

Observation-first versus angioembolization-first approach in stable patients with blunt liver trauma: A WTA multicenter study

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BACKGROUND: Prior studies evaluating observation versus angioembolization (AE) for blunt liver injuries (BLT) with contrast extravasation (CE) on computed tomography imaging have yielded inconsistent conclusions, primarily due to limitations in single-center and/or retrospective study design. Therefore, this multicenter study aims to compare an observation versus AE-first approach for BLT, hypothesizing decreased liver-related complications (LRCs) with observation.

METHODS: We conducted a post hoc analysis of a multicenter, prospective observational study (2019–2021) across 23 centers. Adult patients with BLT + CE undergoing observation or AE within 8 hours of arrival were included. The primary outcome was LRCs, defined as perihepatic fluid collection, bile leak/biloma, pseudoaneurysm, hepatic necrosis, and/or hepatic abscess. A multivariable logistic regression analysis was used to evaluate risk factors associated with LRCs.

RESULTS: From 128 patients presenting with BLT + CE on imaging, 71 (55.5%) underwent observation-first and 57 (45.5%) AE-first management. Both groups were comparable in age, vitals, mechanism of injury, and shock index (all $p > 0.05$), however the AE group had increased frequency of American Association for the Surgery of Trauma Grade IV injuries (51.0% vs. 22.0%, $p = 0.002$). The AE cohort demonstrated increased rates of in-hospital LRCs (36.8% vs. 12.7%, $p = 0.038$), emergency department representation (25.0% vs. 10.0%, $p = 0.025$), and hospital readmission for LRCs (12.3% vs. 1.4%, $p = 0.012$). However, the two cohorts had

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similar mortality rates (5.7% vs. 5.3%, $p = 0.912$). After adjusting for age, ISS, and grade of liver injury, an AE-first approach had a similar associated risk of LRCs compared with observation-first management (odds ratio, 1.949; 95% confidence interval, 0.673–5.643; $p = 0.219$).

CONCLUSION:

Patients with blunt liver injury and CE undergoing an observation-first approach were associated with a similar adjusted risk of LRCs and rate of mortality compared with AE-first approach. Overall, this calls for reevaluation of the role of routine AE in blunt liver trauma patients with CE. Future prospective randomized trials are needed to confirm these findings. (*J Trauma Acute Care Surg.* 2024;97: 764–769. Copyright © 2024 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic/Care Management, Level IV.

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The liver is the most commonly injured abdominal organ following blunt trauma in the United States, with an incidence rate of approximately 5,000 patients per year.^{1,2} Initial management strategies for blunt hepatic trauma are determined by the patient's hemodynamic stability. A cornerstone of the initial assessment of blunt abdominal trauma is the use of an intravenous-enhanced computed tomography (CT) scan. The administration of contrast during these scans is crucial for detailed evaluation of solid organ parenchyma and identification of contrast extravasation (CE), an important indicator for vascular injury. The incidence of CE in patients with blunt solid organ injury has seen a marked increase, a trend likely attributable to the widespread adoption of advanced 64-detector (or better) multiphase CT scanners in modern trauma centers.³

Current clinical guidelines, including those from the Western Trauma Association (WTA) and Eastern Association for the Surgery of Trauma (EAST), endorse hepatic angioembolization (AE) as the standard of care for hemodynamically stable patients with liver injuries accompanied by CE.^{4–6} Initial evidence supporting use of AE are mostly driven by single center and/or retrospective observational studies in design, which consistently demonstrated high AE technical success rates of 85% to 100% for liver hemorrhage control.^{7,8} However, other studies do not support AE as initial treatment for this patient population, pointing to a lack of demonstrable benefits and an increase in liver-related complications (LRC) compared with traditional nonoperative management with close observation.^{9–11}

Given this context, the objective of our study was to prospectively evaluate and compare two management strategies for hemodynamically stable patients with blunt liver trauma: an observation-first approach and an AE-first approach. We hypothesize that an observation-first strategy in this patient population would result in a lower LRC rate while maintaining an equivalent overall mortality rate when compared with the AE-first approach.

METHODS

This is a post hoc analysis of a multicenter, prospective observational study across 23 trauma centers throughout the United States, Canada, and Israel.¹¹ Each participating center obtained local institutional review board approval and a waiver of informed consent due to the observational nature of the study. Data for the original study were prospectively collected at each enrolling center between March 2019 to August 2021. This post hoc analysis included all trauma patients 18-years of age and older sustaining blunt liver injuries with CE (aka blush) within 2 hours of arrival. We excluded patients with penetrating mechanisms of

injury as well as those with non-traumatic hepatic bleeding, preexisting cirrhosis, pregnancy, and transfers from other hospitals. The rationale behind the 2-hour cutoff was to maximize the likelihood that the observed extravasation on imaging was directly attributable to the recent traumatic event. Patients were divided into two groups based on the initial treatment strategy used: observation-first approach versus AE-first approach. The latter was defined as undergoing interventional radiology (IR) AE within 8 hours of arrival to the medical facility. The 8-hour window was chosen to study a cohort where AE was the intended primary modality of treatment rather than a second-line therapy for failed initial observation or as an adjunct after surgical intervention, thereby limiting potential confounding factors.

Variables collected included age, sex, and use of any home anticoagulant or antiplatelet medications. Injury profile data included mechanism of trauma, Injury Severity Score (ISS), radiographic liver American Association for the Surgery of Trauma (AAST) grade, vitals on arrival, Glasgow Coma Scale (GCS), and initial laboratory studies. Other measured variables included administration of blood products, IR AE procedural details, and additional procedures (e.g., endoscopic retrograde cholangiopancreatography [ERCP], IR drainage, operative intervention).

The primary outcome was the occurrence of in-hospital LRCs which was defined as peri-hepatic fluid collection, bile leak or biloma formation, pseudoaneurysm, hepatic necrosis, and/or hepatic abscess. Secondary outcomes included mortality, LRC interventions, hospital length of stay (LOS), intensive care unit (ICU) LOS, ventilator days, emergency department (ED) representation, and hospital readmission.

Bivariate analyses were performed using Student's t test to compare continuous variables and Pearson χ^2 test to compare categorical variables. Categorical data were reported as percentages and continuous data were reported as medians with inter-quartile range.

To assess the effectiveness of the observation-first versus AE-first approach, we conducted a multivariable logistic regression analysis. Initially, covariates demonstrating a statistical significance with a p value of less than 0.20 were selected for inclusion in a more detailed multivariable logistic regression model. This approach aimed to identify independent predictors for LRCs. The variables incorporated into this model as predictors included the ISS, patient age, and the AAST liver injury grade. The selection of variables for our regression model was guided by review of existing literature, the data available within our prospectively collected database and the coauthors collective expertise. The outcomes were expressed as odds ratios (ORs) accompanied by 95% confidence intervals (CIs), with a significance

TABLE 1. Demographics and Injury Profile of Patients With Blunt Liver Trauma Undergoing Observation Versus AE

Characteristic	Treatment		<i>p</i>
	Observation (<i>n</i> = 71)	AE (<i>n</i> = 57)	
Sex (male)	40 (56.3%)	38 (66.7%)	0.234
Age, median (IQR)	36 (24–53)	39 (24–52)	0.607
Blunt mechanism	71 (100.0%)	57 (100.0%)	0.486
Motor vehicle collision	41 (57.7%)	27 (47.4%)	
Auto vs. pedestrian	12 (16.9%)	11 (19.3%)	
Fall	8 (11.3%)	8 (14.0%)	
Motorcycle collision	4 (5.6%)	4 (7.0%)	
Other	6 (8.5%)	7 (12.3%)	
ISS, median (IQR)	22 (17–29)	29 (20–36)	0.039
Vitals on arrival, median (IQR)			
Systolic blood pressure (mm Hg)	120 (101–135)	116 (95–139)	0.580
Heart rate	91 (82–106)	100 (83–115)	0.178
Respiratory rate	20 (17–24)	20 (18–22)	0.269
Temperature (°C)	36.6 (36.2–36.8)	36.4 (36.0–36.7)	0.106
GCS, median (IQR)	15 (13–15)	14 (11–15)	—
Lactate, median (IQR)	3.3 (2.3–4.5)	3.2 (2.2–5.0)	0.837
INR, median (IQR)	1.1 (1.0–1.2)	1.1 (1.0–1.2)	0.915
Home anticoagulation	2 (2.9%)	2 (3.7%)	0.814
Home antiplatelet	5 (7.2%)	3 (5.5%)	0.687
AAST trauma center level	71 (100.0%)	57 (100.0%)	0.693
I	69 (97.2%)	56 (98.2%)	
II	2 (2.8%)	1 (1.8%)	
AAST liver injury grade	59 (83.1%)	49 (86.0%)	0.001
I	3 (5.1%)	1 (2.0%)	0.695
II	10 (16.9%)	3 (6.1%)	0.085
III	28 (47.5%)	10 (20.4%)	0.003
IV	13 (22.0%)	25 (51.0%)	0.002
V	5 (8.5%)	10 (20.4%)	0.074
Units of PRBCs transfused in 24 h, median (IQR)	2 (1–5)	3 (2–4)	0.499
Shock Index	0.8 (0.6–0.9)	0.8 (0.7–1.2)	0.286
Minutes to CT, median (IQR)	48 (31–72)	43 (36–70)	0.429

IQR, interquartile range; INR, international normalized ratio; PRBCs, packed red blood cells.

threshold set at $p < 0.05$ for determining statistical relevance. Given the binary nature of the LRC outcome in our multivariable logistic regression analysis, we opted for the Hosmer-Lemeshow test as our model fit assessment tool.¹² This test calculates a χ^2 statistic and provides a corresponding p value. A p value exceeding 0.05 indicates a satisfactory model fit. Our findings confirmed that the models exhibit a good fit, as evidenced by a Hosmer-Lemeshow χ^2 statistic of 6.72 and a p value of 0.57. Furthermore, the Nagelkerke R square value for the model stood at 0.18, indicating the proportion of variance in the dependent variable predictable from the independent variables. All analyses were performed with IBM SPSS Statistics for Windows (Version 29; IBM Corp., Armonk, NY). This study was in accordance with the STROBE reporting guidelines (Supplemental Digital Content, <http://links.lww.com/TA/D851>).¹³

RESULTS

A total of 128 patients from 23 medical centers presented with blunt liver trauma and CE on imaging, with 71 (55.5%) undergoing observation-first and 57 (44.5%) AE-first management. Both groups were comparable in terms of sex, age, vitals on arrival, mechanism of injury, GCS, initial lactate, shock index, and time to initial CT imaging (all $p > 0.05$). In addition, there were similar rates of anticoagulation and antiplatelet use before arrival (all $p > 0.05$). However, the AE-first group had an increased ISS (median, 29 vs. 22; $p = 0.039$) and incidence of Grade IV AAST liver injuries (51.0% vs. 22.0%, $p = 0.002$), whereas the observation-first group had a higher incidence of Grade III liver injuries (47.5% vs. 20.4%, $p = 0.003$) (Table 1).

Of all ($n = 57$) patients with CE undergoing AE-first management, 29 (52.7%) patients had arterial CE on angiography. Angioembolization was performed on the main hepatic artery in 13 (40.6%) patients and on segmental hepatic arteries in 19 (59.4%) patients. Various embolization materials were used, with coils being employed in 17 (45.9%) patients, gelfoam in 26 (68.4%), and polyvinyl alcohol particles in 1 (2.6%) (Table 2). Within the observation-first group, 7 (9.6%) patients eventually required delayed AE, with indications including continued hepatic extravasation on serial imaging (28.6%), clinical deterioration (42.9%), and ongoing transfusion requirements (14.3%). Six patients underwent AE after the specified 8-hour threshold. For these patients, the median time to intervention in the IR suite was 733 minutes, or approximately 12.2 hours.

The AE-first group experienced a higher rate of overall in-hospital LRCs (36.8% vs. 12.7%, $p = 0.038$) and specifically bile leaks or bilomas (14.0% vs. 2.8%, $p = 0.019$). In addition, the AE-first group had increased rate of two or more simultaneous LRCs (17.5% vs. 2.8%, $p = 0.004$) and LRC interventions (36.8% vs. 4.2%, $p = 0.026$), specifically with IR drainage (15.8% vs. 4.2%, $p = 0.026$) and operative intervention (8.8% vs. 0.0%, $p = 0.011$). Rates of ERCP were equivalent between both groups (10.5% vs. 2.8%, $p = 0.073$). Compared with the observation-first group, AE-first patients had a similar hospital LOS (10 vs. 6 days, $p = 0.132$), ICU LOS (3 vs. 2 days, $p = 0.280$), and rate of mortality (5.3% vs. 5.7%, $p = 0.912$).

TABLE 2. Interventional Radiology AE Procedure Details

IR AE Procedure Details	
Hepatic blush or extravasation on CT	57 (100.0%)
IR active bleed	29 (52.7%)
IR AE attempted	36 (65.5%)
IR AE vessel	32 (56.1%)
Main	13 (40.6%)
Segmental	19 (59.4%)
IR AE material	44 (77.2%)
Coils	17 (45.9%)
Gelfoam	26 (68.4%)
PVA particles	1 (2.6%)
IR AE successful*	33 (97.1%)
IR second attempt	5 (9.1%)

*Defined as no contrast extravasation on completion angiogram.

PVA, polyvinyl alcohol.

TABLE 3. Outcomes of Patients With Blunt Liver Injury Undergoing Observation Versus AE

Outcomes	Treatment		<i>p</i>
	Observation (n = 71)	AE (n = 57)	
LRC	9 (12.7%)	21 (36.8%)	0.038
Perihepatic fluid collection	5 (7.0%)	10 (17.5%)	0.066
Bile leak/biloma	2 (2.8%)	8 (14.0%)	0.019
Pseudoaneurysm	1 (1.4%)	1 (1.8%)	0.087
Hepatic abscess	0 (0.0%)	1 (1.8%)	0.263
Hepatic necrosis	1 (1.4%)	1 (1.8%)	0.087
Patients with ≥2 LRCs	2 (2.8%)	10 (17.5%)	0.004
LRC intervention	9 (12.7%)	21 (36.8%)	0.001
IR drainage	3 (4.2%)	9 (15.8%)	0.026
ERCP	2 (2.8%)	6 (10.5%)	0.073
Operating room	0 (0.0%)	5 (8.8%)	0.011
Hepatic fistula	1 (1.4%)	1 (1.8%)	0.874
Other intervention	3 (4.2%)	3 (5.3%)	0.782
Antibiotics needed	3 (33.3%)	10 (47.6%)	0.469
Tranexamic acid used	3 (4.2%)	15 (26.3%)	<0.001
Prothrombin complex concentrate used	0 (0.0%)	0 (0.0%)	-
Ventilator days, median (IQR)	0 (0–0)	0 (0–4)	0.012
ICU LOS, median (IQR)	2 (0–4)	3 (1–8)	0.280
Hospital LOS, median (IQR)	6 (3–10)	10 (6–26)	0.132
Mortality	4 (5.7%)	3 (5.3%)	0.912
Represented to ED within 30 d	7 (10.0%)	14 (25.0%)	0.025
Readmitted within 30 d	3 (4.2%)	7 (12.3%)	0.091
Readmission LOS, median (IQR)	2 (1–5)	6 (5–20)	0.635
Readmission for hepatic complication	1 (1.4%)	7 (12.3%)	0.012
Perihepatic fluid collection	1 (1.4%)	2 (3.5%)	0.435
Bile leak/biloma	0 (0.0%)	2 (3.5%)	0.112
Pseudoaneurysm	0 (0.0%)	0 (0.0%)	—
Hepatic abscess	0 (0.0%)	2 (3.5%)	0.112
Hepatic necrosis	0 (0.0%)	1 (1.8%)	0.262
Arteriovenous fistula	0 (0.0%)	0 (0.0%)	—
Hemobilia fistula	0 (0.0%)	0 (0.0%)	—

However, the AE-first group had increased rates of representation to the ED within 30 days (25.0% vs. 10.0%, $p = 0.025$) and readmission for hepatic complications (12.3% vs. 1.4%, $p = 0.012$) (Table 3).

After adjusting for covariates, the associated risk for LRCs was similar between observation-first and AE-first approaches (OR, 1.949; 95% CI, 0.673–5.643; $p = 0.219$). However, there was a higher associated risk of LRCs in those with higher AAST liver injury grade (OR, 3.348; 95% CI, 1.643–6.826; $p < 0.001$) (Table 4).

In a subset of patients with only Grade IV injuries, the rate of LRCs was similar (AE (n = 11) 44% vs. observation (n = 4) 30.8%, $p = 0.429$), as was the rate of mortality (AE (n = 2) 8.0% vs. observation (n = 1) 7.7%, $p = 0.973$). We also found the same to be true for Grade V injuries; however, the sample size was much smaller, AE: 50.0% (n = 5) versus observation 40% (n = 2) ($p = 0.714$), and no patients died.

DISCUSSION

The management of blunt liver trauma necessitates prompt and multifaceted approaches to achieve optimal outcomes.^{1,2} Prior guidelines have recommended AE for hemodynamically stable patients with hepatic injuries and CE, owing to its high efficacy in smaller studies and less invasive nature compared with traditional surgical exploration.^{4–11} However, this current multicenter study demonstrated a similar rate of mortality and associated risk of LRCs for an observation-first approach when compared with an AE-first approach. This suggests that we need to reevaluate the role of routine AE for hemodynamically stable patients with blunt liver trauma and CE.

The advent of hepatic AE gave rise to an effective minimally invasive alternative for actively bleeding liver injuries that would have otherwise potentially necessitated operative intervention. Angioembolization allows for selective and targeted control of hemorrhage while mitigating risks inherent to surgical intervention, including reductions in overall mortality, morbidity, abdominal complications, and blood transfusions.¹⁴ In addition, AE is an adaptable tool that is useful during various phases of hepatic injury management, including postlaparotomy bleeding control.^{15–18} Given its versatility and high efficacy, AE remains an integral tool for the treatment of hepatic trauma.

Despite a high success rate, AE is associated with significant morbidity. Approximately one-third of patients undergoing AE experience LRCs, and one-sixth have two or more simultaneous LRCs, with common issues including bile leaks or bilomas, hepatic/perihepatic abscesses, and hepatic ischemia leading to necrosis.^{7,8,18} When complications arise, additional interventions such as IR drain placement, ERCP, or operative intervention may be required.^{10,11,19} The heightened morbidity associated with AE is evident in this study, as reflected by a three-fold increase in both IR drain placement and ERCP, along with a significantly higher rate of operative intervention needed within the same hospital admission when compared with observation. This added morbidity is further underscored by a statistically increased rate of ED representation following index encounter and hospital readmission for hepatic complications by 30 days, which may be attributed to implications of the initial AE or as complications from additional procedures. However, it is important to note that the increased rate of LRCs may be simply attributed to the higher grade of liver injury and not directly related to the initial approach (observation or AE). While AE can cause hepatic necrosis and subsequent abscess or biloma, the intervention is intended to treat active liver hemorrhage. These complications, however, can also arise directly from the liver injury itself. It is our hypothesis that the liver injury, when compounded by the ischemic effects of AE, may elevate the risk of such

TABLE 4. Multivariable Logistic Regression Analysis for Risk of Liver Related Complications

Independent Variables	ORs	95% CIs	<i>p</i>
AE vs. observation	1.949	0.673–5.643	0.219
ISS	0.991	0.949–1.035	0.686
Age	1.003	0.974–1.032	0.851
AAST liver injury grade	3.348	1.643–6.826	<0.001

complications. To definitively answer this question, a future randomized controlled trial is needed, and this work provides the espouse to support this difficult undertaking.

The preliminary data supporting hepatic AE from systematic reviews by Green et al. and Virdis et al. highlighted its feasibility but included studies lacking comparisons with other treatment modalities.^{7,8} The absence of well-designed control groups in these studies led to numerous confounding factors, making it difficult to establish clear associations between LRCs and AE. This study indicates that after accounting for potential confounders, the risk profile for LRCs appears similar between the observation-first and AE-first approaches. In addition, both groups required a comparable amount of blood product resuscitation within the first 24 hours. The similarity in risk profiles may be attributed to the limited statistical power of the study and/or selection bias. However, given a lack of clear benefit with AE (i.e., mortality, LRCs and LOS) with increased risk of representation to the ED and readmission for hepatic complications, reassessment of current guidelines recommending routine use of AE as an initial treatment modality appears warranted. Originally embraced as a less morbid alternative to laparotomy for managing hepatic trauma with CE, and while it still may have a much needed role in the management of patients with blunt liver trauma, it appears that its utilization needs to be reevaluated to best determine which patient population will benefit the most from this minimally invasive option.

This study demonstrated a statistically higher rate of LRCs in the AE-first cohort, however a similar associated risk of LRCs after controlling for other risk factors (e.g., ISS, age, and AAST score); this may be due to limited power. In addition, about half of the patients with initial CE on CT imaging showed persistent bleeding at the time of angiography. This highlights the uncertainty around optimal AE patient selection. Angioembolization may expedite the natural progression of liver injury and thereby increase the incidence of in-hospital LRCs. This hypothesis is grounded on scientific basis. First, AE can cause inadvertent embolization of non-target vessels, particularly in the setting of a negative angiography or numerous extravasations, thereby increasing risk of ischemia to surrounding healthy liver tissue.²⁰ This unintended ischemia can worsen liver injury and increase the risk of necrosis and abscess formation.²¹ Second, AE may further disrupt the liver's natural hemostatic mechanisms, which are already compromised by trauma, thereby increasing the risk of bleeding and other complications.²² Third, the procedural complexity of AE, particularly in an emergency setting, increases the likelihood of technical errors, which can contribute to complications, such as bile leaks and bilomas. These factors, combined with the direct traumatic injury to the liver, initial hemorrhagic shock, and ensuing proinflammatory responses, can exacerbate tissue damage. Immediate AE postinjury could intensify liver injury by inducing additional local devitalization, thereby expediting the injury progression, and increasing the observed LRC rate. This concept is also supported by parallel findings from mouse model studies, where hepatic injuries due to ischemic insults exhibited similar histological and laboratory patterns.^{22–24} Such insights emphasize the necessity of a nuanced approach to managing hepatic trauma, considering the potential for AE to compound liver injury and accelerate LRC development, especially when employed in higher AAST grade injuries

and/or immediately after the traumatic event. This evidence further justifies the exploration of alternative strategies, like an observation-first approach, in specific patient populations to mitigate the risk of LRCs.

Limitations of this study include those inherent to a post hoc analysis of a prospective observational study. Patients were not randomized to either intervention, leading to differences between treatment groups and inability to clearly identify causation between AE and LRCs. We are unable to determine if the LRC was a direct result of the traumatic liver injury or a subsequent and down-stream effect of the AE. The inclusion of polytrauma patients is a potential confounder since presence of other non-hepatic traumatic injuries may necessitate additional interventions that indirectly affect the liver. Furthermore, this study did not collect data on vascular access-related complications (e.g., pseudoaneurysms and dissections) and contrast-related complications (e.g., acute kidney injury), which poses additional risk of morbidity associated with AE. In addition, data pertaining to the reason for ED representation or hospital readmission lack granularity, and it is unknown if these encounters are due to continued or interval development of LRCs. And finally, despite this being a multicenter study we may be underpowered to detect small differences in outcomes.

CONCLUSION

In this prospective multicenter post hoc analysis, hemodynamically stable patients with blunt liver injury and CE undergoing an observation-first approach were associated with a similar adjusted risk of LRCs and rate of mortality compared with AE-first approach. Overall, this calls for reevaluation of the role of routine AE in blunt liver trauma patients with CE. Future prospective randomized trials are needed to confirm these findings and definitively determine whether patients with blunt liver injury and CE benefit from routine AE.

AUTHORSHIP

P.D.N., J.H., J.M.S., L.A.H., and A.G. contributed to the conceptualization of the study design. All authors contributed to the data acquisition. P.D.N., J.H., and A.G. contributed to the data analysis and interpretation. P.D.N. wrote the original draft of the article, and all authors contributed revisions to produce the final article.

DISCLOSURE

Conflicts of Interest: The authors have no conflicts of interest. All JTACS disclosure forms have been supplied and are provided as supplemental digital content (<http://links.lww.com/TA/D852>).

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