Prognosis of trauma patients with liver injury who underwent observation after emergency department evaluation: a single trauma center retrospective study

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Informed consent and consent for publication: it was obtained from patients unless this was not possible for one or more of the following reasons as stated in the study protocol approved by the Ethics Committee: i) unavailability and/or objective organizational constraints resulting from the limited availability of complete and up-to-date patient contact details; ii) unavailability and/or objective organizational constraints due to a high proportion of patients no longer being actively followed by the participating trial center, with telephone contact details recorded in the information system no longer valid; iii) unavailability and/or objective organizational constraints related to the extended time interval between the patient's initial visit to the participating trial center and the data entry into the study database; iv) organizational and/or practical limitations arising from the geographical distance of patients, making their return to the participating trial center for consent procedures excessively burdensome and costly, in addition to the difficulties encountered by elderly patients or those with limited familiarity with electronic or digital tools in interacting remotely.

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Abstract

The prognosis of liver trauma patients not requiring immediate interventions remains unclear. This study aimed to evaluate the clinical outcomes of patients who suffered liver injuries and underwent a period of observation in the Emergency Department (ED). A retrospective single-center observational study was conducted in patients with liver trauma presenting to the ED between 2018-2024. Liver injuries were classified according to the American Association for the Surgery of Trauma (AAST) score. The outcome was the proportion of patients who died because of liver injuries or required surgical/endovascular liver procedures. A total of 120 patients were included. None of these patients died of complications related to their liver injury, while five died from other causes. Among the 101/120 (84%) patients with AAST I-III, one patient (AAST III) required liver-related interventions. On the other hand, among the 19/120 (16%) patients with AAST IV-V, 7/19 (37%) underwent liver interventions. Patients with isolated mild liver trauma (AAST I-II) might benefit from early discharge, while those with severe injuries (AAST IV-V) require monitoring and ready access to interventional radiology.

Introduction

The liver is one of the most commonly injured abdominal organs in trauma patients (16–30%).[1-4] Mortality secondary to liver trauma has decreased from over 50% in 1970 to 5%, as reported by Fodor *et al.* in a time-trend analysis between 2000 and 2016.[5] The leading cause of death in these patients is uncontrolled bleeding, accounting for 54% of overall mortality prior to the routine implementation of arterial embolization.[6]

The current management of liver trauma comprises surgery, endovascular procedures or observation depending on the grade of the liver injury, the hemodynamic status and the presence of other coexisting injuries.[7-9] The prognosis of patients with liver injuries who undergo a period of observation (no immediate surgery or endovascular procedures) and the related risk factors remain unclear.

The aim of this study was to evaluate mortality related to liver injuries and the need for liver surgery or endovascular procedures in patients who suffered liver trauma and underwent a period of observation after the initial evaluation in the Emergency Department (ED). Furthermore, we investigated prognostic factors that could help identify patients at risk of adverse outcomes.

Material and Methods

This observational retrospective study was conducted from June 2018 to January 2024 in an Italian ED of an adult level 1 trauma center serving a population of 1.5 million people, with all medical and surgical specialties, and interventional radiology available 24 hours a day. At our institution, patients older than 14 years are transported to the ED by ambulance or helicopter from the event site or are secondarily transferred from other spoke hospitals. All trauma patients are managed in the ED by a multidisciplinary team according to the Advanced Trauma Life Support (ATLS) guidelines, without being transferred directly to operating theatres, intensive care units or other departments bypassing the ED. A dedicated Computed Tomography (CT) is available in the proximity of the trauma bay, and radiologists provide immediate imaging reporting. According to our local protocols, all patients who suffered major traumas and are not hemodynamically unstable undergo a chest and abdomen CT scan with contrast medium (multiphasic protocol with unenhanced, arterial and venous scans) after the primary evaluation in the ED. CT is also performed irrespective of the mechanism of injury in patients who present with abdominal pain and intra-abdominal organ injuries are suspected or in patients with Ultrasound (US) findings of intraperitoneal fluid or suspected abdominal organ laceration/hematoma. According to our hospital protocols, no patient with liver injuries is discharged from the hospital before a period of observation of at least 24 hours. Blood samples are collected for monitoring of laboratory parameters, while diagnostic imaging (either ultrasound or CT scans) is usually performed at 24 hours and subsequently according to the treating physician's evaluation.

This study was approved by the local Ethics Committee Area Vasta Centro (CEAVC, 26626_oss) and was conducted in accordance with the principles set forth in the Helsinki Declaration. We included adult trauma patients (>18 years old) who suffered a liver injury according to the initial radiologist CT report and did not die or undergo surgery or endovascular procedures within 6 hours from the liver injury diagnosis (Observed Patients, OPs). Patients were excluded if they died or required surgical/endovascular interventions within 6 hours, were transferred from other hospitals or declined consent to participate in the study. This timeframe for patient exclusion was chosen following the local management of major trauma patients at our institution, where disposition must be finalized and the patient transferred from the trauma bay within six hours. The exclusions of patients transferred from other hospitals were deemed necessary considering that they represented a selected subgroup of patients that had already undergone a period of observation in spoke hospitals and required a higher level of care to manage their injuries. For all included OPs, we collected demographics, anthropometric data, comorbidities, concomitant antiplatelet or anticoagulant therapy, mechanism of injury, vital signs, laboratory results and imaging findings and interventions. Abdominal CTs performed upon admission were reviewed to classify the liver injury grade according to the revised 2018 organ injury scale of the American Association for the Surgery of Trauma (AAST), with mild injuries as AAST I-II, moderate injuries as AAST III and severe injury as AAST IV-V (Supplementary materials, Figure 1 and Supplementary materials, Table 1).[10] Liver injuries were also classified according to the 2020 World Society of Emergency Surgery (WSES) guidelines that divides liver injuries into four grades considering the AAST classification and the hemodynamic status, with mild injuries as WSES I, moderate injuries as WSES II and severe injury as WSES III-IV (Supplementary materials, Table 2).[7] Finally, the Injury Severity Score (ISS) was calculated. Data was collected for 30 days from the ED index visit for hospitalized patients or until discharge, whichever occurred first. The primary outcome of this study was a composite outcome,[11] defined as the proportion of patients who died because of liver injuries or required surgical/endovascular liver procedures. Additionally, we evaluated the prognostic performance of AAST and WSES grading.

Statistical analysis

Continuous variables were reported as median and Interquartile Range (IQR). Categorical variables were expressed as counts and percentages. For the AAST and WSES scores on admission, Receiver Operating Characteristic (ROC) curve analyses were also performed to describe the ability of the scores to predict the primary outcome. Sensitivity, specificity, negative and positive predictive values, and the accuracy of AAST and WSES scores were calculated with 95% Confidence Interval (CI). To assess the predictive value of AAST while considering the low frequency of patients who died due to liver injuries or required liver-related interventions, and thus to limit the risk of model overfitting and coefficient inflation, we performed multiple bivariable logistic regressions for the primary outcome investigating the presence or absence of a consistent independent effect of AAST by adjusting for other confounding factors separately. A two-tailed p value <0.05 was considered statistically significant. A complete case analysis was performed. Statistics were performed and graphs generated with RStudio 1.2.1335 (RStudio Inc., MA, USA).

Results

Between 2018 and 2024, liver injuries were diagnosed in 132 trauma patients. Following the exclusion of 12 patients, 120 OPs were included in this study (Figure 1). The median age of the OPs was 43 years (28-59) and male patients were 78/120 (65%). All included OPs suffered a blunt trauma, 21/120 (23%) suffered severe injuries (ISS >15). 112/120 (93%) patients underwent at least one CT or US scan for monitoring their liver injuries and 58/120 (48%) at least two. Overall mortality was 4% (5/120), with 4 patients who

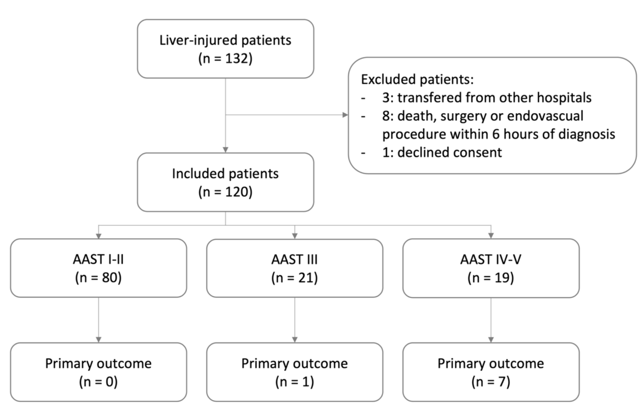

Figure 1. Flow diagram of the study and main results. AAST: American Association for the Surgery of Trauma organ injury score.

died due to severe head trauma and 1 because of traumatic aortic dissection. No patient died due to liver injuries within the study period. Of the 120 OPs, eight (7%) required surgical or endovascular liver procedures, with six requiring arterial embolization and two the drainage of bile collections. Three patients required arterial embolization within 24 hours of diagnosis: two underwent embolization of branches of the hepatic artery, and one underwent embolization of a pseudoaneurysm. One additional patient underwent a procedure within 48 hours, which was also an embolization of hepatic artery branches. The remaining four interventions were performed for non-immediately life-threatening conditions, such as hepatic artery pseudoaneurysm, bilioma, and coleperitoneum, after four days of admission.

Between the eight patients meeting the primary outcome of the study and the remaining cohort, we did not observe significant differences in terms of demographics, comorbidities, concomitant medications, admission physiology and coexisting injuries such as associated pulmonary injury, right ribs and pelvic/proximal limb fractures (Table 1). A large proportion of the patients who required surgical/endovascular interventions were found to have ultrasound findings of intraperitoneal fluid and liver laceration/hematoma on admission when compared to those not requiring liver-related surgery or interventional procedures (8/8, 100%, *vs.* 50/112, 47%, p=0.006). A strong signal for a difference in the proportion of intraperitoneal fluid alone was present between the two groups (6/8, 75%, *vs* 42/112, 39%, p=0.066). Among laboratory parameters, only Alanine Aminotransferase (ALT) levels were found to be significantly different between the two groups, with higher levels in patients who met the primary outcome (362 x10^9/L, 271-584, *vs* 155x10^9/L, 59-290, p=0.004). All patients requiring surgical/endovascular interventions presented with ALT above the upper reference limit. The hospital stay was also non-significantly longer in patients who underwent surgical/endovascular liver procedures (25 days, 18-36, *vs.* 13 days, 7-24, p=0.053). The proportion of patients with moderate/severe (8/8, 100%, *vs.* 32/112, 29%, p<0.001) or severe (7/8, 88%, *vs.* 12/112, 11%, p<0.001) liver injuries according to the AAST score was significantly higher in those who required liver-related interventions (Table 2). Similar findings were present according to the WSES score.

Among the 80/120 (67%) patients with an AAST I-II (mild injuries), no one met the primary outcome definition. Conversely, of the 21/120 (18%) patients with a moderate liver injury and of the 19/120 (15%) patients with a severe injury, 1/21 (5%) and 7/19 (37%) respectively required surgical/endovascular procedures (Figure 1 and Table 3). The patient with AAST who required an intervention underwent arterial embolization. Patients with severe liver injuries were characterized by higher overall ISS (p=0.009) and platelet count (p=0.043). Patients with both moderate and severe liver injuries also showed a higher proportion of positive ultrasound scans for free intraperitoneal fluid (p=0.008).

The ROC curve analyses showed that the ability of the AAST and WSES scores to discriminate patients who died or required

Table 1. Demographics, clinical and laboratory characteristics of the study cohort.

	Required liver-related interventions (n=8)	No liver-related interventions (n=112)	p-value
Demographics and past medical history			
Age (years)	37 (33-48)	44 (28-59)	0.813
Sex (female)	6 (75)	72 (64)	0.712
Comorbidities*	1 (13)	22 (20)	>0.99
Anticoagulation therapy	0 (0)	4 (4)	>0.99
Antiplatelet therapy	1 (13)	7 (6)	0.434
Clinical characteristics			
Glasgow coma scale	15 (12-15)	15 (14-15)	0.973
Systolic blood pressure (mmHg)	123 (110-139)	130 (115-140)	0.659
Hemodynamic instability	1 (13)	2 (2)	0.118
Spontaneous or elicitable abdominal pain	4 (50)	35 (31)	0.435
Ultrasound intraperitoneal fluid or liver laceration/hematoma	8 (100)	50 (47)	0.006
Ultrasound intraperitoneal fluid only	6 (75)	42 (39)	0.066
Pulmonary associated injury	4 (50)	63 (56)	>099
Right ribs fractures	4 (50)	63 (56)	0.731
Associated pelvic or proximal limb fractures	2 (25)	27 (24)	>0.99
Length of hospital stay	25 (18-36)	13 (7-24)	0.053
Laboratory parameters			
ALT (U/L)	396 (351-579)	138 (50-276)	0.001
Lactate level (mmol/L)	1.8 (1.0-1.9)	1.7 (1.0-2.6)	0.814
Hemoglobin (gr/dL)	12.7 (11.7-13.5)	13.6 (12.3-14.9)	0.228
Platelet (x10^9/L)	269 (235-276)	238 (197-267)	0.160
Fibrinogen (mg/dL)	215 (156-221)	238 (197-267)	0.160
INR	1.1 (1.1-1.2)	1.1 (1.0-1.1)	0.169
aPTT (sec)	28.1 (24.6-29.8)	26.1 (24.2-27.9)	0.440
White blood cell count (x10^9/L)	20 (12-24)	15 (11-20)	0.279
Creatinine (mg/dL)	0.87 (0.84-0.93)	0.97 (0.77-1.15)	0.414

Data reported as median (interquartile range) or frequency (percentage). ALT, Alanine aminotransferase; INR, International Normalized Ratio; aPTT, activated partial thromboplastin time. *Comorbidities, coronary artery disease, heart failure, pneumopathies, active neoplasia, previous stroke, cerebral hemorrhage, dementia, chronic kidney failure, dialysis, congenital or acquired coagulative disorder, anticoagulant or antiplatelet therapy.

Table 2. Organ injury score of the study cohort according to the American Association for the Surgery of Trauma (AAST) scale, the World Society of Emergency Surgery (WSES) scale, and the Injury Sever-ity Scale (ISS).

	Required liver-related interventions (n=8)	No liver-related inter-ventions (n=112)	p-value
AAST scale			<0.001
I	0 (0)	47 (42)	
II	0 (0)	33 (29)	
III	1 (13)	20 (18)	
IV	5 (63)	9 (8)	
V	2 (25)	3 (3)	
AAST >II	8 (100)	32 (29)	<0.001
AAST >III	7 (88)	12 (11)	<0.001
WSES scale			<0.001
I	0 (0)	79 (71)	
II	1 (13)	19 (17)	
III	6 (75)	12 (11)	
IV	1 (13)	2 (2)	
WSES >I	8 (100)	33 (29)	<0.001
WSES >II	7 (88)	14 (13)	<0.001
ISS			
ISS	13 (10-17)	12 (7-19)	>0.99
ISS > 15	3 (38)	39 (35)	>0.99

Data reported as median (interquartile range) or frequency (percentage). AAST, American Associa-tion for the Surgery of Trauma; WSES, World Society of Emergency Surgery; ISS, Injury Severity Score.

Table 3. Demographics, clinical and laboratory characteristics of the study cohort.

	AAST I-II (n=80)	AAST III (n=21)	AAST IV-V (n=19)	p-value
Demographics and past medical his-tory				
Age (years)	44 (28-60)	45 (29-53)	34 (28-47)	0.552
Sex (female)	52 (65)	13 (62)	13 (63)	0.911
Comorbidities*	19 (24)	3 (14)	1 (5)	0.175
Anticoagulation therapy	4 (5)	0 (0)	0 (0)	0.790
Antiplatelet therapy	7 (9)	0 (0)	1 (5)	0.486
Clinical characteristics				
Glasgow coma scale	15 (15-15)	15 (14-15)	15 (13-15)	0.812
Systolic blood pressure (mmHg)	130 (115-140)	130 (120-140)	115 (100-140)	0.325
Hemodynamic instability	1 (1)	1 (5)	1 (5)	0.257
Injury severity score	11 (6-17)	12 (6-17)	19 (12-34)	0.009
Spontaneous or elicitable abdominal pain	21 (26)	9 (43)	9 (43)	0.113
Ultrasound intraperitoneal fluid or liver laceration/hematoma	28 (37)	12 (57)	18 (100)	<0.001
Ultrasound intraperitoneal fluid only	25 (33)	10 (48)	13 (72)	0.008
Pulmonary associated injury	42 (53)	9 (43)	14 (74)	0.130
Right ribs fractures	42 (53)	11 (52)	14 (74)	0.233
Associated pelvic or proximal limb frac-tures	15 (19)	7 (33)	7 (37)	0.140
Length of hospital stay	12 (7-24)	13 (6-32)	23 (13-34)	0.052
Required liver-related interventions	0 (0)	1 (5)	7 (37)	<0.001
Laboratory parameters				
ALT (U/L)	80 (37-158)	274 (209-461)	481 (338-741)	<0.001
Lactate level (mmol/L)	1.7 (1.0-2.6)	1.6 (1.0-1.8)	2.0 (1.6-5.1)	0.116
Hemoglobin (gr/dL)	13.6 (12.4-14.8)	13.4 (12.5-14.9)	12.9 (11.9-15.3)	0.917
Platelet (x10^9/L)	228 (185-269)	227 (215-261)	267 (238-308)	0.043
Fibrinogen (mg/dL)	227 (197-275)	228 (188-254)	267 (189-241)	0.584
INR	1.1 (1.0-1.2)	1.1 (1.1-1.1)	1.1 (1.0-1.2)	0.731
aPTT (sec)	26.3 (24.3-28.2)	26.2 (25.1-27.6)	24.2 (22.0-29.8)	0.432
White blood cell count (x10^9/L)	14 (11-19)	18 (13-21)	19 (13-25)	0.064
Creatinine (mg/dL)	0.97 (0.75-1.17)	0.91 (0.75-1.06)	0.98 (0.86-1.14)	0.562

Data reported as median (interquartile range) or frequency (percentage). ALT, Alanine aminotransferase; INR, International Normalized Ratio; aPTT, activated partial thromboplastin time. *Comorbidities: coronary artery disease, heart failure, pneumopathies, active neoplasia, previous stroke, cerebral hemorrhage, dementia, chronic kidney failure, dialysis, congenital or acquired coagulative disorder, anticoagulant or antiplatelet therapy.

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surgical/endovascular procedures was similar (93%, 88-98, *vs* 92%, 87-97, p=0.541) (*Supplementary materials, Figure 2*). Sensitivity, specificity, negative and positive predictive value of AAST ≥ III (moderate/severe injuries) were 1.00 (95% CI 1.00-1.00), 0.71 (95% CI 0.63-0.79), 1.00 (95% CI 1.00-1.00) and 0.20 (95% CI 0.16-0.26) respectively (*Supplementary materials, Table* 3). AAST ≥ IV (severe injuries) showed a more balanced diagnostic accuracy with similar moderate sensitivity 0.88 (95% CI 0.63-1.00) and specificity 0.89 (95% CI 0.83-0.95). WSES cut-offs showed comparable results. A potential independent relationship was found between the AAST liver injury score and the primary outcome of this study after adjusting separately for age, sex, comorbidities, ALT, platelet count, ultrasound findings of intraperitoneal fluid, and associated right rib and pelvic fractures (Table 4).

Discussion

Our study showed that patients with blunt liver trauma who undergo a period of observation following the initial ED evaluation have a good prognosis, and that all patients with mild liver injuries (AAST grade I-II) survived and did not require any surgery or endovascular liver procedures. While patients with moderate liver injuries (AAST III) have a low risk compared to the most severe cases (AAST IV-V), they still might require interventions prior to discharge. The AAST and WSES scores showed similar performance in predicting the need for liver-related interventions, with high sensitivity and NPV with scores higher than two or one respectively.

The paradigm for the management of liver trauma has significantly shifted over the past decades, from surgical interventions to selective Non-Operative Management (NOM). A recent review of the National Trauma Data Bank in the USA showed that 86% of all liver injuries were managed conservatively,[12] and similarly to our results, previous evidence demonstrated that NOM is highly effective with failure rates of less than 10%.[13] Furthermore, the last WSES guidelines concluded that, when feasible, NOM should always be considered the first option.[7] We showed that most of the patients who do not die or require interventions within the first six hours are characterized by an AAST grade of I-III. AAST I-II showed perfect sensitivity and negative predictive value, excluding the need for surgery/interventional procedures and the risk of death due to liver injuries in these patients, while a low risk was present for patients with moderate injuries (AAST III). According to current guidelines,[7] at our institution as in most hospitals, all patients with liver injury are hospitalized for days and undergo serial blood and liver imaging tests. Our data suggests that this approach might be unnecessary in patients who suffered mild liver injuries according to the admission abdomen CT scan. In a 2014 Chinese study,[14] none of the patients with AAST I-III who were managed with NOM required surgery, and only one of them (AAST III) developed a complication (bilioma). A recent systematic review concluded that considering the low incidence of complications, routine CT follow-up does not seem to be necessary, especially in mild to moderate liver injuries.[15] Following this growing body of evidence, we suggest that early, if not immediate, discharge of patients with isolated mild liver traumatic injuries should be further investigated in adequately powered randomized control trials. Such an approach could provide benefits by limiting hospitalization and unnecessary investigations. However, as in our study a patient with AAST III eventually required arterial embolization, further and larger investigations are needed to better stratify this subgroup of patients.

On the other side, the small group of patients with an AAST grade IV-V require strict observation and monitoring within the first 24 hours in hospitals with interventional radiology facilities, as we found that almost half of these patients required endovascular or other interventional procedures during their hospital stay, with around a third of them undergoing endovascular embolization of actively bleeding arteries in the first day after their liver injury diagnosis. This finding corroborates previous studies that have reported similar results. In a 17-year-long study by Fodor *et al*.,[5] NOM failure occurred in only 2% of mild to moderate hepatic and splenic injuries (AAST I-III) compared to 10% of severe injuries (AAST >III). Hu *et al.*[1] showed in 2021 that AAST ≥III and multiple organ injuries were independently associated

Table 4. Bivariable logistic regression analyses for required liver-related interventions.

	Adj. OR	95% CI	p value
AAST Score	5.763	(2.130-15.60)	0.001
Age (years)	1.017	(0.962-1.075)	0.551
AAST Score	5.515	(2.102-14.47)	0.001
Sex (male)	2.044	(0.285-14.66)	0.477
AAST Score	5.996	(2.171-16.56)	0.001
Comorbidities	2.972	(0.214-41.37)	0.417
AAST Score	6.290	(2.168-18.25)	0.001
ALT (U/L)	0.999	(0.996-1.002)	0.457
AAST Score	5.339	(2.041-13.96)	0.001
Platelet (x10^9/L)	1.001	(0.983-1.018)	0.951
AAST Score	4.990	(1.900-13.10)	0.001
Intraperitoneal fluid	1.673	(0.243-11.54)	0.601
AAST Score	7.314	(2.346-22.80)	0.001
Right rib fractures	0.209	(0.027-1.592)	0.131
AAST	5.771	(2.171-15.34)	<0.001
Pelvic fractures	0.441	(0.059-3.287)	0.424

Adj. OR, adjusted odds ratio; OR, odds ratio; AAST, organ injury score according to the American Association for the Surgery of Trauma; ALT, alanine aminotransferase.

with mortality. Similarly, we also found that higher AAST grades might be an independent predictor of worse outcomes. The frequency of complications increases with the injury severity, as illustrated in several studies showing that only 1% of the patients with an AAST grade ≤III suffered complications, while these occurred in 21-25% and 50-63% of those with a AAST grade IV and V respectively.[16,17] Brillantino *et al.* suggested that, even for severe liver injuries, the risk of complications remains low when a standardized treatment protocol based on selected angiographic studies and embolization is used in hemodynamically stable trauma patients.[18]

Currently, there are limited prognostic factors available in the ED that could help stratify patients' risk of worse outcomes in addition to the CT grading of liver injuries (associated or not with hemodynamic instability). In this study we found that only ALT and bedside ultrasonography were related to adverse outcomes. However, these two parameters did not retain an independent effect in the regression analyses. Our findings nevertheless suggest that ultrasound can play a role in risk stratification. Focused Assessment Sonography for Trauma (FAST) is part of the initial evaluation of major trauma patients and it is a useful diagnostic bedside tool. Information on intraperitoneal free fluid could significantly hasten door-to-CT or door-to-theatre time in abdominal trauma patients.[19] According to our results, to identify high-risk liver injuries, FAST alone is not sufficient, and the presence of laceration/hemorrhage of the liver parenchyma also needs to be assessed for prognostication purposes in centers where CT is not available. Larger studies are required to further investigate prognostic variables in addition to CT grading. In our study, other associated injuries, such as right rib fractures, were not associated with adverse outcomes. Previous studies investigated the association of rib fractures with liver injury with variable results. However, no study focused on the association of rib fractures with the prognosis of liver injury in patients who underwent a period of observation in the ED. A 2022 study[20] revealed that spleen and kidney injuries were significantly higher in lower rib fractures, with no significant relationship in the presence of liver trauma. In contrast, Rostas *et al.*[21] performed in 2017 a retrospective chart review of 1103 blunt trauma patients with rib fractures and found that 77% of the 142 patients enrolled in the study who suffered liver injuries also presented with right rib fractures.

Some of the study limitations are i) single-center study performed in a level 1 trauma center of a developed country with no patient who suffered penetrating injuries, leading to limited generalizability of our findings; ii) small sample size, further limiting the statistical power and generalizability of our study; iii) secondary to the limited frequency of patients meeting the primary outcome the results of our regression analyses are only indicative of an independent effect of AAST on the risk of death due to liver injuries or of liver-related interventions, hence larger studies allowing appropriately-powered inferential and time-to-event analyses are required to confirm this finding.

Conclusions

Our study showed that abdominal CT scans on admission can identify a large proportion of patients with mild-moderate liver injuries who have a very low risk of death and complications. Patients with isolated mild injuries might benefit from early or even immediate discharge, though larger confirmatory studies are required. On the other hand, patients with severe liver injuries are at high risk for bleeding and other late complications, thus requiring strict observation and ready access to interventional radiology.

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Online supplementary materials
Figure 1. Computed tomography images of liver trauma based on the 2018 revised liver injury scale of the American Association for the Surgery of Trauma (AAST).
Table 1. American Association for the Surgery of Trauma (AAST) revised liver injury scale 2018.
Table 2. World Society of Emergency Surgery (WSES) injury scale 2020.
Figure 2. Receiver operating characteristics (ROC) curve of AAST and WSES. AAST discrimination 93% (95% CI 88-98), WSES discrimination 92% (95% CI 87-97). AAST vs WSES, p=0.542. AAST: American Association for the Surgery of Trauma organ injury score; WSES: World Society of Emergency Surgery organ injury score.