Nonoperative treatment of liver trauma (NOM)

Mohamed Ismail Abd El Aziz Mohamed [1], Emad salah[2], Ashraf Goda[2], Mohamed Ibrahim Mansour[2]

1 General Surgery Resident Doctor, Kobri El Koba Military Hospital

2 General Surgery Department, Faculty of Medicine, Zagazig University

Email: drmo7mmedisma3il@gmail.com, **mi.mohamed23@medicine.zu.edu.eg**

Article History: Received 10th June, Accepted 5th July, published online 10th July 2023

Abstract

Hemodynamically unstable patients, not responsive to resuscitation, should go directly from the trauma bay to the operating room for laparotomy. In addition, patients with peritoneal signs should go to the operating room. Patients that fail non-operative therapy must undergo laparotomy. Damage control laparotomy principles should be followed in the unstable patient undergoing laparotomy. This includes first controlling hemorrhage, then controlling gastrointestinal (GI) contamination. The abdomen should be packed in all 4 quadrants, allowing for injuries to be localized and the anesthesia team to resuscitate the patient. The “lethal triad” of coagulopathy, acidosis, and hypothermia should trigger a damage control approachIn blunt liver trauma, nonoperative management is a standard of care in hemodynamically stable patients. It is not the grade of the injury, but rather the hemodynamic parameters of the patient which dictate the conservative versus operative management decision. The patient’s positive response to an initial fluid bolus or maintenance of a stable hemodynamic state allows for a CT scan of abdomen and pelvis. If extravasation is identified, angiogram and angioembolization should be considered. Failures of these steps then mandate operative intervention. The most common reasons for failure are advanced age, delayed bleeding, hypotension and active extravasation of contrast not controlled by angioembolization.There is an overall survival benefit and 23% reduction of mortality for conservative approach in blunt liver injury

Keywords: Nonoperative treatment, liver trauma

Hemodynamically unstable patients, not responsive to resuscitation, should go directly from the trauma bay to the operating room for laparotomy. In addition, patients with peritoneal signs should go to the operating room. Patients that fail non-operative therapy must undergo laparotomy. Damage control laparotomy principles should be followed in the unstable patient undergoing laparotomy. This includes first controlling hemorrhage, then controlling gastrointestinal (GI) contamination. The abdomen should be packed in all 4 quadrants, allowing for injuries to be localized and the anesthesia team to resuscitate the patient. The “lethal triad” of coagulopathy, acidosis, and hypothermia should trigger a damage control approach **(6).**

Some temporizing measures can be taken to minimize blood loss from hepatic injuries. The liver can be manually compressed together with the surgeon’s hands on each side of the fracture, allowing for the raw edges to be pushed together. Peri-hepatic packing can also be carried out by placing laparotomy pads in the space between the liver and diaphragm and around the anterior and lateral sides of the liver to reapproximate raw edges of injured parenchyma. Patients that require peri-hepatic packing have a high rate of mortality. For severe bleeding that cannot be controlled, a Pringle maneuver may be helpful. This involves placing a non-crushing vascular clamp on the porta hepatis to occlude the hepatic artery and portal vein. If this results in decreased hemorrhage, then bleeding is likely related to the hepatic inflow vessels. However, if bleeding continues despite the Pringle maneuver, then bleeding is from injury to the hepatic vein or retrohepatic inferior vena cava (IVC). The Pringle maneuver should be released every 20 to 30 minutes to allow intermittent perfusion of the hepatic maneuver. The Pringle maneuver can be combined with the finger fracture technique to control bleeding from liver lacerations **(1).**

The main indication of the operative approach to the blunt liver injury is hemodynamic instability, not the grading of the injury. Although a higher grade injury has higher potential for failure of nonoperative management, hemodynamic instability remains the most important branch of the decision tree indicating operative intervention.Rebleeding, constant decline of hemoglobin and increased transfusion requirement, as well as the failure of angioembolization of actively bleeding vessels are a few factors which indicate the need for laparotomy **(2).**

according to AAST liver trauma classification and WSES liver trauma classification Coccolini et al suggested two management algorithms: one general and one specifically dedicated to hemodynamically unstable patients **(3)**.

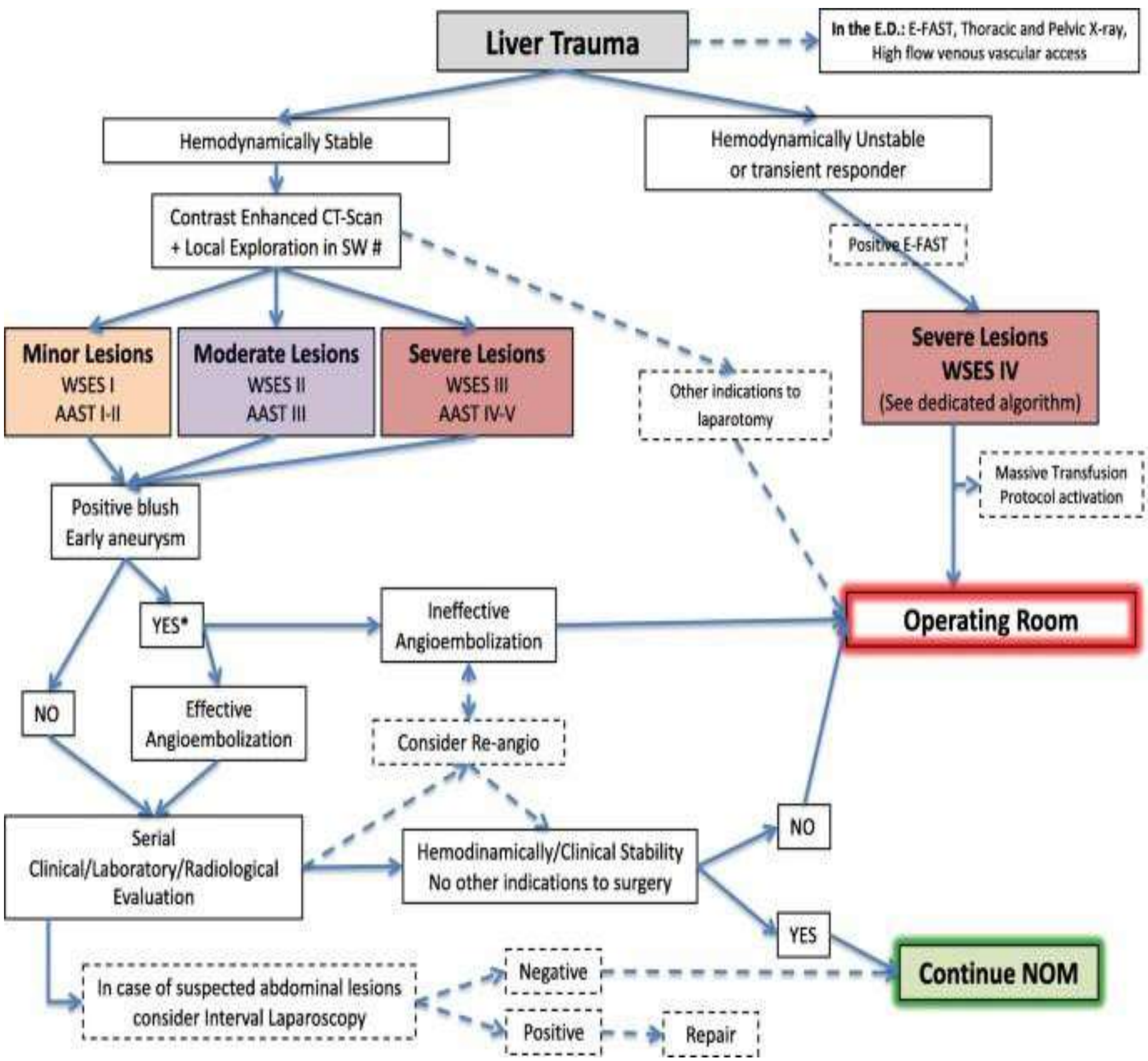

Fig. (1) Liver trauma management algorithm (SW: stab wound. Number sign indicates wound exploration near the inferior costal margin should be avoided if not strictly necessary.

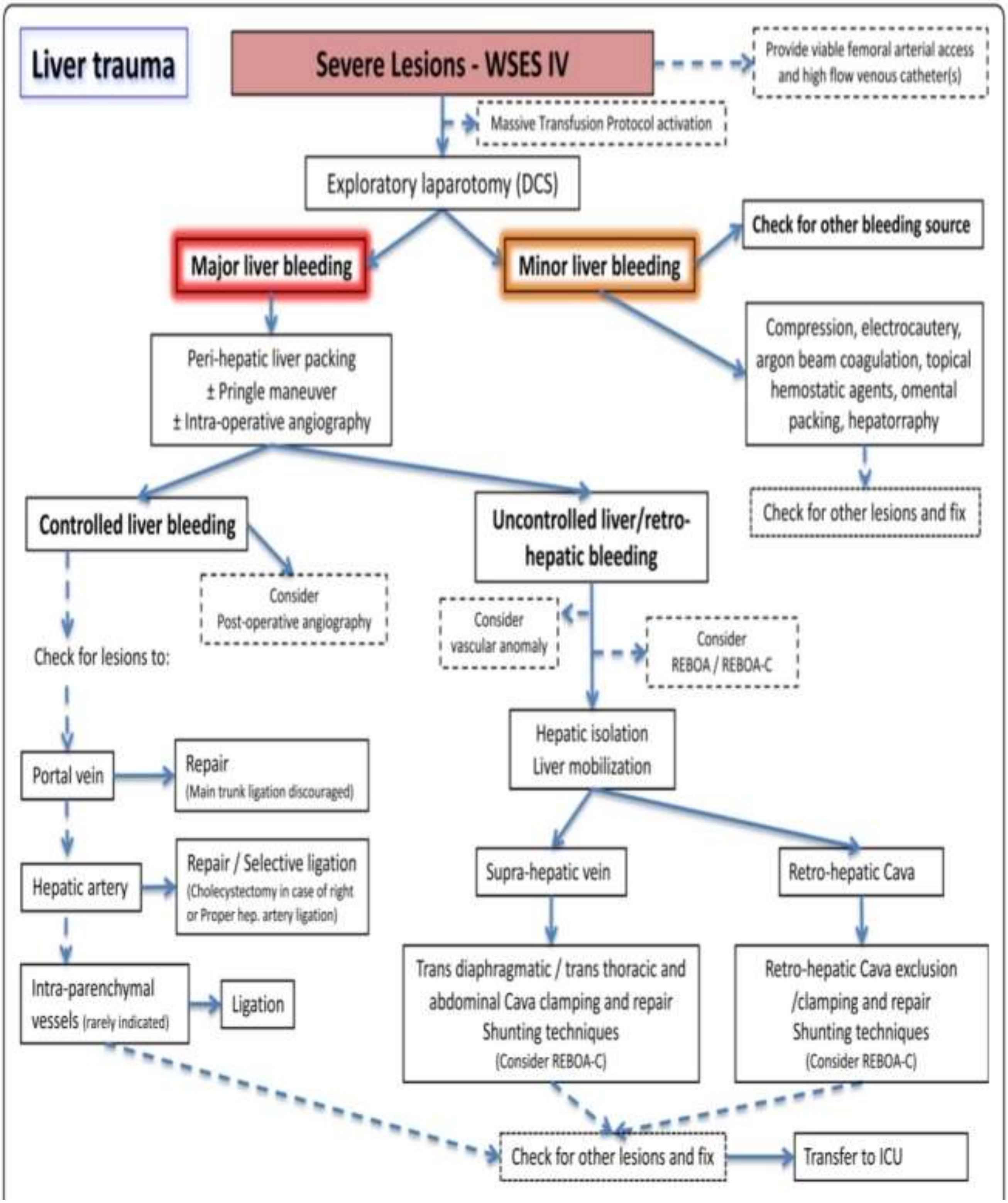

Fig. (2). Hemodynamically unstable liver trauma management algorithm (DCS: damage control surgery, ICU: intensive care unit)

The operative approach has also evolved over the last two decades. Direct suture ligation of the parenchymal bleeding vessel, perihepatic packing, repair of venous injury under total vascular isolation and damage control surgery with utilization of preoperative and/or postoperative angioembolization are the preferred methods, compared to anatomical resection of the liver and use of the atriocaval shunt (**4).**

- **Operative procedure for liver injuries**

The first and the most important step in operative management of blunt liver injury is to pack all four quadrants with laparotomy pads and manually compress the liver using both hands for 15–20 minutes. This allows the anesthesiologist to catch up with the resuscitation. Then remove the lower quadrant packing first, followed by left upper quadrant and finally right upper quadrant. If the spleen is actively bleeding, splenectomy should be performed. Assess the liver laceration and identify the bleeding vessel. Direct suture ligation should be performed using 3-0 or 4-0 absorbable suture. A patch of omentum can be used to fill the gap created by the laceration. If bleeding continues, then perform the Pringle maneuver (apply a noncrushing clamp through the foramen of Winslow). The clamp can be safely applied up to 1 hour **(5).**

- **Operative approach for hepatic vein and/or retrohepatic caval injuries**

If bleeding continues despite the Pringle maneuver, then retrohepatic, caval or hepatic vein injury should be suspected.The preferred method for caval and hepatic vein injury is total vascular isolation. The procedure consists of performing a Pringle maneuver, and clamping of the inferior vena cava above and below the injury. Superiorly, the inferior vena cava can be isolated just below the diaphragm or through the pericardium by extending the incision to a median sternotomy and inferiorly, just above the renal veins. This approach allows direct repair of the vascular injury. Aortic clamping is not recommended for the vena caval or hepatic vein injury. The vascular isolation technique has reported a better survival rate compared to atriocaval shunt. Anatomical lobectomy is rarely performed; however, in the hands of an expert, the outcome is very good.During the operative repair, if the patient develops coagulopathy, acidosis, or hypothermia, damage control surgery should be considered **(6).**

- **Damage control surgery**

Damage control surgery includes perihepatic packing and closure of the abdominal incision either using a Bogata bag or partial closure of proximal abdominal incision. Kreig et al. recommend six folded laparatomy pads to be placed between the liver and the abdominal wall to obtain tamponade. The patient should be transferred to the ICU as soon as possible for continued resuscitation and warming. As soon as the metabolic derangement is corrected, the patient should be taken back to operating room for re-exploration. The timing of re-exploration depends upon the correction of acidosis, coagulopathy and hypothermia. Usually, 12–24 hours is the safe period for re-exploration and formal completion of the surgery **(7).**

- **Role of hemostatic agents in liver trauma**

A number of commercial hemostatic agents are readily available and can be used as an adjunct after repair of liver injuries. The most commonly used agents are gelatin gelfoams, oxidized cellulose, microfibrillar collagen, thrombin, thrombin with gelatin (floseal) and fibrin sealant (tisseel). Application of extracorporeal circulation in the massive liver and/or retrohepatic caval injury. The use of extracorporeal circulation devices during the repair of the juxtahepatic caval injuries has been noted in the past with variable success. The concept behind this device is to bypass the flow from the injured area using an extracorporeal circuit, with or without an active pump **(2).**

Therefore, repair can be performed in a bloodless field. These devices increase the complexity of the operation, and the physician must be familiar with the technique and concept as well. Successful use of venovenous bypass following clamping of the inferior vena cava during anhepatic phase of liver transplant provided the idea in the management of retrohepatic caval injuries. This technique allows blood to be diverted from the inferior vena cava, with or without portal vein decompression, and drain it into the right atrium either directly or through internal jugular vein or superior vena cava **(6).**

- **Liver transplantation in massive liver and hepatic venous and retrohepatic caval injury**

Orthotopic liver transplantation has been reported as an extreme measure in massive hepatic venous and retrohepatic caval injuries. Since the mortality rate associated with these injuries is extremely high and there is a shortage of organs available for procurement as well, the indication for liver transplantation is very restricted. Most of the indications described in the literature are uncontrolled bleeding despite repeated previous surgery and acute or progressive liver failure following repair of injury. In the last two decades, less than 20 liver transplantations have been performed for liver trauma with variable success, however, the biggest series was reported by Delis and colleagues, in which three out of four patients survived after liver transplantation. A case of extracorporeal repair and "autotransplantation" has also been reported in the case of total avulsion of hepatic veins and a retrohepatic caval injury **(5).**

Interventional radiology in liver trauma

The interventional radiologist plays an integral role in the nonoperative management of liver injuries. Angiography and angioembolization has become the gold standard in the management of liver injuries for hemodynamically stable patients, if a contrast extravasation is seen on CT scan. Furthermore, conservative management may cause vascular/or biliary complications, particularly in high-grade injuries which require imaging intervention. Post-traumatic pseudoaneurysm, intrahepatic arteriovenous fistula and hemobilia are a few vascular complications which may appear following liver injuries and angioembolization is the first step in the management of these complications. Symptomatic biloma, liver and intra-abdominal abscesses can also be successfully managed by CT-guided percutaneous drainage **(5).**

Angiography plays a vital role in the conservative management of the liver injury. Extravasation of contrast seen on CT scan requires emergency angiography and angioembolization in hemodynamically stable patients. Post-operative angioembolization is also reported in damage control surgery prior to removal of packing, if rebleeding is suspected. The sensitivity and specificity of angiogram identifying active bleeding in liver injuries is 75% and the success rate of controlling the hemorrhage is 68–93%.The multidisciplinary approach to conservative management of high-grade liver injuries shows better outcome with less blood transfusion, early recovery time and less intensive care days. The mortality is low as well **(7).**

Angiography with selective embolization is an effective treatment for patients undergoing non-operative therapy of bleeding liver injuries, especially those with blunt hepatic injuries. Success rates for angiography and embolization are as high as 83%. No clear consensus guidelines exist as to when and in which patients to perform angiography with embolization. Some trauma surgeons prefer to do angiography and embolization in any blunt hepatic injury higher than grade III. In contrast, others will only do so if there is contrast extravasation on a CT scan (**8).**

Adjunct Treatments

Other therapies can be used to treat patients with traumatic liver injuries. For example, endoscopic retrograde cholangiopancreatography (ERCP) can be used to identify and treat bile duct injuries, whether done pre- or post-operatively. Stents can be placed at the time of ERCP to help treat bile duct lacerations. In addition, bile duct stents can be placed to decrease hepatic parenchymal bile leak and facilitate healing of injured bile ducts.Interventional radiology (IR) can also be used as an adjunct for hepatic trauma. Bilomas or hepatic abscesses can develop as a result of traumatic injury or as a complication of angioembolization and hepatic necrosis. Closed suction drains can be placed by IR to drain infections or bilious fluid collections **(2).**

Nonoperative treatment of liver trauma (NOM)

In blunt liver trauma, nonoperative management is a standard of care in hemodynamically stable patients. It is not the grade of the injury, but rather the hemodynamic parameters of the patient which dictate the conservative versus operative management decision. The patient's positive response to an initial fluid bolus or maintenance of a stable hemodynamic state allows for a CT scan of abdomen and pelvis. If extravasation is identified, angiogram and angioembolization should be considered. Failures of these steps then mandate operative intervention. The most common reasons for failure are advanced age, delayed bleeding, hypotension and active extravasation of contrast not controlled by angioembolization.There is an overall survival benefit and 23% reduction of mortality for conservative approach in blunt liver injury **(6).**

- **Indications and Cotraindications**

NOM should be the treatment of choice for all hemodynamically stable minor (WSES I) (AAST III), moderate (WSES II) (AAST III), and severe (WSES III) (AAST IV–V) injuries in the absence of other internal injuries requiring surgery . In patients considered transient responders with moderate (WSES II) (AAST III) and severe (WSES III) (AAST IV–V) injuries, NOM should be considered only in selected settings provided the immediate availability of trained surgeons, operating room, continuous monitoring ideally in an ICU or ER setting, access to angiography, angioembolization, blood, and blood products, and in locations where a system exists to quickly transfer such patients to higher level of care facilities. A CT scan with intravenous contrast should always be performed in patients being considered for NOM **(3)**.

NOM is contraindicated if free intra- or retroperitoneal air, free intra-peritoneal fluid in the absence of solid organ injury, localized bowel wall thickening, bullet tract close to hollow viscus with surrounding hematoma, and in high-energy penetrating trauma are detected at CT scan **(9).**

Patients affected by neurotrauma (i.e., spinal cord or moderate-severe traumatic brain injury) in fact, for several instances, differ from the others because they need a higher perfusion pressure to adequately supply oxygen to the brain and to the spinal cord to reduce the subsequent burden of disability and mortality. A disruption of the normal blood flow regulation in the central nervous system (CNS) characterizes the trauma and eventually leads to a blood flow dependent on perfusion pressure in ischemic tissue **(10).**

Specific hemodynamic goals for Spinal Trauma (ST) and Sever Traumatic Brain injury (STBI) are defined as Systolic Blood Pressure (SBP) > 110 mmHg and/or Cerebral Perfusion Pressure (CPP) between 60 and 70 mmHg in the case of moderate/severe Traumatic Brain Injury (TBI) and an Mean Blood Pressure(MBP) > 80 mmHg in case of ST. no study specifically addressed the NOM of abdominal solid organ injuries in the neurotrauma patient, and several authors have considered It an exclusion criterion from NOM **(11).**

- **Advantages and Disadvantage**

One of the main advantages of nonoperative management is that it reduces the risks inherent to surgery and anesthesia procedures. 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 illness **(12).**

Blood transfusion is a life-saving measure during excessive bleeding and related complications. However, it is also associated with many complications. Commonly seen complications include intravascular volume overload, transfusion associated circulatory overload (TACO),transfusion-related acute lung injury (TRALI), immunologic and allergic reactions, as well as immunomodulation (transfusion-related immune modulation, TRIM), hypothermia, and coagulopathy. Hepatic embolization is also associated with additional risks. These includes risk of bleeding, complications at the arterial access site, necrosis of liver, abscess in the liver or subdiaphragmatic space, inadvertent embolization of other organs (e.g., bowel, pancreas) or lower extremities, arterial intimal dissection, contrast-induced allergic reactions, and contrast-induced renal toxicity and nephropathy. When embolization is performed following contrast CT scan, particularly in patients who with volume depletion, the risk of contrast induced nephropathy is even greater. Repeated clinical monitoring and surgical intervention is a must if conservative treatment fails **(13).**

- **Complications**

In blunt hepatic trauma, particularly after high-grade injury, complications occur in 12–14% of patients. Diagnostic tools for complications after NOM include clinical examination, blood tests, ultrasound, and CT scan. Routine follow-up with CT scan is not necessary unless there is clinical suspicion of a complication. In the presence of abnormal inflammatory response, abdominal pain, fever, jaundice, or drop of hemoglobin level, repeated CT scan is recommended

Bleeding, abdominal compartment syndrome, infections (abscesses and other infections), biliary complications (bile leak, hemobilia, biloma, biliary peritonitis, biliary fistula), and liver necrosis are the most frequent

Complications associated with NOM **(14).**

Ultrasound is useful in the assessment of bile leak/biloma in grade

IV–V injuries, especially with a central laceration. Re-bleeding or secondary hemorrhage is the most frequently reported complications after NOM as in subcapsular hematoma or pseudo-aneurysm (PSA) rupture (range 1.7–5.9%) with a mortality rate up to 18%. In the majority of cases (69%), "late" bleeding can be treated non-operatively. Hepatic artery PSA is a rare complication with a prevalence of 1% . Asymptomatic PSA should be treated as early as possible with AE because of the high risk of rupture and the associated high morbidity. In patients with melena or hematemesis following liver trauma, bleeding from the ampulla of Vater (hemobilia) is highly suggestive of ruptured intrahepatic PSA **(3)**.

AE is the treatment of choice. In the presence of intrahepatic bilio-venous fistula (frequently associated with bilemia), endoscopic retrograde cholangiopancreatography (ERCP) represents an effective tool. Biliary complications include biloma, biliary fistula, bilhemia, and bile peritonitis (incidence 2.8–30%). Most traumatic bilomas regress spontaneously. Enlarging, symptomatic or infected bilomas can be successfully managed with percutaneous drainage. Percutaneous drainage may be combined with therapeutic ERCP with eventual endobiliary stent placement.Bile peritonitis has been usually treated with laparotomy. Combination of laparoscopic irrigation/drainage and endoscopic bile duct stent placement may represent a valid alternative **(3)**.

Abscesses are rare after NOM and usually happen in severe lesions (prevalence 0.6–7%). CT scan or ultrasound-guided percutaneous drainage is the treatment of choice with high success rate and no reported mortality. In the presence of necrosis and devascularization of hepatic segments, surgical management may be indicated whenever affecting patient condition **(3)**.

Generally, once stabilization of traumatized patient is obtained, late complications should be managed preferentially by minimally invasive procedures. Laparoscopy and endoscopy are part of this approach, which became possible in a delayed surgery setting **(15).**

References

1. **Harman K, Verma A, Cook J, Radia T, Zuckerman M, Deep A and Gupta A (2020):** "Ethnicity and COVID-19 in children with comorbidities" The Lancet Child and Adolescent Health; 4(7): 24-25.
2. **Panjaitan M, Yudianto A and Purwanti T (2021):** "An Autopsy Review of Liver Injuries Resulting From Blunt Trauma: Case Report" Malaysian Journal of Medicine and Health Sciences; 17: 183-185.
3. **Coccolini F, Coimbra R, Ordonez C (2020):** "Liver trauma: WSES 2020 guidelines" World Journal of Emergency Surgery; 15:24.
4. **Jeschke G, van Baar E, Choudhry A, Chung K, Gibran S and Logsetty S (2020):** "Burn injury" Nature Reviews Disease Primers; 6(1): 1-25.
5. **Paltiel J, Barth A, Bruno C, Chen E, Deganello A, Harkanyi Z and Back J (2021):** "Contrast-enhanced ultrasound of blunt abdominal trauma in children" Pediatric Radiology;51(12): 2253-2269.
6. **Camarata A, Gottfried M, Rule A, Ala A, Lee M, Todd Stravitz R and Schilsky L (2020):** "Outcomes of acute liver injury in adults due to Wilson's disease: is survival without transplant possible?" Liver Transplantation; 26(3): 330-336.
7. **Hamid S, Nicolaou S, Khosa F, Andrews G, Murray N, Abdellatif W and Qamar R (2020):** "Dual-energy CT: a paradigm shift in acute traumatic abdomen" Canadian Association of Radiologists Journal; 71(3): 371-387.
8. **Fodor M, Primavesi F, Morell-Hofert D, Haselbacher M, Braunwarth E, Cardini B and Stättner S (2018):** "Non-operative management of blunt hepatic and splenic injuries–practical aspects and value of radiological scoring systems" European Surgery; 50(6):285-298.
9. **Demetriades D, Hadjizacharia P, Constantinou C, Brown C, Inaba K, Rhee P,Salim A (2006):** "Selective nonoperative management of penetrating abdominal solid organ injuries"Ann Surg;244(4):620-8.
10. **Launey Y, Fryer TD, Hong YT, Steiner LA, Nortje J, Veenith TV, Hutchinson PJ, Ercole A, Gupta AK, Aigbirhio FI, Pickard JD, Coles JP, Menon DK (2019):** "Spatial and temporal pattern of ischemia and abnormal vascular function following traumatic brain injury". JAMA Neurol;13(6):265.
11. **Navsaria P, Nicol A, Krige J, Edu S, Chowdhury S (2019):** "Selective nonoperative management of liver gunshot injuries" Eur J Trauma Emerg Surg; 45(2):323–8.
12. **Li M, Yu WK, Wang XB, Ji W, Li JS (2014):** "Non-operative management of isolated liver trauma" Hepatobiliary & Pancreatic Diseases International; 13(5):545-550.
13. **Perumean JC, Martinez M, Neal R, Lee J, Olajire-Aro T, Imran JB, Williams BH, Phelan HA (2017):** "Low-grade blunt hepatic injury and benefits of intensive care unit monitoring"American Journal of Surgery; 214(6):1188-1192.
14. **Piper GL, Peitzman AB (2010):** "Current management of hepatic trauma" Surg Clin North Am; 90(4):775–785.
15. **Parrado R, Notrica DM, Garcia NM, Alder AC, Eubanks JW, Maxson RT, Letton RW, Ponsky TA, St Peter SD, Leys C, Bhatia A, Tuggle DW, Lawson KA, Ostlie DJ (2019):** "Use of laparoscopy in pediatric blunt and spleen injury: an unexpectedly common procedure after cessation of bleeding" J Laparoendosc Adv Surg Tech A; 29(10):1281–4.