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Outcome and Efficacy of Non-Operative Management (NOM) in Traumatic Liver Injuries

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Background: Liver traumas accounts for 5% of all emergency room admissions. Advancement in diagnostic & interventional modalities led to obvious development in traumatic liver injury diagnosis & management.

The aim of this study: Is to analyze & evaluate outcome of non-operative management in 131 patients with blunt traumatic liver injuries.

Patients and methods: This was a retro and prospective study to patients admitted to our department of surgery, King Abdulaziz specialized hospital at Taif, Ministry of health, Saudi Arabia between December 2016 and December 2021. Patients were divided into 2 groups: non-operative & operative.

Results: One hundred & thirty-one patients with blunt abdominal traumas: 97 (74%) patients managed by non-operatively, while 34 (26%) underwent surgery. Road traffic accidents were the main trauma cause. Grade III injuries (43.5%) were the commonest. Biliary complications were the most frequent complications. Biliary complications, such as leakage or strictures, were the most frequent complications that occurred in 39 (29.6%) patients & most of these complicated biliary cases were managed conservatively by either US or CT guided drainage in 47 (36.8%) patients [43 (32.8%) cases of the NOM group & 4 (3%) cases of the operative group] and/or ERCP with stenting in 33 (25.2%) patients [28 (21.4%) cases of the NOM group & 5 (3.8%) cases of the operative group]. The mortality rate was 3%.

Conclusion: Non-operative management of liver trauma is highly efficient with high success rate even in high-grade liver injuries.

Introduction

Trauma is a worldwide public health issue that affects all ages in varying degrees of severity. Trauma is responsible for around 10% of global mortality.[1]

Over the past three decades, the incidence of liver injury has increased due to the increased number of road traffic accidents and the advanced detection of injuries due to improved diagnostic techniques. The anterior anatomical location of the liver with its high blood supply and fragile parenchyma makes it particularly vulnerable to injury. Liver trauma is associated with a 10%-15% mortality rate and is the leading cause of death from blunt abdominal trauma.[2]

Liver injuries account for approximately 5% of all trauma admissions. The liver is the most common solid organ injured in blunt trauma, and patients with liver injury usually have other associated injuries. Mortality from liver trauma depends on the degree of injury. The majority of traumatic liver injuries is mild, with 80-90% of cases having grade I-II. Mortality increases when the degree of injury increases, and grade VI liver injuries are often fatal. The mechanism of injury for blunt abdominal trauma is often due to road traffic accidents, pedestrian accidents, and falls. Agricultural and industrial accidents can also result in a variety of liver injuries. In addition, its anterior location and large size compared to other abdominal organs make it susceptible to injury in penetrating abdominal injuries from stab wounds or gunshots. In both blunt and penetrating trauma, the right hepatic lobe is the most usually affected part.[3]

Liver trauma can range from minor lacerations or capsular hematomas with minimal morbidity and mortality to liver avulsion with high mortality.[4]

Surgical management was the gold standard for treating traumatic liver injuries before to 1990. However, in the last three decades, advances in diagnostic and therapeutic methods, such as computed tomography (CT), use of ultrasound in trauma, availability of angiography, and improved monitoring of critical care have led to a drastic change in treatment strategy.[5]

As a result, conservative non-operative management (NOM) has been increased and became more dependable.[2]

As in all trauma patients, the evaluation must be guided by advanced trauma life support (ATLS) principles. The primary survey should be done immediately to detect life-threatening injuries. For patients with liver injury, the primary survey should exclude the presence of hypovolemic shock from liver hemorrhage. Hemorrhagic shock is characterized by a narrowed pulse pressure, hypotension, and tachycardia. After the primary survey is completed, the secondary survey should then be performed by performing a head-to-toe exam that can detect any possible injuries. Patients with hepatic injuries may have tenderness at the right upper quadrant, and the presence of abdominal distention may indicate hemoperitoneum.[6]

Patients of trauma with the appropriate mechanism of injury seen in the trauma unit should receive a series of standard laboratory tests. This can include, among other things, a comprehensive metabolic panel, a complete blood count (CBC), coagulation profile, and serum lactate level. In addition, liver function tests may be abnormal, although this may not be seen until several hours to days after the liver injury. Focused assessment with sonography for trauma (FAST) exam can also be utilized to begin radiological evaluation in the trauma unit. The FAST exam is used to identify the presence of bloody collection in the peritoneal cavity or pericardium. It does not specify the severity degree of injured organ. The FAST exam is highly operator dependent, and its sensitivity and specificity ranged from 63% to 100% and from 95% to 100% respectively. It can guide management in the trauma unit and help physicians decide whether patients with hepatic injuries should be taken directly to the operating room.[7]

Patients who have responded to resuscitation and are hemodynamically stable in the trauma unit may receive additional imaging to guide treatment. CT abdomen and pelvis with intravenous (IV) contrast material has become almost routine in hemodynamically stable abdominal trauma patients. It is the best modality for identifying liver injury. CT allows identification of liver injury and grading of severity. It also allows physician to detect other abdominal injuries and to quantify the hemoperitoneum. Administration of intravenous contrast agent with CT scan allows identification of patients with active extravasation of blood, evidenced by a blush on CT from the liver. This can help the physician to decide whether the patient can benefit from angiographic embolization or surgery. Surgeons must correlate radiological data with the clinical status of the patient to guide management plan and exclude hemodynamic instability and peritoneal signs. While magnetic resonance cholangiopancreatography (MRCP) has no role in acutely injured trauma patients due to its time-consuming nature, it may have a role in patients with suspected bile duct injury or leak.[8]

Injury Grading

Triage and prediction of polytrauma patients are helpful to the treating physicians, especially those with limited resources. Trauma scores can be used for both triage and prediction. For example, the Revised Trauma Score has two versions: A triage version used for prehospital triage and a prediction version used during hospitalization to predict the mortality.[1]

1. Injury scoring systems

The trauma scoring system is a common tool that is used in trauma clinical studies. It can make it easier to assess the severity of the injury and compare treatment outcomes.[9]

a. Injury Severity Score (ISS)

Injury Severity Score (ISS) was introduced in 1974. It is the most widely used trauma scoring system based on anatomical parameters, providing an overall evaluation score for patients with multiple injuries.[10]

It is one of the most commonly used trauma scores. To calculate ISS, the body is divided into six regions: head and neck, face, thorax, abdomen, extremities (including pelvis), and external. Each injury to the body is assigned a score on the Abbreviated Injury Scale (AIS) and only the highest score in each region is used. ISS is calculated as the sum of the squares of the highest three AIS values. The maximum ISS score is 75. An ISS of 75 is assigned to a patient who has AIS 6 in one body region.[11]

However, ISS has limitations because multiple injuries within the same body region are assigned only a single score, and this can underestimate the severity for the trauma patient.[12]

b. New Injury Severity Score (NISS)

the ISS includes only one injury in each body region, resulting in the possibility of including a less severe injury in other body regions than another severe injury in the same body region. To overcome this limitation, Osler et al. in 1997 have modified ISS into the New Injury Severity Score (NISS). NISS is simply the sum of the squares of the three most serious injuries, regardless of the body region injured.[13]

c. Exponential Injury Severity Score (EISS)

Wang et al. (2014) created the Exponential Injury Severity Score (EISS) in 2014 by modifying the AIS system. they calculated EISS as a simple change in AIS scores by increasing each AIS severity score (1-6) by 3, taking a power of AIS minus 2, and then summing the three most severe scores (I.e., highest AIS scores) independently were summed from the body regions. If an AIS severity code is 6 anywhere in the body, other injured body regions of the AIS score are not calculated. If the AIS score is 2, the total of AIS 2 should be removed from the total score. Mathematical expression: EISS = 3A - 2 + 3B - 2 + 3C - 2, where A, B and C are the three most severe AIS codes **(Table 1).** With this exponential transformation of the AIS scores, the EISS is expected to better reflect the true severity of injuries in polytrauma patients. In Wang's study, the EISS is reported to be better at predicting survival; hence, it could be used as a standard summary measure of human trauma.[14]

To assess the clinical outcome and medical costs of trauma patients, they can be classified into:12

- ► Mildly injured patients (ISS < 16, NISS < 16, and EISS < 9).[12]
- ► Moderately injured patients (ISS of 16–24, NISS of 16–24, and EISS of 9–16).[12]
- ► Severely injured patients → (ISS ≥ 25, NISS ≥ 25, and EISS ≥ 27).[12]

2. Liver injury grading systems

There were minor inter-study variations in the system used to grade liver injury.[2]

All liver injuries have been graded in one study using only CT scans.[15] One study mainly re-assessed CT scan, using intraoperative findings or ultrasound for grading only when a CT scan was not available.[16] Also, one study used CT scan in all hemodynamically stable patients and intraoperative findings in all unstable patients.[17] Three studies used both CT scan and intraoperative findings, but it was unclear exactly when each was used (Prichayudh et al., 2014),[18] (Hommes et al, 2015)[19] & (Afifi et al, 2018).[20] Two studies did not specify the modality used to grade hepatic injuries.[21,22]

a. American Association for the Surgery of Trauma (AAST) Hepatic Injury Scale

Radiological data are used for grading liver injuries as defined by the American Association for the Surgery of Trauma (AAST) Hepatic Injury Scale.[23]

The American Association for the Surgery of Trauma (AAST) classifies liver injury on a grade 1 through 6 severity scale **(Table 2)**: Grades 1 and 2 are considered minor injuries, grades 3 - 5 are considered severe, or "high-grade", and grade 6 lesions are frequently fatal and highly associated with rapid mortality.[24]

It is generally accepted that conservative (NOM) management is the standard management plan for minor liver injuries. However, it is debatable whether it is effective for high-grade liver injury. But in the study by Saqib (2019), they concluded that conservative management is appropriate for hemodynamically stable patients with all grades of liver injuries.[2]

In 2018, the AAST liver injury scale was updated to include "Vascular injury" (i.e., pseudoaneurysm, arteriovenous fistula) in the imaging criteria for visceral injury **(Table 3).**[25]

b. World Society of Emergency Surgery (WSES) classification:[26]

The World Society of Emergency Surgery (WSES) recommended a classification that divides liver injuries into four grades from I to IV considering the AAST-OIS classification and hemodynamic status of the patient:

- Minor (WSES grade I).
- Moderate (WSES grade II).
- Severe (WSES grade III and IV).

► Minor hepatic injuries:

WSES, grade I involves AAST-OIS grade I–II hemodynamically stable lesions.

► Moderate hepatic injuries:

WSES, grade II involves AAST-OIS grade III hemodynamically stable lesions.

► Severe hepatic injuries:

- WSES, grade III involves AAST-OIS grade IV–V hemodynamically stable lesions.
- WSES grade IV involves AAST-OIS grade I–VI hemodynamically unstable lesions.

1. Operative management

Hemodynamically unstable patient who doesn't respond to resuscitation should proceed directly from the trauma unit to the operating room for immediate laparotomy. Also, patient with signs of peritonitis should proceed to the operating room. Patient who fails conservative non-operative management must undergo laparotomy. In hemodynamically unstable patient, damage control laparotomy principles should be followed.[4]

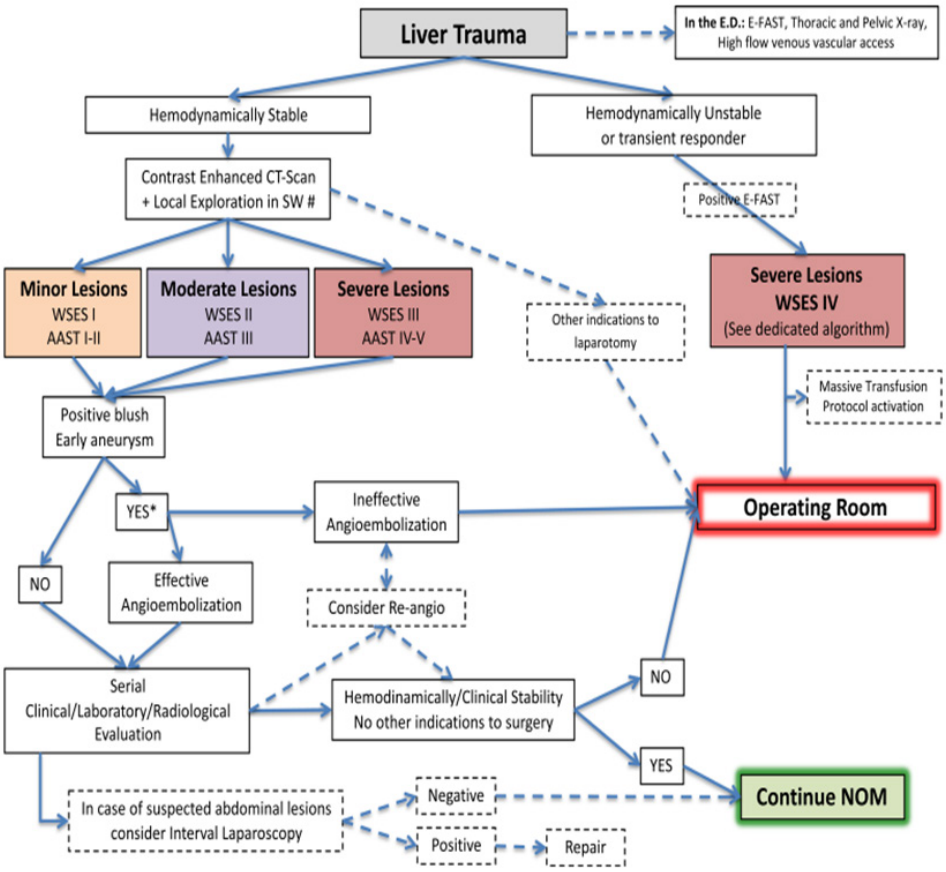

Fig 1: Algorithm of liver trauma management.[26]

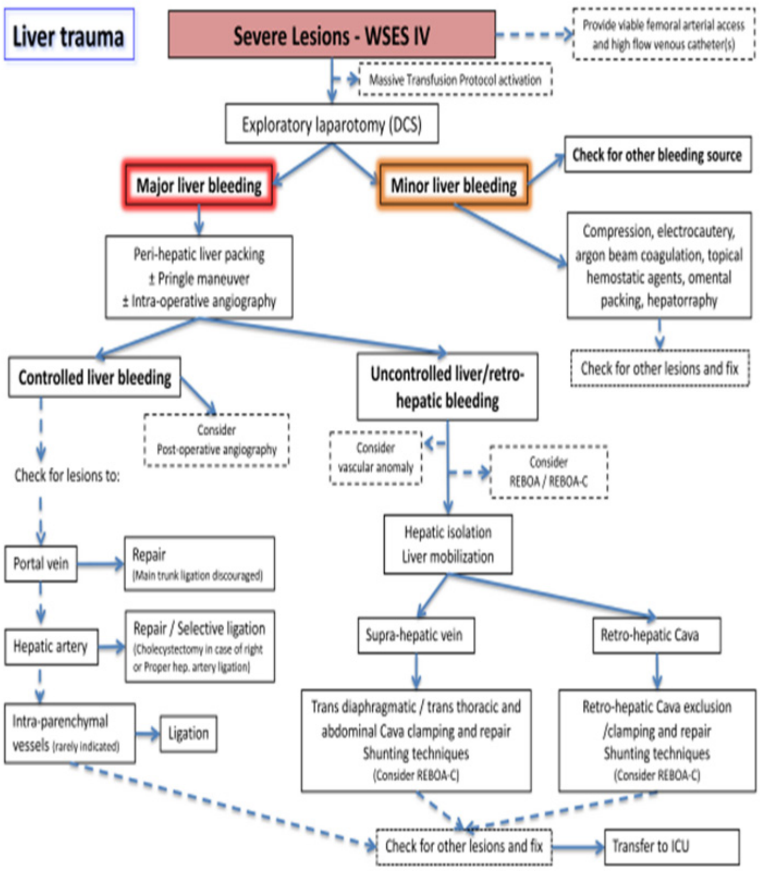

Fig 2: Algorithm of operative management of liver injury.[26]

Treatment of liver trauma has undergone a paradigm shift throughout history. It was mentioned for the first time in Greek and Roman mythology, then, in 1908, Hogarth Pringle described the "Pringle maneuver". Most patients with liver injury have traditionally been treated in the operating room using different techniques, including packing, hepatorrhaphy, and vascular ligation, for liver resection **(Figure 2)**.[7]

2. Non-operative management (NOM):

Non-operative conservative management (NOM) of blunt liver injury in hemodynamically stable patients has become the standard therapeutic technique in most trauma centers. Success rates in excess of 90% have been reported. Many factors contribute to this success: (a) more accurate imaging of the liver with the development of the computed tomography (CT) and multi-detector CT, (b) better understanding of surgical anatomy of the liver and pathophysiology of hepatic injury, (c) objective assessment of severity of liver injury through universal adoption of the American Association for Surgery of Trauma (AAST) of Liver Injury Scale.[15]

There were minor differences between studies in the definition of hemodynamic stability. Four studies defined hemodynamic stability as a systolic blood pressure (BP) > 90 mmHg on admission or after resuscitation. Among these studies, Li et al. (2014)[21] and Tian et al. (2014)[27] described adequate resuscitation as 1 liter of intravenous (IV) fluids within an hour, while Ghnnam et al. (2013)[17] defined it as 2 liters of IV fluids; Prichayudh et al. (2014)[18] did not describe adequate resuscitation. The remaining studies did not frankly state their definition of hemodynamic stability.[2]

However, hemodynamic stability in pediatric patients can be defined as a systolic blood pressure of 70 mmHg plus twice the child's age in years. A positive response to fluid resuscitation in the child is defined as two boluses of 20 mL/kg crystalloid replacement given before blood replacement, resulting in an acceptable hemodynamic condition with a decrease in the heart rate, cleared sensorium, return of peripheral pulses, normal color of skin, raising of the blood pressure and urine output, and increase in skin warmth on extremities. However, clinical judgment is fundamental when evaluating pediatric patients.[26]

Consistently lower liver-related complication rates (0–11%) were reported with the non-operative management.[28]

In addition, the more recent literature showed that surgical outcomes in cases that failed with NOM had also improved due to the more liberal use of perihepatic packing in high-grade injuries, in contrast to the earlier enthusiasm for major hepatic resections or the use of atriocaval shunts.[29]

3. Angiographic Embolization

Conservative non-operative management is also possible using selective angiographic embolization, that is an effective method for treating hepatic active extravasation & bleeding and also, corrects post-traumatic vascular lesions, such as pseudoaneurysms and arteriovenous fistulas.[30]

The success rate for angiographic embolization is up to 83%. There are no clear consensus guidelines on when and in which patients to undergo angiographic embolization. Some trauma surgeons prefer to perform angiographic embolization for any blunt liver injury greater than Grade III. In contrast, others do so only when contrast extravasation is detected in CT scan.[31]

4. Adjunct Treatments

Other therapy modalities can be used to manage patients with traumatic liver injury. For example, endoscopic retrograde cholangiopancreatography (ERCP) can be used to confirm and treat bile duct injuries, whether preoperative or postoperative. Stents can be inserted at the time of ERCP to aid in the management of bile duct injuries. In addition, bile duct stents may be inserted to reduce bile leakage originating from liver parenchyma and facilitate healing of injured bile ducts. Interventional radiology (IR) may be also used as an adjunct to liver trauma. Bilomas, or liver abscesses, may develop as a result of traumatic injury or as a complication of angioembolization and liver necrosis. Percutaneous transhepatic closed suction drains can be placed via IR to drain infected or bilious fluid collection.4

Short-and long-term follow-up[26]

- Liver abscesses can be successfully managed by percutaneous drainage.
- Delayed bleeding with no severe hemodynamic compromise can be treated initially with selective angiographic embolization.
- A hepatic artery pseudoaneurysm can be treated with angiographic embolization for prevention of its rupture.
- Symptomatic or infected bilious collections should be treated with percutaneous transhepatic drainage.
- A combination of percutaneous transhepatic drainage and endoscopic techniques may be considered in the management of post-traumatic biliary injuries that are not amenable to percutaneous management alone.
- In case of delayed post-traumatic biliary fistulas, lavage/drainage and endoscopic stent placement can be used as a first line of treatment without the need for surgery.

- In case of delayed surgery, Laparoscopy can be considered as initial approach to limit invasiveness of the surgical procedure and to tailor the procedure to the lesion.

Aim of the work

The aim of this study is to analyze & evaluate the outcome of the non-operative management (NOM) in patients with blunt traumatic liver injuries & also to assess the success rate, morbidity and mortality of NOM in these patients. medical records of 131 patients with liver trauma in our unit were analyzed retro- & prospectively.

Patients and methods

This was a retrospective and prospective cohort study to patients with blunt abdominal traumas who were admitted to our department of surgery, King Abdulaziz specialized hospital (KAASH) at Taif, Ministry of health (MOH), Saudi Arabia, in the period between December 2016 and December 2021. All the patients assigned informed consent before surgery to use their related prospective database as needed for research work.

Inclusion & exclusion criteria

Our inclusion criteria were all blunt liver trauma patients who subsequently underwent damage control surgery or conservative treatment. Patients with liver injuries were resuscitated and initially treated According to the principles of advanced trauma life support. Hemodynamic instability or signs of peritonitis were the main indications for exploratory laparotomy.

patients with penetrating liver injuries or those previously managed in other surgical departments and then transferred to our ward as well as all those with penetrating liver injuries were excluded.

Data collection

Data was extracted from preoperative and operative data records, post-operative and follow-up files. Patients were divided into two groups: those initially managed non-operatively, and those who required emergent or late surgery.

Patient data

I. Preoperative variables:

A. Demographic findings:

- Age.
- Gender: Male/female.
- Occupation.
- Residence.
- Special habits of medical importance.

B. History & clinical examination:

- Symptoms and physical signs.
- Past history including co-morbidity & drug history.
- **Laboratory study:**
  1. Complete blood picture (CBC).
  2. Liver function tests (bilirubin, total protein, albumin), liver enzymes (AST & ALT), prothrombin time and concentration.
  3. Kidney function tests (Urea, creatinine).
  4. Serum electrolytes & blood gases.
- **Imaging studies**:

  Liver injuries were detected in computed tomography (CT) scan, Extended-focused abdominal sonography for trauma (E-FAST) or during abdominal exploration.

  1. Ultrasonographic findings (U/S): To assess nature of liver injury, associated any other organ injuries and amount of intra-abdominal collection detected.
  2. Triphasic abdominal C.T.: To confirm the diagnosis of liver injury, grading of the liver injury, associated any other organ injuries and amount of intra-abdominal collection detected. Before being definitively recorded in the database, the surgical and radiological teams double-checked all CTs to confirm the liver segments affected and the severity grade. The injuries were classified using the criteria of the American Association for the Surgery of Trauma's Injury Scaling Committee (AAST).
  3. MRI Abdomen: Was done to confirm diagnosis and assess biliary or pancreatic complications (MRCP).
  4. HIDA Scan: Was done to confirm diagnosis and assess biliary leakage.
  5. Endoscopic etrograde cholangiopancreatography (ERCP): Was done to confirm diagnosis and assess biliary complications with curative intervention e.g., sphincterotomy & stenting when indicated.

The indications for surgical treatment were (1) haemodynamic instability (Advanced Trauma Life Support/ATLS protocol); (2) associated severe injuries to the spleen, bowel or other organs that were not suitable for NOM; and (3) intra-abdominal free fluid found with CT or Focused Assessment with Sonography for Trauma scan (FAST) associated with deterioration/worsening of haemodynamic stability.

The indications for NOM featured (1) haemodynamic stability and (2) hepatic injury in the absence of other injuries needing surgical exploration detected by CT. Patients with intrahepatic haematoma who were treated with NOM were discharged after being counseled on possible symptoms of negative haematoma progression

All patients were followed in the outpatient clinic and by weekly ultrasound up to complete healing.

The follow up of the patients was from the day of the admission or surgery to December 2021.

Statistical analysis

Statistical analysis was done using the SPSS software (v.20, IBM, New York, USA). The two groups of patients were compared using Fisher's exact or Chi-square tests for categorical variables, and for continuous non-normally distributed variables we used Mann-Whitney U test. A Logistic regression test was used for multivariate analysis to compare between the two groups. P values less than 0.05 were considered statistically significant.

Results

From December 2016 and December 2021, 131 patients with blunt abdominal traumas were admitted to department of surgery, King Abdulaziz specialized hospital (KAASH) at Taif, Ministry of health (MOH), Saudi Arabia. Ninety-seven (74%) patients were managed by non-Operative management (NOM), while the remaining 34 (26%) patients underwent immediate surgical management **(Table 4)**

The mean age of patients was 36 ± 14 years with a range from 8 –66 years. Thirty-two (24.4%) of patients were pediatrics with the majority of them (23 patients) were managed by NOM. Whereas, adult patients were 99 (75.6%) with only 25 (19.1%) were managed by surgery. The majority of patients were male (108 patients) who represented 82.5%.

The main cause of blunt trauma of patients was road traffic accidents (RTA) (109 patients) that represented (83.2%) and most of them (82 patients) were treated by NOM.

Most of liver injury sites were peripheral either right in 86 (65.6%) cases or left in 17 (13%) patients and it was noted that most of right peripheral injuries]81 (61.8%) [was managed conservatively, while most of the left peripheral injuries]11 (8.4%) [was treated surgically. Twenty-eight (21.4%) patients had central liver injury with 18 (13.8%) were managed by Surgical intervention; 15 (11.4%) cases underwent immediate surgery to control bleeding, bile leak & to manage other associated injuries. Whereas the remaining 3 (2.2%) cases were exposed to late surgical management for definite management of biliary stricture and underwent biliary reconstruction (Hepaticojejunostomy HJ). **(Figure 3).**

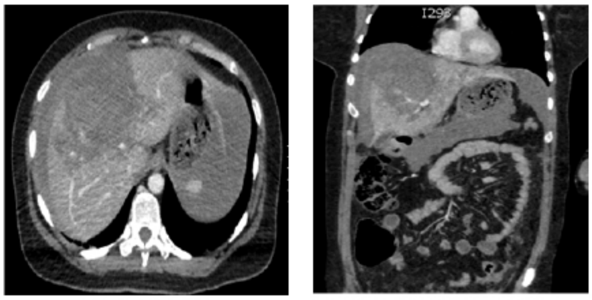

Fig 3: CT images showing post traumatic grade IV liver laceration.

Twenty-one (16%) patients had isolated liver injury, whereas 110 (84%) patients had liver injuries with other associated injuries in brain, vertebrae, thoracic, abdominal, bone & others.

The mean Injury Severity Score (ISS) was 19 ± 7 and the mean New Injury Severity Score (NISS) was 23 ± 8, whereas the mean Exponential Injury Severity Score (EISS) was 17 ± 6. In all systems of injury severity score, the moderate injury scores were the predominant (ISS = 16–24, NISS of 16–24 & EISS of 9–16).

Regarding AAST grading of liver injuries, the grade III injuries]57 (43.5%) [Were most common with 50 patients (38.2%) were managed by NOM & only 7 (5.3%) cases were managed by immediate surgical intervention. Grade IV injuries involved 12 (9.2%) patients who were managed by surgery either immediate or late & represented the most grade managed surgically. There was only one case (0.7%) that was grade IV that was a 16-year-old female patient presented post RTA with combined severe brain, bone & liver injury. She had massive intra-abdominal bleeding with marked drop in serum hemoglobin, so she was admitted immediately to OR and avulsion of hepatic pedicle was found with trials to control bleeding, but unfortunately, she was arrested & died in OR.

Thirty-nine (29.8%) patients received blood products during their hospital stay that involved 17 (13%) cases of the NOM group & 22 (16.8%) of the operative group.

The mean serum total Bilirubin at admission was 3.6 ± 2.4 mg/dl. It was elevated in 30 (22.9%) patients; 21 (16%) of the NOM group & 9 (6.9%) of the operative group.

The mean serum ALT level at admission was 68

± 43 IU/L. It was increased in 87 (66.4) patients; 70 (53.4%) of the NOM group & 17 (13%) of the operative group.

The mean serum GGT level at admission was 84 ± 38 IU/L. It was elevated in 37 (28.3%) patients; 24 (18.3%) of the NOM group & 13 (10%) of the operative group.

Thirty-four (26%) patients were managed by surgical intervention; 9 (26.6%) cases were admitted to OR due to other associated injuries, 6 (17.6%) patients underwent external biliary drainage for associated Diffuse bile leak, biloma & intra-abdominal abscesses, 4 (11.8%) underwent simple hemostasis of liver injury by cauterization & absorbable hemostat with/without external biliary drainage for Diffuse bile leak or biloma, 3 (8.8%) cases underwent suturing of liver injury by mattress sutures with/without external biliary drainage for Diffuse bile leak or biloma, 2 (5.9%) patients were controlled intraoperatively by continuous suturing of spurter with/without external biliary drainage for Diffuse bile leak or biloma, 3 (8.8%) cases underwent debridement of devitalized liver tissue & two of them developed postoperative bile leak that was managed conservatively with percutaneous drainage & ERCP with stenting, only one patient (2.9%) underwent left lateral liver resection who also developed postoperative diffuse bile leak and re-explored again for external biliary drainage due to sepsis & definitely managed by postoperative ERCP with stenting, also one patient (2.9%) underwent packing then re-laparotomy with formal left hepatectomy. two (5.9%) patients underwent Packing then re-laparotomy with liver suturing and 3 (8.8%) patients underwent late surgery for biliary enteric anastomosis (HJ) for biliary strictures.

The most common complication in patients with liver injury in this study was biliary complications; diffuse bile leak in 15 (11.4%) patients, biloma in 21 (16%) cases & biliary strictures in 3 (2.2%). Most of complicated biliary cases were managed conservatively by either US or CT guided drainage in 47 (36.8%) patients (43 (32.8%) cases of the NOM group & 4 (3%) cases of the operative group [and/or ERCP with stenting in 33 (25.2%) patients]28 (21.4%) cases of the NOM group & 5 (3.8%) cases of the operative group).

The second common complication was re-bleeding in 16 (12.1%) cases after surgical intervention at admission; 11 (8.3%) of re-bleeding patients were managed conservatively & 5 (3.8%) patients underwent re-laparotomy & control of bleeding by different techniques. Unfortunately, one patient died postoperatively after re-laparotomy due to sudden cardiac arrest after start of inotropes.

Other complications included intraabdominal abscess/es in 13 (9.9%) patients, intrahepatic abscess/es in 8 (6.2%) patients & acute liver failure in 3 (2.2%) patients in whom 2 of them died; the first one was of the operative group & had severe intraoperative bleeding & the second one was of the NOM group & developed sepsis.

In univariate analysis, significant differences were found between both groups in site of liver injury (P = 0.04), high grades liver trauma (P = 0.03), elevated serum level of ALT at time of admission (P = 0.01) & ICU stay (P = 0.017).

The mortality rate was 3% (4 patients); 3 (2.2%) of the operative group & 1 (0.8%) patient of the NOM group. The mean length of ICU stay was 6 ± 14 days with a range of 2-36 days. While the mean length of hospital stay was 19 ± 7 days with a range 6–32 days, and the hospital readmission rate was 21 (16%).

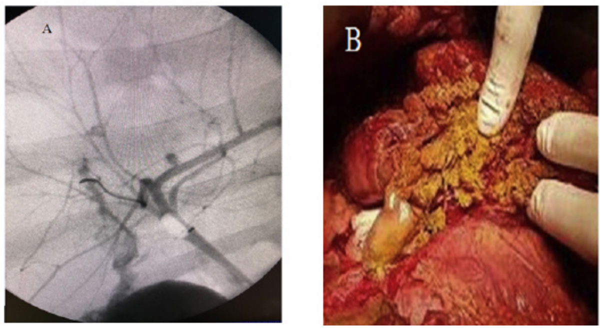

Fig 4: a) ERCP image with contrast leak at the right hepatic lobe denoting injury of bile duct of segment VI, b) Operative image after laparotomy of the patient due to peritonitis post ERCP → closure of the suspicious small bile duct on cut surface with proline 6/0 & insertion of drain.

Table 1: Calculation of the Exponential Injury Severity Score (EISS) according to Abbreviated Injury Scale (AIS) codes

AIS codes (A)	3^{A-2} (B)	(C)	(D)
1	3^{1-2}	3^{-1}	0.3
2	3^{2-2}	3^{0}	1
3	3^{3-2}	3^{1}	3
4	3^{4-2}	3^{2}	9
5	3^{5-2}	3^{3}	27
6	3^{6-2}	3^{4}	81

Table 2: AST liver injury scale (1994 revision)[23]

Grade	Type	Injury description
I	Hematoma	Subcapsular, non-expanding <10% surface area
	Laceration	Capsular tear, non-bleeding <1 cm parenchymal depth
II	Hematoma	Subcapsular non-expanding 10–50 % surface area Intraparenchymal, non-expanding <10 cm diameter
	Laceration	Capsular tear, active bleeding 1–3 cm parenchymal depth, <10 cm in length
III	Hematoma	Subcapsular >50 % surface area or expanding, ruptured subcapsular with active bleeding Intraparenchymal haematoma >10 cm or expanding
	Laceration	>3 cm parenchymal depth
IV	Hematoma	Ruptured intraparenchymal with active bleeding
	Laceration	Parenchymal disruption involving 25–75 % of hepatic lobe or one to three Couinaud’s segments within a single lobe
V	Laceration	Parenchymal disruption involving >75 % of hepatic lobe >3 Couinaud’s segments within a single lobe
	vascular	Juxta hepatic venous injuries (i.e., retro hepatic vena cava or central major hepatic veins
VI	vascular	Hepatic avulsion

Table 3: Liver Injury Scale-2018 Revision[25]

AAST Grade	AIS Severity	Imaging Criteria (CT Findings)	Operative Criteria	Pathologic Criteria
I	2	Subcapsular hematoma <10% surface area	Subcapsular hematoma <10% surface area	Subcapsular hematoma <10% surface area
		Parenchymal laceration <1 cm in depth	Parenchymal laceration <1 cm in depth Capsular tear	Parenchymal laceration <1 cm in depth Capsular tear
II	2	Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <10 cm in diameter	Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <10 cm in diameter	Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <10 cm in diameter
		Laceration 1–3 cm in depth and ≤ 10 cm length	Laceration 1–3 cm in depth and ≤ 10 cm length	Laceration 1–3 cm depth and ≤ 10 cm length
III	3	Subcapsular hematoma >50% surface area; ruptured subcapsular or parenchymal hematoma	Subcapsular hematoma >50% surface area or expanding; ruptured subcapsular or parenchymal hematoma	Subcapsular hematoma >50%-surface area; ruptured subcapsular or intraparenchymal hematoma
		Intraparenchymal hematoma >10 cm	Intraparenchymal hematoma >10 cm	Intraparenchymal hematoma >10 cm
		Laceration >3 cm depth	Laceration >3 cm depth	Laceration >3 cm depth
		Any injury in the presence of a liver vascular injury or active bleeding contained within liver parenchyma		
IV	4	Parenchymal disruption involving 25–75% of a hepatic lobe	Parenchymal disruption involving 25–75% of a hepatic lobe	Parenchymal disruption involving 25–75% of a hepatic lobe
		Active bleeding extending beyond the liver parenchyma into the peritoneum		
V	5	Parenchymal disruption >75% of hepatic lobe	Parenchymal disruption >75% of hepatic lobe	Parenchymal disruption >75% of hepatic lobe
		Juxtahepatic venous injury to include retrohepatic vena cava and central major hepatic veins	Juxtahepatic venous injury to include retrohepatic vena cava and central major hepatic veins	Juxtahepatic venous injury to include retrohepatic vena cava and central major hepatic veins

Table 4: Preoperative, operative and postoperative data for both groups of traumatic liver injuries

	Total	NOM	Operative	P value
Total number of patients	131	97 (74%)	34 (26%)	
Age (year)				
Mean ± SD	36 ± 14	22 ± 12	34 ± 16	
Range (year)	8 – 66	8-61	22-66	0.26
Pediatrics	32 (24.4%)	23 (17.5%)	9 (6.9%)	
adults	99 (75.6%)	74 (56.5%)	25 (19.1%)	
Sex				
Male	108 (82.5%)	82 (62.6%)	26 (19.8%)	0.6
Female	23 (17.5%)	15 (11.4%)	8 (6.2%)	
Mechanism of blunt injury				
RTA trauma	109 (83.2%)	82 (62.6%)	27 (20.6%)	
Fall down from a height	13 (9.9%)	9 (6.9%)	4 (3%)	0.17
Hit by hard object	9 (6.9%)	6 (4.5%)	3 (2.4%)	
Site of liver injury				
Central	28 (21.4%)	10 (7.6%)	18 (13.8%)	
Right peripheral	86 (65.6%)	81 (61.8%)	5 (3.8%)	0.04
Left peripheral	17 (13%)	6 (4.6%)	11 (8.4%)	
Isolated liver injury	21 (16%)	15 (11.4%)	6 (4.6%)	
Associated injury	110 (84%)	82 (62.6%)	28 (21.4%)	
Brain	19 (14.3%)			
vertebral	25 (19.1%)			
Thoracic	46 (35.1%)			
Abdominal	36 (27.5%)			
Bone	44 (33.6%)			
Others	35 (26.7%)			
Injury Severity Score (ISS)	19 ± 7			
ISS < 16	45 (34.4%)	41 (31.4%)	4 (3%)	0.12
ISS = 16–24	62 (47.3%)	48 (36.4%)	14 (10.9%)	
ISS ≥ 25	24 (18.3%)	8 (6.2%)	16 (12.1%)	
New Injury Severity Score (NISS)	23 ± 8			
NISS < 16	42 (32%)	35 (26.7%)	7 (5.3%)	
NISS of 16–24	58 (44.3%)	49 (37.4%)	9 (6.9%)	0.09
NISS ≥ 25	31 (23.7)	13 (9.9%)	18 (13.8%)	
Exponential Injury Severity Score (EISS)	17 ± 6			
EISS < 9	41 (31.3%)	35 (26.7%)	6 (4.6%)	
EISS of 9–16	72 (54.9)	57 (43.5%)	15 (11.4%)	0.11
EISS ≥ 27	18 (13.8%)	5 (3.8%)	13 (10%)	
AAST grading				
Grade I	13 (10%)	10 (7.6%)	3 (2.4%)	
Grade II	17 (13%)	12 (9.2%)	5 (3.8%)	
Grade III	57 (43.5%)	50 (38.2%)	7 (5.3%)	0.03
Grade IV	32 (24.4%)	20 (15.2%)	12 (9.2%)	
Grade V	11 (8.4%)	5 (3.8%)	6 (4.6%)	
Grade VI	1 (0.7%)	0 (0%)	1 (0.7%)	
Blood transfusion				
NO	92 (70.2%)	80 (61%)	12 (9.2%)	0.18
YES	39 (29.8%)	17 (13%)	22 (16.8%)	
Total Bilirubin (mg/dl)				
Mean ± SD	3.6 ± 2.4			
Normal	101 (77.1%)	76 (58%)	25 (19.1%)	0.11
elevated	30 (22.9%)	21 (16%)	9 (6.9%)	
Serum ALT (IU/L)				0.01
Mean ± SD	68 ± 43			
Normal	44 (33.6%)	27 (20.6%)	17 (13%)	
elevated	87 (66.4)	70 (53.4%)	17 (13%)	
Serum GGT (IU/L)				0.15
Mean ± SD	84 ± 38			
Normal	94 (71.7%)	73 (55.7%)	21 (16%)	
elevated	37 (28.3%)	24 (18.3%)	13 (10%)	

	Total	NOM	Operative	P value
Surgical procedure			34 (100%)	
• Surgery for associated injuries			9 (26.6%)	
• External biliary drainage for Diffuse bile leak/biloma/intraabdominal abscess			6 (17.6%)	
• Simple hemostasis of liver injury by cauterization & absorbable hemostat ± External biliary drainage for Diffuse bile leak/biloma			4 (11.8%)	
• Suturing of liver injury by matress sutures ± External biliary drainage for Diffuse bile leak/biloma			3 (8.8%)	
• Control of spurter by continuous suturing ± External biliary drainage for Diffuse bile leak/biloma			2 (5.9%)	
• Debridement of devitalized liver tissue			3 (8.8%)	
• Liver resection			1 (2.9%)	
• Packing then re-laparotomy with liver suturing			2 (5.9%)	
• Packing then re-laparotomy with liver resection			1 (2.9%)	
• Roux-en-Y hepaticojejunostomy (HJ)			3 (8.8%)	
Complications				0.31
Diffuse bile leak	15 (11.4%)	11 (8.4%)	4 (3%)	
Biloma	21 (16%)	19 (14.5%)	2 (1.5%)	
Intraabdominal abscess/es	13 (9.9%)	9 (6.9%)	4 (3%)	
Re-bleeding	16 (12.1%)	11 (8.3%)	5 (3.8%)	
Intrahepatic abscess/es	8 (6.2%)	8 (6.2%)	0 (0%)	
Acute liver failure	3 (2.2%)	1 (0.7%)	2 (1.5%)	
Biliary stricture	3 (2.2%)	0 (0%)	3 (2.2%) → HJ	
US or CT guided drainage for bilomas, bile leak, abscess	47 (36.8%)	43 (32.8%)	4 (3%)	0.09
ERCP with stenting	33 (25.2%)	28 (21.4%)	5 (3.8%)	0.07
Mortality	4 (3%)	1 (0.8%)	3 (2.2%)	0.25
ICU stay				
mean ± SD	6 ± 14	3 ± 10	7 ± 15	0.017
Range	2-36	2-13	5-36	
Hospital stay				
mean ± SD	19 ± 7	14 ± 11	22 ± 10	0.14
Range	6–32	6–21	9–32	
Readmission				
No	110			
Yes	21 (16%)	18 (13.7%)	3 (2.3%)	

Discussion

The paradigm shift in the management of traumatic liver injuries has resulted in most injuries being treated conservatively instead of surgically as before.[32]

widespread use of ultrasound and computed tomography (CT) has facilitated decision making and non-operative management (NOM) has been shown to minimize mortality rates. NOM is now the standard management plan for blunt hepatic injuries in hemodynamically stable patients in whom an abdominal CT scan with IV contrast can accurately identify the pathology, the presence of complications and the proper severity grade of injury.[33]

laboratory tests should include serum aminotransferases. Elevated serum levels of ALT, AST, LDH, and GGT have each been associated with liver injury, and it has been shown that the degree of elevation of ALT, AST, and LDH correlates with the degree of injury and ALT as the best laboratory screening test. While the majority of patients with blunt trauma to the abdomen are evaluated with CT, serum aminotransferase levels can be useful screening tests for those who do not undergo immediate exploration or imaging.[34]

In Patients with traumatic liver injuries who are hemodynamically stable patients without peritonitis, non-operative management (NOM) is preferred.[35]

Reported success rates for non-operative treatment of traumatic hepatic injury are over 85%. About 70–80% of traumatic liver injuries can be safely managed conservatively; even for the most serious injuries, the non-surgical management rate approaches 50%. About 80-85% of blunt hepatic injuries are grade I–III and only 15% are high grade injuries (Grades IV–V). In addition, the patient requiring immediate surgical intervention for hemodynamic reasons generally has grade IV or V hepatic injury. Therefore, trauma surgeons rarely operate on blunt liver injuries, but in those cases, operations are often challenging technically.[34]

In the current study, 131 patients with blunt liver injuries of all grades that were diagnosed by CT scan or at laparotomy. Ninety-seven (74%) patients were managed by non-Operative management (NOM), while the remaining 34 (26%) patients underwent immediate surgical management.

In the current study, the mean age of patients was 36 ± 14 years with a range from 8 – 66 years. Thirty-two (24.4%) of patients were pediatrics with most of them (23 patients) were managed by NOM. Whereas, adult patients were 99 (75.6%) with only 25 (19.1%) were managed by surgery. In Hommes et al. study (2015),[19] They performed their study on 134 patients (mean age = 29 years with a range of 23-38 years) with all grades of blunt liver injury. Also, in studies by Prichayudh et al. (2014)[18] & Asfar et al. (2014),[15] they reported that mean age was 30.4 years, 29.02 ± 11.18 years (Range 7-63) respectively.

In the study by Li et al. (2014),[21] The mean age of NOM group was 35.9 years (With a range of 17-69 years) with 55 males and 17 females, while the mean age of the surgical group was 38.2 years (With a range of 19-62), with 7 males and 2 females.

blunt traumatic liver injuries are more common in young men, and road traffic accidents are the leading cause.[7]

This corresponds to what was detected in this current study as the majority of patients were male (108 patients) who represented 82.5% & the main cause of blunt trauma of patients was road traffic accidents (RTA) (109 patients) that represented (83.2%). Also, this corresponds to what reported in Ghnamm et al. (2013),[17] Saltzherr et al. (2011).[16] & Tian et al. (2014)[27] that traumatic liver injuries were more common in males than females. Ghnamm et al. (2013),[17] also confirmed that road traffic accidents were the cause of 89.2% (50 patients out of 56) of hepatic injuries, while 8.9% (5 patients out of 56) were due to non-traffic related causes (E.g., fall from a height).

Liver injuries involving a hepatic vein are associated with an increased risk of arterial injury and need for surgical intervention. Although not related to injury, periportal edema may be seen associated with traumatic liver injury because patients with high grade injuries have received aggressive fluid resuscitation. Also, injuries that involve porta hepatis increase the risk for biliary tract injuries, specially delayed biliary complications. Biliary tract injuries are more common in high grade injuries, central injuries, injuries close to inferior vena cava (IVC) and penetrating trauma versus blunt trauma.[36]

In the current study, most of liver injury sites were peripheral either right in 86 (65.6%) cases or left in 17 (13%) patients. Twenty-eight (21.4%) patients had central liver injury with 18 (13.8%) were managed by Surgical intervention. We found significant difference between both groups in site of liver injury (P = 0.04). In a study by Schembari et al. (2020)7, the majority of patients had more than one liver segment injured, and the most frequently affected segments were VII (50.3%), VI (48.3%), V (40.7%) and VIII (35.9%), while IV, III, II, and I segments were injured in 16.0%, 17.2%, 14.5% and 12.4% of cases respectively. All liver segments were affected in 11 patients (4.1%), while only one segment was injured in 38 (26.2%) patients.

Many studies of patients with hepatic trauma have suggested that early death is due to uncontrolled hemorrhage from associated intra- and extra-abdominal injuries, while late death results from head trauma and septicemia with multiple organ failure. Patients with traumatic liver injuries usually have other complicated injuries, and NOM outcome have been affected by co-existing trauma.[21]

In the current study, twenty-one (16%) patients had isolated liver injury, whereas 110 (84%) patients had liver injuries with other associated injuries; 82 (84.5%) of 97 patients in the NOM group & 28 (82.4%) patients in the operative group. The most common associated injury was thoracic injuries 46 (35.1%). In Hommes et al. study (2015),[19] 46 (46%) patients of 99 patients in the NOM group had associated injuries, compared to 28 (80%) of 35 patients in the surgical group. In Tian et al. 2014)[27] study, Associated injuries were present in 205 (69.3%) of 296 patients. In the study by Ghnamm et al. (2013),[17] Most patients (85.7%) had concomitant abdominal or extra-abdominal injuries, with the most common being thoracic injuries (26.8%), consistent with the results of this current study.

The Injury Severity Score (ISS) and the New Injury Severity Score (NISS) are anatomical scores. they depend on the Abbreviated Injury Scale (AIS) but differ in method of calculation. The majority of studies have shown that NISS is superior to ISS in assessing injured patients. although some have shown to have similar accuracy. ISS is the most widely used scoring system worldwide.[1]

The EISS prediction of mortality is based solely on the anatomical information provided by a patient's AIS injury descriptors. Part of the value of a summary injured score is that it can be calculated by physicians. The NISS (And the ISS) are both popular because they are simple to calculate.[14]

In the current study, the mean Injury Severity Score (ISS) was 19 ± 7 and the mean New Injury Severity Score (NISS) was 23 ± 8, whereas the mean Exponential Injury Severity Score (EISS) was 17 ± 6. In all systems of injury severity score, the moderate injury scores were the predominant (ISS = 16–24, NISS of 16–24 & EISS of 9–16). The median Injury Severity Score (ISS) In Saltzherr et al. (2011)[16] study was 20 (with a range of 9-34). In the study by Prichayudh et al. (2014),[18] the ISS was significantly lower in the conservative group compared to the surgical group (20.8, SD 9.0 vs. 28.1, SD 15.4 respectively). This was also confirmed by a study where patients in the surgical group had a higher ISS, and this higher ISS was associated with a considerably higher mortality rate ($p<0.0001$).

the revised Organ Injury Scale (OIS) is the most commonly used scoring system at the current time. It was published in 1989 by the American Association for Surgery of Trauma and firstly modified in 1994. It has long been regarded as the gold standard for trauma classification. Despite its widespread clinical application, the original intent of this classification was to provide an anatomical description rather than to direct treatment paths. Low grade AAST-OIS lesions (I–III) are frequently regraded as non-severe and treated with conservative management, whereas high grade injuries (Higher than III) are more likely to require operative management. However, patients with hemodynamically stable severe injuries can be successfully managed conservatively in some circumstances, whereas low grade injuries in patients with hemodynamic instability indicate surgery. As a result, the AAST-OIS should be always supported with the hemodynamic status and associated injuries when deciding the treatment strategy.[37]

In the current study, regarding AAST grading of liver injuries, 87 (66.4%) of 131 patients had low grade injuries in whom a success rate of NOM was 82.8% & failed NOM in 15 (17.2%) of the 87 low-grade injury patients. The high-grade injury patients represented 33.6% (44 of 131 patients). The success rate of NOM in high grade injury patients was 56.8% 25 of the forty-four patients), while NOM failed in 19 (43.2%) of 44 patients. This means that the success rate of NOM is higher in both low & high-grade liver injuries in this current study. the grade III injuries [57 (43.5%)] were most common with 50 patients (38.2%) were managed by NOM & only 7 (5.3%) cases were managed by immediate surgical intervention. Grade IV injuries involved 12 (9.2%) patients who were managed by surgery either immediate or late & represented the most grade managed surgically. There was only one case (0.7%) at grade IV that was a mortality case. Also, significant difference was found between the both groups in high grades liver trauma ($P = 0.03$).

In 2015 research by Hommes et al.,[19] 44 (44%) of 99 patients in the non-operative management group experienced high grade liver injury. NOM succeeded in 41 of these 44 patients, with 93% success rate in patients with high-grade injuries. Higher-grade injuries were not more common in patients who failed the non-operative management. In the study of (Li et al., 2014),[21] 53 (73.6%) of NOM group's patients had high-grade hepatic injuries, whereas all nine (100%) the operative group's patients had high-grade injuries (grades IV or V). NOM had a 97.2 percent total success rate (70 patients out of 72). Also, NOM had a 96.2 percent success rate in patients with high-grade injuries (51 patients out of 53). The two patients who failed NOM had liver injury grade IV and grade V.

According to Ghnamm et al. (2013) study,[17] 21 (58%) patients in the non-operative management (NOM) group (12 with grade III, 9 with grade IV) had high-grade liver injury in comparison to all 20 (100%) patients in the surgical group (2 with grade III, 12 with grade IV, 6 with grade V or VI). The overall NOM success rate was 100 percent, as was the NOM success rate in high-grade liver injury patients. While the percentages of hepatic injury grades in Afifi et al. (2018)[20] study were as follows: 28.8 percent grade I, 44.7 percent grade II, 19.1 percent grade III, 7 percent grade IV, and 0.4 percent grade V. NOM was had 97% overall success rate (192 patients out of 198); however, it failed in six cases due to delayed hemorrhage from liver hematoma, concomitant splenic rupture, and small bowel injury. Furthermore, in Asfar et al. (2014) study,[15] the non-operative management had 96 percent success rate (94 cases of 98). Due to delayed hemorrhage (rupture of intrahepatic right lobe hematoma), splenic or diaphragmatic rupture, or small bowel injury, 4 patients (4%) who were initially managed conservatively had surgery. A study by Schembari et al. (2020)[7] reported that NOM was 100% effective, with no patient in the group requiring surgical intervention.

providing simultaneous intraoperative intense resuscitation with early initiation of a massive transfusion protocol (MTP) to preserve organ perfusion and ultimately correct any trauma-induced physiological disorder is critical during operative management of traumatic liver injury.[38]

In the current study, 39 (29.8%) patients received blood products during their hospital stay that involved 17 (13%) cases of the NOM group & 22 (16.8%) of the operative group. In Schembari et al. (2020) study,[7] only 18 patients required blood transfusions: 9 in the non-operative group (10.4) and 9 in the operative group (15.2%).

In predicting hepatic injuries, elevated serum liver transaminases (ALT/AST) are 93% sensitive & 100% specific.[39]

This corresponds to what was reported in this current study as serum ALT was increased in 87 (66.4) patients; 70 (53.4%) of the NOM group & 17 (13%) of the operative group with significant difference between both groups in elevated serum level of ALT at time of admission (P = 0.01).

In case of liver trauma (Blunt and penetrating) with hemodynamic instability, associated internal organ injury necessitating surgical intervention, evisceration or impalement, Patients should be managed by surgery. Primary surgical goal is to stop bleeding, control biliary leakage and start intense resuscitation as early as possible. Major liver resection should be avoided at first and taken into account later (Delayed fashion) only in case of major devitalized liver segments and in centers with essential expertise. Angioembolization is an effective modality of treatment for persistent hemorrhage of arterial origin. hemorrhage is the major cause of death in traumatic liver injury. hemodynamic status of the patient and concomitant injuries play a big role in surgery decision.[38]

Other criteria for success of NOM in addition to that mentioned in guidelines are the presence of a competent multidisciplinary team, the ability to provide high quality CT imaging, critical care facility, and the necessity for surgeons with good expertise and skills. Availability of interventional radiology facilities for percutaneous transhepatic drainage & embolization along with endoscopy for ERCP and stenting, is critical for the use of NOM for traumatic liver injuries.[7]

In this study, 34 (26%) of 131 patients were managed by surgical intervention; 9 (26.6%) of the 34 patients due to other associated injuries, 6 (17.6%) patients underwent external biliary drainage for associated Diffuse bile leak, biloma & intra-abdominal abscesses, 13 (38.3%) underwent hemostasis of the liver injury by different techniques e.g., simple hemostasis by cauterization & absorbable hemostat, suturing of the injury cut surface or a spurter, debridement of devitalized liver tissue or liver resection. These different techniques were/were not associated with external biliary drainage for Diffuse bile leak or biloma. Some cases were complicated with postoperative bile leak that was managed conservatively with percutaneous drainage & ERCP with/without stenting. Also, three (8.8%) patients underwent packing then re-laparotomy & definitive controlling of bleeding. Three (8.8%) patients underwent late surgery for biliary enteric anastomosis (HJ) for biliary strictures.

In Hommes et al. study (2015),[19] hemodynamic instability (11 patients), peritonitis (16 patients) and presence of other associated intra-abdominal injuries requiring surgery, were the reasons for operative interventions. While, in the study by Schembari et al. (2020),[7] surgery was the definitive management for 59 patients (40.7%). Liver suturing (23 patients), simple haemostasis (16 patients), packing (10 patients), laparoscopy (6 patients) & liver resections (4 patients) were the operative procedures used to treat the liver injuries. Five of the six laparoscopies (83%) were conducted to rule out or confirm suspected bowel injury in borderline stable patients.

In this current study, no patient was managed by angioembolization, while, in Schembari et al. (2020) study,[7] Angioembolization was used to treat 3 patients with active bleeding.

In this current study, Biliary complications such as leakage or strictures were the most common complications that occurred in 39 (29.6%) of patients with the majority of these complicated biliary cases being managed conservatively by either US or CT guided drainage in 47 (36.8%) patients [43 (32.8%) cases of the NOM group & 4 (3%) cases of the operative group] and/or ERCP with stenting in 33 (25.2%) patients [28 (21.4%) cases of the NOM group & 5 (3.8%) cases of the operative group]. The second common complication was re-bleeding in 16 (12.1%) cases after surgical intervention at admission. Other complications included intraabdominal abscess/es in 13 (9.9%) patients, intrahepatic abscess/es in 8 (6.2%) patients & acute liver failure in 3 (2.2%) patients in whom 2 of them died; the first one was of the operative group & had severe intraoperative bleeding & the second one was of the NOM group & developed sepsis.

This corresponds to Schembari et al. (2020) study[7] in which 14 patients (23.7%) had complications, including 5 bilomas (8.5%), 5 abscesses (8.5%), and 4 bleeding (6.7%). Percutaneous transhepatic drainage and ERCP with stenting were used to treat three patients with bilomas. percutaneous drainage with embolization of a peripheral bile duct leakage were performed to successfully manage one biloma, and Pedinelli catheter placed during the prior surgery was used as a guide to put the micro coils. angioembolization was used to treat 3 patients with persistent active hemorrhage, while percutaneous drainage was used to manage four abscesses. In 3 cases (5.1%), laparotomy was essential for: Drainage of an abscess associated with intestinal obstruction, infected biliary collection and management of hemorrhage that happened during re-laparotomy for removal of packs. While in Li et al. study (2014),[21] The overall complication rate for patients who had successful conservative management (NOM) was 10% (7 cases out of 70). One, three, and three successful NOM patients had complications with liver injury grades III, IV, and V respectively, making the overall complication rate in patients managed non-operatively approximately 13.7% (7 out of 51) in these high-grade liver injuries. There were bilomas in 4 of the patients and biliary fistulas in 3 of them. Five out of nine patients who were managed surgically had complications (45.5%). All those patients had high-grade hepatic injury, resulting in a 45.5% complication rate in the high-grade liver injury operative group. Two of these patients had biliary fistulas (both grade V), while two suffered biliary fistulas with bleeding (grade IV & grade V), and one had intra-abdominal abscess & bleeding (grade V).

In this current study, the overall mortality rate was 3% (4 cases). The mean length of ICU stay was 6 ± 14 days with a range of 2-36 days. While the mean length of hospital stay was 19 ± 7 days with a range 6–32 days, and the hospital readmission rate was 21 (16%).

In Schembari et al. (2020) study,[7] the overall rate of mortality was 16.9%. The average hospital stay was 18 days (with a range of 11–34 days), and the hospital readmission rate was 0%, while in Hommes et al. study (2015),[19] mortality rate was 5%. Only one of the 99 patients who were managed initially with NOM died (Mortality rate of 1), compared to six of 36 patients who managed by laparotomy from the start (Mortality rate of 17%).

Conclusions

Non-operative management of liver trauma is highly effective and safe with high success rate even in high-grade liver injuries particularly in pediatric group patients.

success of non-operative management is highly depending on hemodynamic stability of the patient, site & AAST grade of liver injury. Also, non-operative management (NOM) can be tried in case of associated intra or extra-abdominal injuries such as head trauma and in the severe high grade liver injuries as long patient is hemodynamically stable & no signs of peritonitis.

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