Management and outcomes of traumatic liver injury: a tertiary care center experience

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Abstract

Background

Trauma is considered a significant public health problem worldwide. Abdominal trauma is generally divided into blunt and penetrating. Blunt trauma could affect any organ, and the sequelae of such injury may not always be clinically apparent. Liver injury is one of abdominal trauma's most critical and fundamental complications. We aimed to investigate the mechanism, type, and extent of injuries for patients with liver trauma and compare the outcomes between operative and non-operative management.

Methods

This retrospective study analyzed data of patients with liver injuries who presented to King Khalid University Hospital, King Saud University from 2016 to 2022. Management included conservative, conservative to laparotomy, laparotomy, and interventional radiological procedures, including hepatic artery angioembolization and percutaneous transhepatic drainage. Injury severity was graded based on the American Association for the Surgery of Trauma (AAST) liver injury scale.

Results

We analyzed 45 liver injury patients, with mean age of 29.3 years and most of them being male (77.8%). The most common injury mechanism was blunt trauma (86.7%), whereas penetrating injuries accounted only for 8.9% of cases. The most dominant type of injury was laceration (95.6%), followed by contusion (28.9%). Regarding liver injury severity, the majority of patients (37.8%) had a grade 3 injury level as per AAST liver injury scale. Among all patients, 31 (68.9%) were hemodynamically stable, whereas 14 patients (31.1%) were unstable, with a mortality rate of 2.2%. Most patients (82.2%) underwent conservative management. Six patients (13.3%) require surgical laparotomy. Two patients (4.4%) who underwent conservative management first needed surgical laparotomy. The complication rate was 24.4%, with delirium being the most common (6, 13.3%), followed by fever and sepsis (3, 6.7%) and acute renal failure, pneumonia, cardiac arrest, biliary leaks, meningitis/seizures, which were all reported in a subset of patients.

Conclusions

Liver trauma is considered a significant public health problem worldwide. The management of traumatic liver injuries has evolved significantly over the years, with the addition of interventional radiological modalities, a more inclined approach toward non-operative management.

1. Background

Trauma is considered a significant public health problem worldwide. It is the leading cause of death, hospitalization, and long-term disabilities in the first four decades of life and one of the leading causes of death in all ages [1,2]. Specifically, abdominal trauma is considered the second leading cause of death in polytrauma patients, following head trauma and thoracic injuries [1]. The abdominal region is the third most commonly injured body area, with approximately 25% of all abdominal trauma cases requiring exploration [3].

Abdominal trauma is generally divided into two main categories, i.e., blunt and penetrating. Blunt trauma could affect any organ, and the sequelae of such injury may not always be clinically apparent. Thus, a careful and thorough investigation is always needed [2]. The most common causes of blunt abdominal trauma include, but are not limited to, motor vehicle collisions, falls from height, and assaults, whereas gunshots and stab wounds are the most common causes of penetrating trauma [3].

Liver injury is one of abdominal trauma's most critical and fundamental complications. The liver and spleen are the most commonly injured organs after blunt abdominal trauma, whereas other organs such as the pancreas, bladder, and kidneys are less commonly involved [2]. The prevalence of liver injury in blunt trauma patients was reported to be between 1% and 8% [4]. Owing to its increased size, vascular content, unique location, weak parenchyma, and fragile capsule, the liver is considered one of the most commonly injured solid abdominal organs [5].

In the setting of acute life-threatening conditions, trauma can be assessed immediately with the help of Extended-Focused Assessment with Sonography in Trauma (E-FAST). E-FAST has been widely accepted and utilized in trauma cases by emergency physicians and trauma surgeons alike. However, when it comes to the assessment of the extent or grade of hepatic injuries, computed tomography (CT) is the mainstay of evaluating hepatic injury; CT findings may include lacerations, contusions, parenchymal hematoma, devascularization, subcapsular hematoma, hemoperitoneum, active bleeding, pseudoaneurysm of the hepatic artery, bile leak, and periportal edema [6]. In cases where CT examination may not be feasible, diagnostic markers such as serum alanine aminotransferase are used.

The management of liver injuries is complicated, as it considers many essential variables, such as patient’s hemodynamic stability and serum pH. The management can be divided into operative (OM) and non-operative (NOM), with non-operative conservative management being the mainstay of treatment for hemodynamically stable healthy individuals [7].

OM of traumatic liver injuries should be done when non-operative management (NOM) fails and is considered the first-line treatment for hemodynamically unstable patients. Additionally, the presence of other organ injuries and perforating live injuries also necessitate surgical intervention [8]. The main goal of surgical intervention is to control the bleeding, prevent bile leak, and remove any necrotized tissue [8,9]. However, surgical intervention is time-bound, and decisions must be made promptly, as any delay or hesitancy may increase the mortality risk [10]. Among the several surgical options for managing patients with liver injury, the most prevalent is the laparoscopic surgical exploration, which can provide a detailed view of the structures, making it easier to control any organ damage. Another way of treating hepatic injuries is through hepatic artery embolization, especially if contrast extravasation is noted on a CT scan regardless of the patients' hemodynamic status [10]. Even though OM is considered the treatment of choice in case of hemodynamic instability, the overall mortality rate was much higher for patients undergoing OM than those undergoing NOM [8]. The present study aimed to detect the mechanism, type, and extent of injuries of patients with liver trauma and compare the outcomes between those receiving OM and NOM at King Khalid University Hospital.

2. Methods

This retrospective study analyzed the data of 45 patients with liver injuries who presented to King Khalid University Hospital from 2016 to 2022. The inclusion criteria were patients with a traumatic liver injury on CT scan. We included pregnant patients and patients with negative CT scan for liver injury. The patients' medical records were collected using a computerized sheet that included all the variables for each patient.

Management was divided into conservative, conservative to laparotomy, laparotomy, and interventional radiological procedures that included both hepatic artery angioembolization and percutaneous transhepatic drainage (PTD). Patients seen and evaluated by the surgical team and who underwent a laparotomy within the first 12 hours of arrival to the emergency department were categorized under laparotomy management. Meanwhile, patients who were evaluated and underwent surgical intervention after 12 hours since arrival underwent conservative management to laparotomy. Finally, patients not receiving any surgical intervention were categorized as the conservative management group.

Our patient's liver injuries were graded according to the American Association for the Surgery of Trauma (AAST) liver injury scale (Table 1) [11].

Patient's demographic data, mechanism of injury, grade of injury on CT, presence of additional injuries, hemodynamic status at presentation, need for blood and blood products, total length of hospital stay, duration of intensive care unit (ICU) and ward stay, OM and NOM done, laboratory values at first admission including alanine aminotransferase (ALT) and aspartate aminotransferase (AST), and Glasgow coma scale (GCS) score were recorded and analyzed.

Table 1
The American Association for the Surgery of Trauma (AAST) classification of liver injury [11].

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

2.1 Statistical Analysis

Descriptive statistics were summarized as numbers, percentages, mean, and median (min–max). The relationship between the treatment and hemodynamic stability according to the patients' baseline characteristics and outcome was determined using Fischer's Exact test, independent sample t-test, and Mann–Whitney test. The normality test was performed using the Shapiro–Wilk test. A P-value of 0.05 was considered statistically significant. The data were analyzed using Statistical Packages for Social Sciences version 26 (Armonk, NY: IBM Corp, USA).

3. Results

We reviewed 45 patients who sustained a traumatic liver injury over the past 6 years. As seen in Table 2, the patients' mean age was 29.3 (SD 15.5), with most patients being males (77.8%). The most common mechanism of injury was blunt trauma (86.7%), whereas penetrating injuries accounted only for 8.9% of cases. The most dominant type of injury was laceration, found in approximately (97.8%) of patients, followed by Contusion / Hematoma in 51.1% of cases. Regarding the severity of liver injuries, the majority of patients (37.8%) had a grade 3 injury level (Table 2). The median length of ICU stay for all patients was 4 days (range: 1–54 days). An expected difference was noticed in the length of stay between the ICU and ward, as the median of the latter was 7 days (range: 1–262 days). E-FAST (Extended-focused assessment with sonography in trauma) was done immediately upon admission in 42 cases and was positive only in 16 cases. Among all patients, 31 (68.9%) were hemodynamically stable at presentation, whereas 14 patients (31.1%) were unstable, with a mortality rate of 2.2%. (Table 3).

3.1 Associated Injuries

Forty-one patients (91.1%) developed additional or associated injuries, with thoracic related injuries being the most common (77.8%), followed by orthopedic injuries (51.1%), whereas head and abdominal injuries were 48.9% and 40.0% respectively. The list of the associated injuries is presented in (Fig. 1).

Some patients, especially those that had blunt injury to the abdomen, developed additional abdominal organ injuries, including injury to the spleen, kidney, and the adrenal gland. These three organs were the most commonly associated abdominal organs to be injured with each being reported in 13.3% of patients. Meanwhile other organs such as the pancreas, bowel, mesentery, hepatic duct, and the diaphragm were reported in a subset of patients (Fig. 2).

Table 2
Baseline characteristics of the patients (n = 45).

Study variables	N (%)
Age in years (mean ± SD)	29.3 ± 15.5
Gender	
·Male	35 (77.8%)
·Female	10 (22.2%)
Mechanism of injury	
·Blunt trauma	39 (86.7%)
·Penetrating	04 (08.9%)
·Iatrogenic	02 (04.4%)
Type of injury †	
·Laceration	44 (97.8%)
·Contusion / Hematoma	23 (51.1%)
·Hemoperitoneum	13 (28.9%)
Grade	
·Grade 1	05 (11.1%)
·Grade 2	13 (28.9%)
·Grade 3	17 (37.8%)
·Grade 4	09 (20.0%)
·Grade 5	01 (02.2%)
† Some patients have multiple types of injury	

Figure 1 shows the associated injuries of the study patients. The most commonly reported associated injury was thoracic injury (77.8%), followed by orthopedic (51.1%) and head (48.9%) injuries.

Figure 2 shows the type of abdominal injuries that patients suffered. The most commonly reported associated intra-abdominal injury were the Spleen, Kidney, and the Adrenal Gland (13.3%) each.

3.2 Isolated Liver Injury

Isolated liver injury was relatively rare, occurring in approximately four patients only (8.9%). All four patients had a grade 2 liver injury; in one case, the laceration was a result of iatrogenic injury following sleeve gastrectomy; in the second case, the patient suffered from a nail gunshot to the abdomen resulting in isolated trauma to the liver. Meanwhile, the remaining two patients both suffered from blunt trauma to the abdomen. Isolated liver injuries were all treated conservatively, with the exception of the penetrating nail gunshot, that required a surgical operation.

3.3 NOM

Majority of the patients (82.2%) underwent conservative management and did not require surgery. Conservative management consists of continuous liver function tests (LFTs), blood studies and hemoglobin levels, careful surveillance in the ward or ICU, and blood product and intravenous fluid transfusions. LFT results were recorded for all patients upon admission. ALT had a median value of 229 units/L (21–1277 units/L). AST had a lower median of approximately 198.5 units/L (19–1000 units/L). GCS was recorded upon admission; the median score was 15 (3–15). Rebleeding was defined as any decrease in hemoglobin level beyond 7 g/dl or any significant decrease from the initial baseline recorded upon admission with or without hemodynamic changes, given that it was not a complication of any of the associated injuries or their management. The median rebleeding rate was 1 (1–5 times per average). Twenty-five patients required transfusion with blood products, including packed red blood cells (PRBCs) [mean ± standard deviation (SD): 5.91 ± 4.48], fresh frozen plasma (FFP) (6.36 ± 3.67), and platelets (5.89 ± 3.79). In three patients, radiological interventional measures were performed, with two patients undergoing angioembolization (4.4%) and one patient (2.2%) receiving PTD.

3.4 OM

The current practice of our institute when it comes to the management of liver trauma goes in alignment with the World Society of Emergency Surgery (WSES) guidelines, where patients that are hemodynamically stable at presentation are treated with NOM irrespective of their injury grade. On the other hand, patients that are hemodynamically unstable are generally treated with OM.

We divided patients requiring OM into two groups: those who directly underwent laparotomy (6, 13.3%) and those who underwent conservative management first and then needed laparotomy with at least a 12-hour gap between admission and surgery (2, 4.4%). For those who directly underwent laparotomy (n = 6), two had a grade 4 injury, two had a grade 3 liver injury, and the remaining two had grade 1 and 2 injuries. Of those patients, four were hemodynamically unstable at presentation, one presented with a penetrating gunshot wound associated with a massive diaphragmatic injury that necessitated prompt surgical repair. Meanwhile, the remaining patient had a history of a second story window fall that resulted in high grade liver injury as well as signs of retroperitoneal hemorrhage.

All patients underwent careful observation in the ICU post-surgery. Four out of six patients developed massive rebleeding, which required blood transfusions. The mechanism of injury in these patients was evenly divided, with half experiencing blunt trauma, and the other half experiencing a penetrating type of injury. Four patients developed postoperative complications, including sepsis, disseminated intravascular coagulation, pneumonia, renal failure, delirium, cardiovascular arrest, and splenic infarction. Only two patients failed their conservative management and subsequently needed a surgical laparotomy. Both had a grade 2 liver injury with multiple concomitant injuries. One patient had a GCS of 5 on admission; the patient was observed in the ICU for 16 days, had three rebleeding events, and required multiple transfusions throughout his stay. Eventually, he died as a result of cardiac arrest after 30 days of admission. Meanwhile, the other patient that was treated conservatively developed a subhepatic abscess, which required PTD insertion. However, this line of management eventually failed, thus requiring a surgical laparotomy.

3.5 Complications

The rate of complications was 26.7%, with the most commonly reported complication being sepsis and delirium, occurring in 13.3% of patients each, this is followed by acute renal failure, pneumonia, and seizures each taking place in 4.4% of patients. Cardiac arrest, meningitis, splenic infarction, disseminated intravascular coagulation, and acute respiratory distress syndrome were all reported in a subset of patients. Even though the most common complication was delirium, this could be attributed to multiple factors including, head trauma, history of substance abuse, sepsis and not necessarily due to liver injury.

Biliary leaks were recorded in four patients. Two of them underwent endoscopic retrograde cholangiopancreatography (ERCP). In the first case, the ERCP of the patient showed proximal common bile duct leak; as a result, common bile duct and pancreatic duct stenting was done. In the second case, the patient underwent endoscopic stent insertion for a gastric leak, as well as ERCP for the biliary leak that was present in the patient’s drain. The two remaining patients did not undergo ERCP. In one case, the leak was noticed during magnetic resonance cholangiopancreatography (MRCP), which showed a complete cut-off of the common hepatic duct that required drainage by PTD for subhepatic collection. Finally, in the last case, the biliary leak was apparent intra-operatively from a bile-stained fluid coming from the liver parenchyma, for which an abdominal washout and repair was done.

Table 3
Treatment and outcome of the patients (n = 45).

Variables	**N (%)**
Treatment done	
·Conservative	37 (82.2%)
·Laparotomy	06 (13.3%)
·Conservative to laparotomy	02 (04.4%)
Interventional radiology measures done	
·Angioembolization	02 (04.4%)
·PTD	01 (02.2%)
Complication	
·Yes	12 (26.7%)
·No	33 (73.3%)
Specific complication	
·Delirium	06 (13.3%)
·Sepsis	06 (13.3%)
·Acute renal failure	02 (04.4%)
·Pneumonia	02 (04.4%)
·Seizure	02 (04.4%)
·Cardiac arrest	01 (02.2%)
·Splenic infarction	01 (02.2%)
·Meningitis	01 (02.2%)
·Acute respiratory distress syndrome	01 (02.2%)
·Disseminated intravascular coagulation	01 (02.2%)
Mortality	
·Yes	01 (02.2%)
·No	44 (97.8%)
Presence of Biliary leak	
·Yes	04 (08.9%)
·No	41 (91.1%)

Variables	N (%)
E-FAST	
·Not done	03 (06.7%)
·Positive	16 (35.6%)
·Negative	26 (57.8%)
Hemodynamic stability	
·Unstable	14 (31.1%)
·Stable	31 (68.9%)
	Mean ± SD
PRBC	5.91 ± 4.48
FFP	6.36 ± 3.67
Platelet	5.89 ± 3.79
	Median (min–max)
ALT	229.0 units/L (21–1277)
AST	198.5 units/L (19–1000)
Re-Bleed rate	1.0 (1.0–5.0)
GCS score	15 (3.0–15)
Length of hospital stay in days	11 (1–316)
ICU stay in days	4.0 (1–54)
Ward stay in days	7.0 (1–262)

Table 4
Relationship between the type of treatment and outcome of the patients according to patients' baseline characteristics (n = 45).

Factor	Type of Treatment		P-value §
	Conservative N (%) (n = 37)	Laparotomy/ Conservative to laparotomy N (%) (n = 08)	
Age in years (mean ± SD)	27.6 ± 14.4	37.2 ± 18.6	0.110
Gender			
·Male	29 (78.4%)	06 (75.0%)	1.000
·Female	08 (21.6%)	02 (25.0%)	
Mechanism of injury			
·Blunt trauma	35 (94.6%)	04 (50.0%)	**0.006 ****
·Penetrating	01 (02.7%)	03 (37.5%)	
·Iatrogenic	01 (02.7%)	01 (12.5%)	
Type of injury †			
·Laceration	36 (97.3%)	08 (100%)	1.000
·Contusion / Hematoma	21 (56.8%)	02 (25.0%)	0.135
·Hemoperitoneum	9 (05.4%)	4 (50.0%)	0.202
Grade			
·Grade 1	04 (10.8%)	01 (12.5%)	0.876
·Grade 2	10 (27.0%)	03 (37.5%)	
·Grade 3	15 (40.5%)	02 (25.0%)	
·Grade 4	07 (18.9%)	02 (25.0%)	
Grade 5	1 (2.7%)	0	
Complication			
·Yes	07 (18.9%)	05 (62.5%)	0.022
·No	30 (81.1%)	03 (37.5%)	
E-Fast *			

Factor	Type of Treatment		P-value §
	Conservative N (%) (n = 37)	Laparotomy/ Conservative to laparotomy N (%) (n = 08)	
·Positive	10 (28.6%)	06 (85.7%)	**0.008 ** **
·Negative	25 (71.4%)	01 (14.3%)	
Hemodynamic stability			
·Unstable	10 (27.0%)	04 (50.0%)	0.231
·Stable	27 (73.0%)	04 (50.0%)	
	Mean ± SD	**Mean ± SD**	**P-value ¥**
PRBC	5.59 ± 4.24	6.83 ± 5.42	0.571
FFP	6.57 ± 3.05	6.00 ± 5.09	0.818
Platelet	5.33 ± 4.08	7.00 ± 3.61	0.570
	Median (min–max)	**Median (min–max)**	**P-value ‡**
ALT	241.0 (21–1277)	207.5 (63–935)	0.715
AST	198.5 (19–1000)	232.5 (39–950)	0.785
Re-Bleed rate	1.0 (1.0–2.0)	2.0 (1.0–5.0)	0.117
GCS score	11.5 (5.0–15.0)	15.0 (5.0–15.0)	0.877
Length of hospital stay in days	22.0 (8.0–92.0)	30.0 (15.0–316)	**0.010 ** **
ICU stay in days	11.0 (2.0–20.0)	16.0 (4.0–54.0)	**0.012 ** **
Ward stay in days	13.5 (4.0–76.0)	14.0 (4.0–262.0)	**0.047 ** **

*Three patients who had not undergone E-FAST (Extended Focused Assessment with Sonography in Trauma) were excluded from the analysis.

§ P-value was calculated using Fischer's Exact test.

¥ P-value was calculated using an independent sample t-test.

‡ P-value was calculated using the Mann–Whitney test.

** Significant at $p < 0.05$ level.

When measuring the relationship between the type of treatment according to the patients' baseline characteristics and outcome (Table 4), the prevalence of patients who sustained blunt trauma ($p = 0.006$) was significantly higher in the conservative treatment group, whereas the prevalence of positive E-FAST (Extended Focused Assessment with Sonography in Trauma) ($p = 0.008$) was significantly higher in the laparotomy and conservative to laparotomy groups. Moreover, the median days of ICU ($p = 0.012$) and ward ($p = 0.047$) stay, and the total length of hospital stay ($p = 0.010$) were statistically significantly longer in the laparotomy and conservative to laparotomy groups, whereas the differences in age in years, grade injury levels, complication, hemodynamic stability, PRBCs, FFP, platelet, ALT, AST, rebleeding rate, and GCS score did not reach statistical significance (all $p > 0.05$).

Table 5
Relationship between hemodynamic stability and outcome according to patients' baseline characteristics (n = 31) *.

Factor	Hemodynamic stability		P-value §
	Unstable N (%) (n = 14)	Stable N (%) (n = 31)	
Age in years (mean ± SD)	28.9 ± 14.0	29.5 ± 16.3	0.907
Gender			
·Male	12 (85.7%)	23 (74.2%)	0.469
·Female	02 (14.3%)	08 (25.8%)	
Mechanism of injury			
·Blunt trauma	12 (85.7%)	27 (87.1%)	0.618
·Penetrating	02 (14.3%)	02 (06.5%)	
·Iatrogenic	0	02 (06.5%)	
Type of injury †			
·Laceration	14 (100%)	30 (96.8%)	1.000
·Contusion / Hematoma	05 (35.7%)	18 (58.1%)	0.208
·Hemoperitoneum	05 (35.7%)	8 (25.8%)	0.502
Grade			
·Grade 1	01 (07.1%)	04 (12.9%)	0.832
·Grade 2	04 (28.6%)	09 (29.0%)	
·Grade 3	07 (50.0%)	10 (32.3%)	
·Grade 4	02 (14.3%)	07 (22.6%)	
Grade 5	0	1 (3.2%)	
Complication			
·Yes	08 (57.1%)	04 (12.9%)	**0.004**
·No	06 (42.9%)	27 (87.1%)	
E-Fast *			
·Positive	05 (38.5%)	11 (37.9%)	1.000

Factor	Hemodynamic stability		P-value §
	Unstable N (%) (n = 14)	Stable N (%) (n = 31)	
·Negative	08 (61.5%)	18 (62.1%)	
	Mean ± SD	**Mean ± SD**	**P-value ¥**
PRBC	8.36 ± 4.50	3.67 ± 3.20	**0.008 ****
FFP	7.29 ± 4.31	4.75 ± 1.50	0.293
Platelet	7.00 ± 4.00	3.67 ± 2.52	0.236
	Median (min–max)	**Median (min–max)**	**P-value ‡**
ALT	165.5 (34–935)	259.0 (21–1277)	0.900
AST	155.5 (27–950)	230.5 (19–1000)	0.821
Re-Bleed rate	1.0 (1.0–5.0)	1.0 (1.0–3.0)	0.558
GCS score	10.0 (5.0–15.0)	15.0 (5.0–15.0)	**0.001 ****
Length of hospital stay in days	29.0 (8.0–316.0)	19.0 (10.0–30.0)	**< 0.001 ****
ICU stay in days	16.0 (2.0–54.0)	9.0 (4.0–16.0)	**0.002 ****
Ward stay in days	19.0 (4.0–262.0)	9.0 (4.0–18.0)	**0.002 ****

*Three patients who had not undergone E-FAST (Extended Focused Assessment with Sonography in Trauma) were excluded from the analysis.

§ P-value was calculated using Fischer's Exact test.

¥ P-value was calculated using an independent sample t-test.

‡ P-value was calculated using the Mann–Whitney test.

** Significant at $p < 0.05$ level.

When measuring the relationship between hemodynamic stability (stable vs. unstable) and outcome according to the patients' baseline characteristics (Table 5), the absence of complications ($p = 0.004$) was more associated with stable hemodynamics. Moreover, we noted that a higher number of PRBC transfusions was more associated with unstable hemodynamics ($p = 0.008$), whereas the median days of ICU ($p = 0.002$) and ward ($p = 0.002$) stay, and the overall length of hospital stay ($p < 0.001$) were statistically significantly longer in patients with unstable hemodynamics. In addition, the median GCS score was statistically significantly higher in patients with stable hemodynamics ($p = 0.001$). However, the relationship between hemodynamic stability and age, mechanism of injury, grade injury levels, E-FAST, FFP, platelet, ALT, AST, and rebleeding rate did not reach statistical significance ($p > 0.05$).

4. Discussion

Liver injuries are the most common cause of death in trauma settings due to the adjacent large vascular structures. It is also the second most frequent solid organ to be injured following blunt abdominal trauma [12]. In the present study, we assessed the outcomes and management of liver injury cases in a tertiary care center and specified the grade, type, and mechanism of each injury.

At our center, we rely on the AAST liver injury scale, 2018 version, which categorizes liver injuries into five grades, depending on the CT findings, as well as operative and pathological criteria [11]. The most frequent injury grade observed in our 45 hepatic trauma patients was grade III. More recently, the World Society of Emergency Surgery (WSES) 2020 has classified liver injuries into four main categories, taking into account the AAST liver injury scale score and hemodynamic status of the patients. They classified patients into: minor (WSES grade 1), moderate (WSES grade 2), and severe (WSES grade 3 and 4) injuries [8].

The incidence of different mechanisms of liver trauma varies according to the injury location. However, a quarter-century study on liver trauma found that blunt abdominal trauma is more common than penetrating injury [13], which was consistent with the results of the current study, showing blunt abdominal trauma as the most common cause of liver injury (86.7%).

In this study, the majority of our patients were young adults, with a mean age of 29.3 ± 15.5 years (18 months–67 years). Regarding sex, 77.8% were male, and 22.2% were female, consistent with Hommes et al.'s findings, demonstrating 134 patients with liver trauma and a mean age of 29 years with a male predominance of 72% [14].

In the present study, the most common cause of liver injury was blunt abdominal trauma (86.7%), followed by penetrating trauma (8.9%) and iatrogenic injuries (4.4%). These results were consistent with Petrowsky et al.'s findings. In their 25-year study that included 468 patients, blunt trauma was the most common cause of liver injury (84%), whereas penetrating injury accounted for only 16% of the cases [13]. Additionally, this study demonstrated that 91.1% of our patients had additional associated injuries, the most common of which being thoracic, followed by orthopedic and head injuries (77.8%, 51.1%, and 48.9%, respectively). Other studies have shown similar findings, with one study showing that thoracic injuries as the most prevalent injury type, followed by extremity and head trauma [15].

NOM is generally considered to be the standard of care when it comes to blunt liver trauma, with more than 95% of these types of injuries being managed without surgical intervention and still having a success rate between 80% and 100% [14]. However, the major determinants for the NOM approach are the patients' hemodynamic stability and absence of peritoneal irritation or other internal injuries requiring surgery, irrespective of their initial grade [8,15,16]. Our results showed similar findings, with 82.2% of the patients managed conservatively, with none of them succumbing to cardiac arrest. These findings were also similar to those reported by Sinha et al., in that 71.2% of their patients were managed by NOM with a success rate of 90% [17]. Moreover, a prospective Saudi study conducted by Ghnnam et al. that evaluated liver trauma patients over a four-year period revealed that those patients that were managed conservatively showed a success rate of 100% [18]. Additionally, Yildirim et al. (2021) retrospectively analyzed the NOM of 104 patients with liver injuries. The study showed that the NOM was successful in 94 patients, while surgical management was done for only for 10 patients who had failure of the NOM [15]. Moreover, another study revealed that, among 181 traumatic liver injury cases, 96.7% had a successful NOM [19]. This suggests that NOM can be, in fact, successful in multiple patients when executed in a correct manner.

The main issue that could render conservative management questionable or problematic is the possibility of missing other less clinically apparent injuries that are unclear on CT imaging [20]. The modern way of hepatic injury treatment utilized the help of interventional radiologists, as their work is becoming an integral part of the NOM. An increasing shift toward angioembolization is observed in patients with contrast extravasation as seen by CT scan and in those who are hemodynamically stable [21]. In our study, interventional radiology has played a crucial part in the management of patients, as angioembolization was done for two patients to control active bleeding following the decrease in their hemoglobin readings, and one patient also required PTD insertion due to the biliary leak that occurred following their liver injury. Although there has been a wide shift toward the NOM approach to treating liver trauma, OM is still the mainstay of treatment in hemodynamically unstable patients following hepatic trauma [7,8]. However, it should be noted that surgical treatment for liver injuries is associated with higher mortality and morbidity [7]. In our study, eight patients required surgical interventions, two of which had failed their NOM and were subsequently taken to the operating theater, while the remaining patients were managed directly by laparotomy. Of these patients, blunt trauma was the most common mechanism of injury ($p = 0.006$), and E-FAST was positive in 85.7% ($p = 0.008$) of the total cases that required a surgical intervention. Similarly, in Jyothiprakasan et al.'s study involving 70 patients with liver trauma, 11 required surgical management, specifically exploratory laparotomy, and five had NOM failure [22].

Multiple prognostic factors play an important role in liver trauma. A multivariate analysis done by Nishida et al. showed that GCS, postoperative blood urea nitrogen, number of associated organs injured, preoperative ALT levels, and systolic blood pressure readings were determined to be significant prognostic factors [23]. Similarly, in our study we demonstrated lower GCS scores in hemodynamically unstable patients ($p = 0.001$) and higher blood transfusion requirements with a mean of 8.36 ± 4.50 of PRBC given. When it comes to the durations of ICU, ward, and total hospital stay, we noted that the median days of ICU ($p = 0.012$) and ward ($p = 0.047$) stay and total length of hospital stay ($p = 0.010$) were statistically significantly longer in those requiring OM, either laparotomy or those with NOM failure who subsequently required laparotomy. This has been demonstrated in several studies, with one Chinese study reporting that the median hospitalization of patients who underwent NOM, and of those requiring urgent laparotomy was 25 and 27 days, respectively [24]. Additionally, when comparing the length of stay among patients stratified according to their hemodynamic status, the median days of ICU ($p = 0.002$) and ward ($p = 0.002$) stay and overall length of hospital stay ($p < 0.001$) were statistically significantly longer in those with unstable hemodynamics at presentation. These results were also found by Afifi et al. who reported that patients who underwent OM had longer ICU stay and total length of hospital stay than those only requiring NOM [25].

Regarding complications following hepatic trauma, they can range from simple fever to sepsis and acute respiratory distress syndrome. This broad range of complications was found to be less common among hemodynamically stable patients upon arrival ($p = 0.004$). Interestingly, our study revealed that delirium was the most common complication in our patients. We believe that this can be attributable to multiple factors and not necessarily related to liver trauma, as few of our patients sustained head trauma, whereas others had a history of substance abuse and sepsis. Additionally, biliary leaks were found in four of our patients, with two patients requiring ERCP. Of the remaining two patients, a biliary leak was noted on MRCP for one of them, which was then treated by PTD for the subsequent development of subhepatic collection. Finally, in the remaining case, the biliary leak was apparent intra-operatively, for which an abdominal washout and repair was done. A 10-year retrospective analysis of 398 patients with liver injuries showed that patients who developed biliary leaks received similar management, wherein they were treated with both ERCP and PTD [26]. Additionally, it is worth noting that liver-related complications of hepatic injury are less common among patients treated conservatively than those treated with OM (27). Mortality concerning liver injuries is divided into two types: early deaths, usually related to hemorrhage or significant vascular compromise, and late deaths. The mortality rate differs based on the mechanism of injury and associated injuries, with the rate ranging from 1–40%. Late deaths can result from sepsis, closed head injury, and multiple organ dysfunction syndrome (28). Among our 45 enrolled patients, only one had cardiopulmonary arrest. The cause of death was not direct; however, the patient suffered from multiple concomitant injuries, such as diffuse axonal injury, multiple intracranial hemorrhages, and descending thoracic aorta transaction, which all could have played a role in his death.

5. Limitation Of The Study

The limitation of our study is the small sample size. For this reason, the present study included patient data for a period of 6 years to enable as large a sample population as possible. Another limitation of the study is that it is restricted to patients from a single trauma center. Larger, multi-centric studies are required to obtain a clear picture about the management and outcomes of traumatic liver injuries in Saudi Arabia.

6. Conclusion

The management of liver trauma is critical and requires a complex multi-disciplinary approach with the aid of experts from various fields to maximize the overall patient outcome.

NOM of liver trauma in hemodynamically stable patients is safe and effective and can be applied to most patients irrespective of their injury grade.

Abbreviations

(AAST): American Association for the Surgery of Trauma.

(CT): Computed tomography.

(OM): Operative management.

(NOM): Non-operative management.

(PTD): Percutaneous transhepatic drainage.

(ICU): Intensive care unit.

(ALT): Alanine aminotransferase.

(AST): Aspartate aminotransferase.

(GCS): Glasgow coma scale.

(LFTs): Liver function tests.

(PRBCs): Packed red blood cells.

(FFP): Fresh frozen plasma.

(ERCP): Endoscopic retrograde cholangiopancreatography.

(MRCP): Magnetic resonance cholangiopancreatography.

(E-FAST): Extended Focused Assessment with Sonography in Trauma.

(WSES): World Society of Emergency Surgery.

Declarations

Author Contribution

TA: Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; and final approval of the version to be published.

AT: Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; and final approval of the version to be published.

AA: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

ZA: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

TT: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

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SA: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

NM: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

MT: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

AO: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

FA: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

MYD: Substantial contributions to the design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; and final approval of the version to be published.

Ethical Approval and Consent to Participate

The study was approved by the Institutional Review Boards of King Saud University – College of Medicine [Ref.No. 22/0773IRB], all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. All research methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable

Acknowledgments

Not applicable

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Competing Interests

The authors declare no competing interests.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Figures

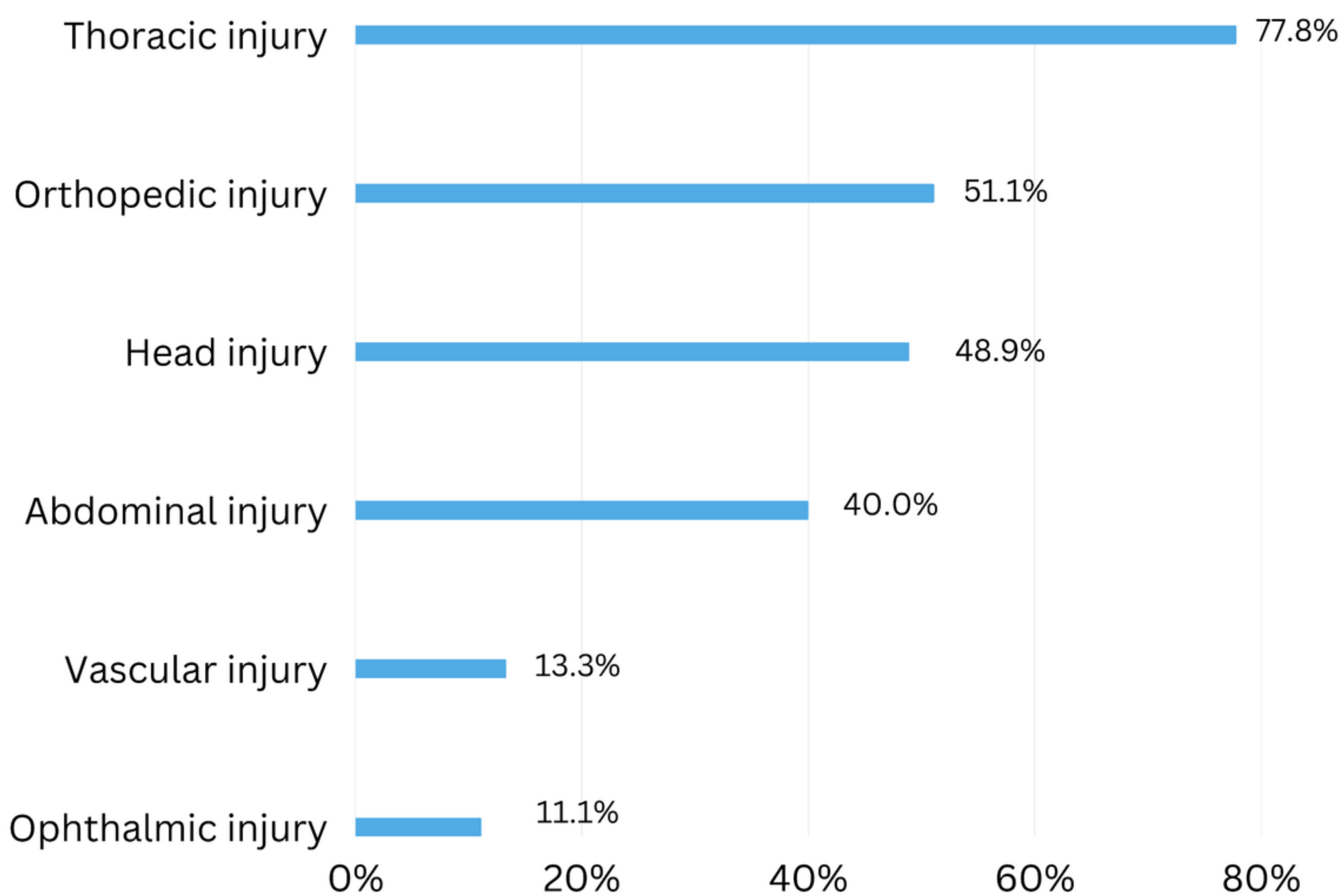

Figure 1

Patient-associated injuries.

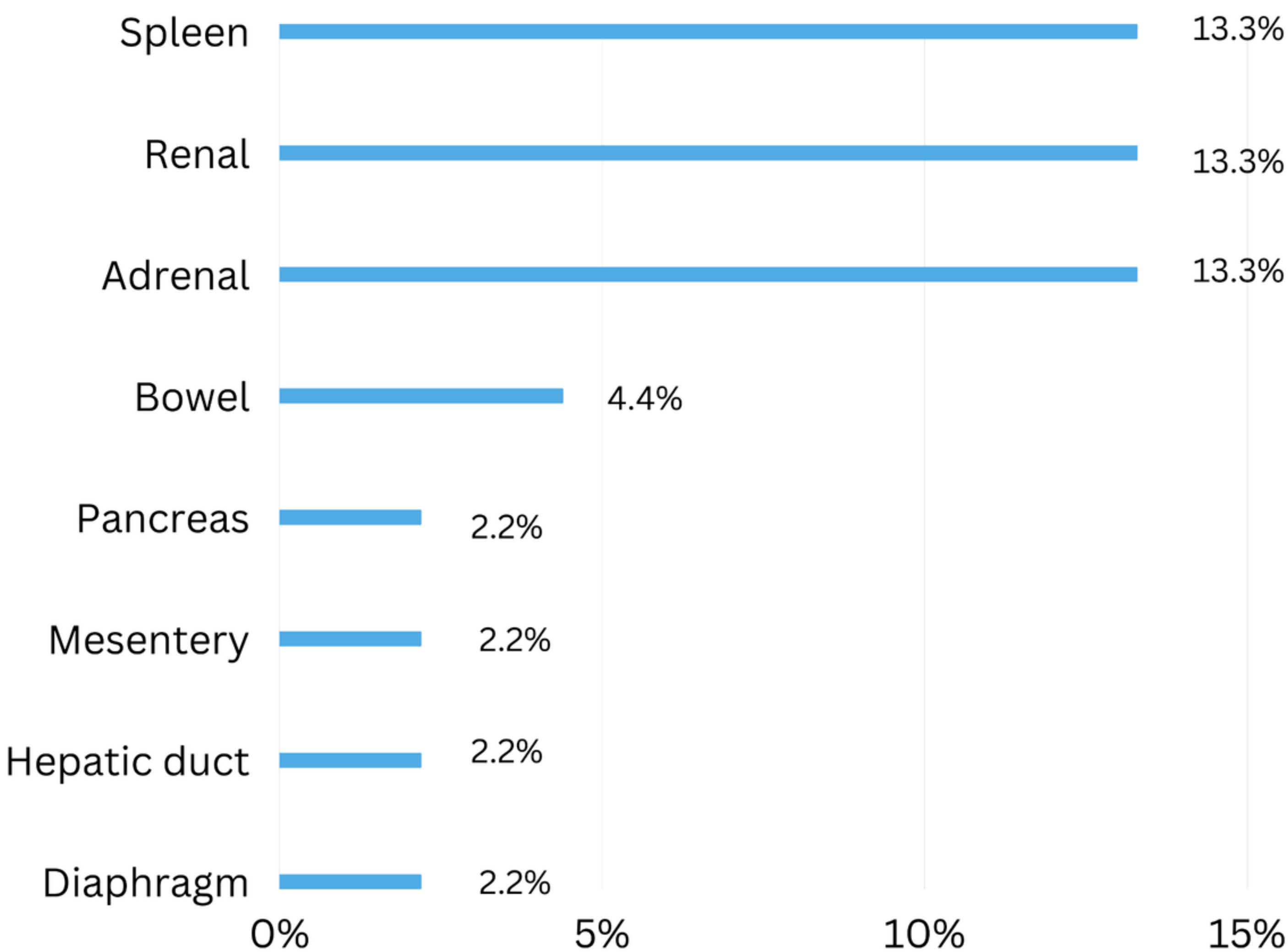

Figure 2

Additional abdominal organ injuries.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- 2Liverlacerationdatasheet.xlsx