgical intervention is required. In high-grade liver injury patients, liver-related complication rates occur in 11–13% of patients. These can be predicted by the volume of packed red blood cells transfused at 24-h postinjury and the grade of liver injury.

**MANAGEMENT**

The operative versus NOM strategy depends on the presence of other injuries and medical comorbidities, hemodynamic status of the patient and grade of liver injury. A positive FAST scan and DPL in HDUS trauma patients necessitate emergency abdominal exploration to establish the source of intraperitoneal hemorrhage and a damage-control approach depending on the extent of the liver injury and presence of associated injuries.

Patients with right-sided penetrating thoracoabdominal injuries, which can lacerate the liver, can remain HDS. Such patients can also be kept under observation provided there are no associated intra-abdominal injuries. All grades of liver injury can be managed by NOM as long as they are HDS. Nonoperatively managed patients who continue to bleed, even with ongoing blood transfusion if hemodynamic instability is present, require surgical exploration. It is also indicated in those patients who manifest a persistent systemic inflammatory response such as the presence of ileus, fever, tachycardia and oliguria. Grade III and higher injuries often need a combined angiographic and surgical management and have a higher failure in NOM.

**Nonoperative management**

In NOM, a repeated assessment, close monitoring and supportive intensive care management with utilization of indicated arteriography and hepatic artery (HE) are needed. Furthermore, NOM is now recommended for penetrating injury such as stab wound, as well as low-velocity gunshot wounds to the upper right quadrant in HDUS patients after exclusion of other injuries requiring urgent laparotomy. Angiogram and HE are part of all liver trauma NOM algorithms to improve the success rate of NOM (if contrast extravasation is demonstrated). The grade of liver injury alone and the volume of hemoperitoneum are not considered definitive criteria for selecting operative versus NOM.

Large retrospective reviews reported that more than 80% of patients with blunt hepatic injury could be treated by NOM with success rates higher than 90%. A recent Cochrane review also supported NOM by concluding that currently there is no evidence to support the use of surgery over NOM for patients with abdominal trauma.
Patients with isolated penetrating hepatic injuries due to abdominal stab wounds have been previously managed using nonoperative approach, but management of patients with gunshot wounds remains controversial. Up to one-third of patients with a gunshot wound, who are treated using NOM, continue to bleed and develop abdominal compartment syndrome. One of the most important concerns is missed injuries to the gastrointestinal tract.\[^{41}\]

Patients managed by NOM need hospitalization, bed rest and continuous monitoring. If the patient has a normal abdominal examination and stable hemoglobin for at least 24 h, they can be discharged from the hospital. Large observational studies support the practice of discharging patients with liver injury regardless of the grade of injury. The clinical judgment of the surgeon is important when deciding the length of observation.\[^{42}\] Intensive care monitoring for a period of at least 48–72 h of hemodynamics and overall clinical condition is required as recommended by large case series.\[^{43}\]

Thromboprophylaxis is indicated in patients with liver injury or other severe injuries who require hospitalization and are at a high risk for thromboembolism. At the same time, delay in the chemical thromboprophylaxis may be safer due to an increased risk of cerebral or bleeding from other sites. Otherwise, it can be used when hemoglobin is stabilized with <1 g hemoglobin decrement over a 24 h period.\[^{44}\]

**Hepatic embolization**

HE can be used to prevent bleeding. Success rates for HE depend on many factors including institution policy, technique of embolization, access to arteries, operator skill and type of embolization material used. A properly carried out HE has replaced the need for initial operative intervention from many sites. The highest success of HE appears to be when used preemptively in patients who demonstrate extravasation of contrast on the initial abdominal CT scan and when the patient is HDS. The technical success of this technique ranges from 68% to 87%. It can also be used adjunctively to manage patients with ongoing bleeding or rebleeding from the liver after surgical treatment for liver injury.\[^{22}\]

**Benefits and risks of nonoperative management**

One of the main advantages of NOM is that it reduces the risks inherent to surgery and anesthesia. However, one of the main disadvantages associated with NOM includes an increased risk of missed intra-abdominal injury (particularly hollow viscus injury) risks associated with embolization and transfusion-related complications. HE is associated with additional risks including complications at the arterial access site, liver necrosis, liver abscess, inadvertent embolization of other organs (e.g., bowel or pancreas) or lower extremity ischemia due to arterial intimal dissection, contrast-induced allergic reactions and contrast-induced renal toxicity.

Studies have shown some significance, in terms of requirements, for blood transfusion and intra-abdominal complications when comparing patients receiving NOM versus operative management. However, there is no difference in the length of hospital stay.\[^{45}\] The underlying important requirement for the use of NOM is that this should be under the guidance of highly trained surgeons.\[^{46}\]

**Failure of nonoperative management**

Failure of NOM is defined as the need for urgent surgical intervention and is generally related to hemodynamic instability and bleeding that becomes apparent by increased requirements for fluid resuscitation or transfusion. Arterial embolization is less favored after NOM failure, mainly due to the time needed to setup the interventional radiology suite, the complexity of the embolization procedure and the possible failure that will delay a definitive surgical intervention.\[^{47}\]

One of the most common complications of NOM is biliary tree disruption with the formation of biloma and/or persistent bile leak. Furthermore, hepatic necrosis can occur following HE. It may also occur following other procedures such as laparotomy and hepatorrhaphy. Factors that may contribute to the failure of NOM include the advanced age of the patient, delayed bleeding, sudden and severe hypotension and active extravasation of contrast not controlled by HE.\[^{34,48,49}\]

**Surgical management**

Emergency laparotomy is the safest choice in the event of hemodynamic instability (rather than the grade of injury), failed NOM, high-velocity gunshot wound or if there is an associated hollow viscus injury.\[^{50,51}\] Various surgical methods described include direct suture ligation of the parenchymal bleeding vessel, repair of venous injury under total vascular isolation and damage control surgery with utilization of preoperative and/or postoperative HE and perihepatic packing. Less preferred methods include anatomical resection of liver, vascular ligation and the use of atriocaval shunt.\[^{52}\]
Damage control or damage limitation surgery is a concept that originated from a naval strategy, whereby a ship which has been damaged can be managed with minimal repairs to prevent it from sinking, and definitive repairs can wait until it reaches port. One of the approaches includes perihepatic packing and closure of the abdominal incision using either a Bogota bag or a partial closure of proximal abdominal incision. With a similar approach, minimal surgery is needed to stabilize the patient’s condition, and in the meantime, the physiological derangement can be corrected. Damage control surgery is done with specific objectives including stopping any active surgical bleeding and controlling any contamination. The timing of re-exploration depends on many factors including the correction of acidosis, coagulopathy and hypothermia (trauma’s lethal triad). The window considered safe during damage control surgery is 12–48 h for re-exploration and formal completion of the surgery.\textsuperscript{[53,54]}

MORBIDITY AND MORTALITY

Mortality rates for hepatic injury vary depending on the grade of the injury, associated injuries and general condition of the patient. A reduction in operative mortality, especially for higher-grade liver injuries (Grades III, IV and V), is attributed to new approaches in the form of NOM strategies, damage control and use of perihepatic packing. The overall mortality rate may vary from 10% to 42% as per the higher grade of injuries.\textsuperscript{[30]} Various factors have been found to have a strong association with the mortality rate, which includes hemodynamic instability, coexisting musculoskeletal and chest injury, high levels of aspartate aminotransferase (AST), alanine aminotransferase, lactate dehydrogenase, long activated partial thromboplastin time, prothrombin time, low fibrinogen levels and platelet count on admission. Not surprisingly, mortality is notably decreased when liver trauma is managed by hepatobiliary surgery, if feasible.\textsuperscript{[55,56]}

CONCLUSION

Chest X-ray and FAST are useful preliminary investigations to determine a correctible major injury. DPL may be preferred over FAST when the latter is not available. Further radiological assessment may aid in diagnosis, but this approach should only be used if it does not delay operative management of a patient. CT scan remains the gold standard investigation if the FAST is positive and patient is HDS, as it delineates the extent of liver injury and identifies other associated injuries. NOM is the preferred approach over surgical intervention for HDS patients with liver injury, irrespective of the grade of liver injury. HE may have a better outcome for HDS patients with liver injury who demonstrate pooling of IV contrast on the initial or subsequent abdominal CT scan, rather than NOM without embolization. Failure of HE to control bleeding indicates the need for surgery. Operative management initially involves controlling any hemorrhage and contamination followed by perihepatic

\textbf{Figure 1: Algorithm for nonoperative management of blunt hepatic trauma}
packing and rapid closure, allowing for resuscitation to normal physiology in the Intensive Care Unit and subsequent definitive re-exploration. In HDUS patients alternative techniques may be considered such as Pringle’s maneuver (clamping of the hepatoduodenal ligament), simple suture and compression, hepatectomy and vascular ligation or atriocaval shunt. There is substantial evidence that indicates mortality is reduced when hepato-pancreato-biliary surgeons manage patients with liver trauma.

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