

Transcatheter arterial embolization of severe blunt liver injury in hemodynamically unstable patients: a retrospective 15-year study

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Abstract

Background Non-operative management with Transcatheter arterial embolization(TAE) was the first line of treatment for severe blunt liver injury in hemodynamically stable patients, but in the case of hemodynamically unstable, Operative management(OM) was recommended. We evaluated the efficacy of TAE in our hospital where intervention radiology was available 24 hours a day if the patient responds to initial infusion therapy even unstable.

Methods We conducted a retrospective study of severe blunt liver injury of AAST Organ Injury Scale(OIS) grade 3–5 transported to our hospital between 2005 and 2019. If the patient responded to initial infusion therapy, even though hemodynamically unstable(Shock Index ≥ 1), CT was taken and initial treatment was decided. We compared patients who underwent OM or TAE on initial treatment.

Results 62 patients were included (8 OM, 54 TAE), with a mean ISS of 26.6, in hospital mortality of 6%(13% OM VS 6% TAE, $p = 0.50$), hemodynamically unstable of 35% (88% OM VS 28% TAE, $p < 0.01$) and Time from Door to start OM/TAE 81.8 min(120.0 OM VS 76.1 TAE, $p = 0.02$). Unstable patients who undergo TAE were associated with 7% in hospital mortality and 7% clinical failure. After logistic regression the choice of treatment was not a predictor of outcome, the predictor of in-hospital mortality death was GCS on arrival(OR0.48, $P < 0.01$), hemodynamically unstable was independent predictor of duration of ICU ≥ 7 days(OR 3.80, $p = 0.05$) and massive blood transfusion(OR 7.25, $p = 0.01$). the predictor of complication was OIS grade4-5(OR 6.61 $p < 0.01$).

Conclusions The strategy of performing TAE even in the presence of hemodynamically unstable in a facility where TAE can be performed promptly was acceptable mortality and clinical failure. The choice of treatment did not affect the outcome, and hemodynamically unstable and OIS affected the prognosis.

Background

The nonoperative management (NOM) through transcatheter arterial embolization (TAE) of blunt liver injury is reportedly associated with a success rate of 80–97% when used with advanced techniques in interventional radiology (IR).¹ In addition, guidelines recommend TAE as the first-line therapy in hemodynamically stable patients with blunt liver injury.² However, there are recommendations (Level of Evidence I) for laparotomy in patients who are hemodynamically unstable, and NOM should not be selected for the management of patients with hemodynamic instability.³ A small case series reported that TAE could be useful for hemodynamically unstable patients in facilities that could facilitate quick and accurate application of the procedure,⁴ but there are no reports from comparative studies of TAE and operative management (OM) in hemodynamically unstable patients with liver injury.

Our institution has an IR-equipped emergency department, which facilitates a quick TAE; therefore, we attempted TAE even in hemodynamically unstable patients with liver injury. This retrospective study of a 15-year study period was undertaken to determine whether TAE for severe blunt liver injury is associated with poorer prognosis in hemodynamically unstable patients. Moreover, we comparatively evaluated the differences in prognosis between TAE and OM.

Methods

Study Design and Methodology

This retrospective observational study reviewed all patients with severe blunt liver injury (American Association for the Surgery of Trauma [AAST] grades III–V) who were treated at the Kitasato University Hospital Emergency and Critical Care Center from 2005 to 2019. We excluded patients with cardiac arrest on arrival. Regardless of age, all patients who received OM or TAE as initial treatment were included in this study. The OM group included patients who underwent laparotomy for hemostasis and the TAE group included patients who underwent embolization for the treatment of severe blunt liver injury.

Our facility was the only regional trauma center serving a population of more than one million people, and our IR physicians were full-time staff at this center. Therefore, 24-hour IR facility was available at the study center.

Clinical Management and Procedures

All trauma patients received initial infusion therapy, and patients in shock without elevated blood pressure were treated by OM and underwent damage control surgery. If the clinical condition of the patient responded to initial infusion therapy, the patient underwent computed tomography (CT) scanning. If an intestinal injury was detected, the patient was transferred to the operating room (OR) for OM

and, in patients with an extravascular leak of contrast on CT, a TAE was undertaken in the IR room. A Shock Index > 1 at the time of the admission to the emergency department or immediately before transfer to the OR/IR room was defined as hemodynamic instability.

For embolization, the celiac artery was selected and accessed by using a 5-Fr shepherd hook-type catheter (Hanaco Disposable Torque Catheter, Hanaco Medical Co., Saitama, Japan) or a 5-Fr cobra-type catheter (Torcon NB Advantage Catheter, Cook Japan, Tokyo, Japan). In pediatric patients, we used 4-Fr catheters. The site of hemostasis was selected by using a microcatheter and a TAE was carried out. In principle, we undertook selective embolization; however, embolization from the right and left hepatic arteries or a more proximal site was acceptable if the patient was hemodynamically unstable. The embolic agents included gelatin sponge (via pumping method) and coils or N-butyl cyanoacrylate, if there was an arterioportal shunt or coagulopathy, although choice of embolization material was determined at the IR physician's discretion.

Data Collection

From electronic and paper medical records, we collected data on age, sex, mechanism of injury, vital signs at the time of visit, base excess (BE), fibrinogen, Injury Severity Score (ISS), Trauma and Injury Severity Score (TRISS), time from arrival to CT, time from arrival to admission into OR/IR room, and Operation/TAE time. The AAST classification⁵ was used to grade patients based on intraoperative findings or on a retrospective examination of CT images. The following outcomes were compared between the two study groups: in-hospital mortality, the number of units of blood transfusion within 24 h of admission, massive transfusions (≥ 10 units of RBC), length of intensive care unit (ICU) stay, complications, and clinical failure. Clinical failure was defined as patient death due to hemorrhage within 24 h of OM (OM group) and switching from TAE to OM (TAE group) due to hemostatic challenges. Complications included biloma, hepatic ischemia, pseudoaneurysm, gallbladder necrosis, arterioportal shunt, and rebleeding detected on CT scanning undertaken 1 week after admission.

Statistical Analysis

Statistical analyses were undertaken in JMP[®] (SAS Institute Inc., Cary, NC, USA) by using the Student's *t*, chi-square, and Wilcoxon rank sum tests for comparisons between the OM and TAE groups as well as the stable TAE and unstable TAE groups. A *p*-value < 0.05 was considered indicative of statistical significance. Logistic regression analysis was conducted with regard to the outcome, and incorporated variables with *p* < 0.10 and treatment choice as the variables on univariate analysis. A multivariate analysis was carried out after organizing the cointegrated variables. The odds ratios (OR) for each explanatory variable were calculated.

Results

During the study period, 92 cases of severe blunt liver injury (AAST Grade \geq III) were admitted, of which 30 chose NOM without TAE for initial treatment; therefore, 62 cases (8 OM and 54 TAE) were included in the analysis dataset. Four OM cases were treated with damage control surgery without CT scanning because of nonresponse to the initial infusion therapy (Fig. 1). The median age in this study population was 29.5 (interquartile range [IQR] 20–54). The mechanism of injury was traffic accident (*n* = 50, 81%), fall (*n* = 9, 14%), and compression trauma (*n* = 3, 5%); in this study population, the AAST grades were III in (*n* = 36, 58%), IV in (*n* = 21, 34%), and V (*n* = 5, 8%). The mean ISS was 26.6 ± 13.5 . There were 4 (6%) deaths on admission, 2 (3%) clinical failures, 18 (29%) massive transfusions, and 34 complications in total. The median ICU stay of patients in this study population was 5.5 (IQR 3–12) days.

Comparison of the OM and TAE groups showed statistically significant differences with regard to the mechanism of injury (*p* = 0.02), blood pressure on arrival (OM 98.3 mmHg vs. TAE 125.9 mmHg, *p* = 0.01), GCS score on arrival (OM 9.5 vs. TAE 15, *p* = 0.04), BE (OM – 7.8 vs. TAE – 2.6, *p* < 0.01), ISS (OM 37.5 vs. TAE 24.9, *p* = 0.01), TRISS (OM 0.78 vs. TAE 0.96, *p* = 0.05), time from arrival to OM/TAE (OM 120.0 min vs. TAE 76.1 min, *p* = 0.02), time for OM or TAE (OM 146.5 min vs. TAE 29.4 min, *p* < 0.01), and hemodynamically instability (OM 88% vs. TAE 28%, *p* < 0.01) (Table 1). Outcomes were statistically significant for length of ICU stay (OM 20.5 days vs. TAE 5 days, *p* = 0.01) and massive transfusion (OM 75% vs. TAE 22%, *p* < 0.01). Clinical failures included one case each in the OM (death due to hemorrhage) and TAE (hypotension during IR that revealed a portal vein injury, with good postoperative outcome). Deaths in the TAE group were due to cancer, cerebral infarction, and sepsis.

In the TAE group, we further compared the subgroups of patients who were unstable and stable and found statistically significant differences (Table 2) in the AAST grade (*p* = 0.05), admission blood pressure (stable 133.0 mmHg vs. unstable 107.3 mmHg, *p* < 0.01), BE (stable – 1.6 vs. unstable – 4.9, *p* < 0.01), ISS (stable 21.5 vs. unstable 33.9, *p* < 0.01), and TRISS (stable 0.98 vs. unstable 0.91, *p* = 0.02). Outcomes were statistically significant for length of ICU stay (stable 4 days vs. unstable 8 days, *p* < 0.01) and massive transfusion (stable 10% vs. unstable 53%, *p* < 0.01).

On univariate analyses of outcomes, only the GCS score (OR 0.65, $p < 0.01$) showed statistical significance for in-hospital mortality. However, multivariate analysis with GCS, age, and TAE as objective variables found that the GCS score (OR 0.48, $p < 0.01$) and age (OR 1.08, $p = 0.04$) were statistically significant factors.

The GCS (OR 0.83, $p = 0.04$), BE (OR 0.83, $p = 0.04$), ISS (OR 1.08, $p < 0.01$), hemodynamic instability (OR 7.03, $p < 0.01$), and TAE (OR 0.08, $p < 0.01$) showed statistical significance on univariate analysis for length of ICU stay > 7 days; however, in multivariate analysis adjusted for multicollinearity, only hemodynamic instability (OR 3.80, $p = 0.05$) showed statistically significant associations.

With regard to massive transfusion, systolic blood pressure (SBP) on arrival (OR 0.97, $p < 0.01$), the GCS score (OR 0.79, $p = 0.01$), BE (OR 0.84, $p = 0.02$), fibrinogen (OR 0.99, $p = 0.01$), ISS (OR 1.18, $p < 0.01$), hemodynamic instability (OR 15.8, $p < 0.01$), and TAE (OR 0.10, $p < 0.01$) showed statistical significance on univariate analysis. However, only hemodynamic instability (OR 7.25, $p = 0.01$) showed statistically significant associations on multivariate analysis accounting for multicollinearity. Only severe liver injury (grades IV and V; OR 6.61, $p < 0.01$) showed statistically significant associations for the development of complications (Table 3) on univariate and multivariate analysis.

Discussion

The present study showed that, in the treatment of severe blunt liver injury, the mortality rate was 6% in patients with hemodynamic instability who underwent TAE but responded to initial infusion therapy; TAE for hemodynamically unstable patients did not increase the mortality rate versus the stable group. A recent observational study from a trauma center reported a mortality rate of 3–8%^{6,7} for blunt liver injury and 15% for grades IV and V liver injury, with comparable results. The choice of treatment was not a predictor of outcome; the GCS score on arrival was a predictor of in-hospital mortality, and hemodynamic instability was an independent predictor of length of ICU stay ≥ 7 days and massive blood transfusion. The AAST grades ≥ 4 and ≥ 5 were a predictor of complication.

There are reports that, under certain conditions, TAE for hemodynamically unstable patients with liver injury does not increase mortality. Previous studies^{8–10} have shown that factors contributing to failed NOM include high ISS, need for massive transfusion, hypotension at hospital arrival, high AAST, and intraperitoneal contrast extravasation; however, some controversy prevails because AAST has been reported to be unrelated to the NOM failure rate.^{11–13}

A cohort study of 3627 patients with severe blunt liver injury of AAST Grade IV or higher reported that SBP < 90 mmHg was more likely to result in failed NOM (OR 2.07) and that higher rates of NOM failure and mortality in hypotensive patients were associated with higher rates of NOM.¹³

There are a few case reports of successful NOM with TAE for hemodynamically unstable patients,^{14–16} but a recent observational study reported that failure and mortality from NOM with TAE were independent of hemodynamic status, when hemodynamic instability was defined as a case where the patient required rapid infusion or transfusion to maintain SBP > 90 mmHg.⁴

The success rate of TAE in patients with cardiovascular instability may depend on how quickly the procedure is initiated and completed. A historical cohort study¹⁷ at the same institution reported that the introduction of a protocol wherein CT scanning and TAE was performed within 30 minutes in case of a response to the initial infusion therapy, even if the patient was in shock at the time of admission, resulted in a decreased rate of OM without alterations in the failure or mortality rates. On the other hand, it was reported that only 6% of the NOM were TAE undertaken in facilities with IRs situated far from the trauma unit.¹⁸ In the present study, good access to IR and shortening of the duration from ER visit to TAE could have contributed to the results.

Patients who underwent TAE had fewer massive transfusions and shorter ICU stay than patients who received OM. These results are consistent with those in previous reports^{6,7} and suggest that TAE is less invasive than OM and, thus, results in fewer transfusions and a faster recovery. However, in multivariate analysis, hemodynamic status was the only predictor of ICU stay and massive transfusion and may not depend on treatment. With regard to complications, only AAST showed a correlation. This finding is consistent with reports that major complications after NOM occurred only in patients with AAST grade 3 or higher injuries¹² and that risk factors for complications in 453 NOMs were AAST Grade 4 (OR 4.4) and AAST Grade 5 (OR 12) independent of other factors.¹⁹ The most common complications after TAE include hepatic necrosis, abscess, and biloma, according to a systematic review.²⁰ Complications are reported to occur in 70% of cases,²¹ suggesting that TAE may increase the rate of complications.²² There are reports that embolization should be undertaken

more selectively than at the level of the proper hepatic artery to reduce complications.^{23,24} In the present study, we tried to use selective embolization if the circulation dynamics so permitted.

There were more severe cases in the OM group than in the TAE group because of the inability to undertake CT scanning if the patient was hemodynamically unstable and did not respond to initial infusion therapy. The mortality rate of severe blunt liver injury requiring OM is more than 50%,²⁵ and there are two ways to effectively utilize TAE in such cases. One is the resuscitative endovascular balloon occlusion of the aorta (REBOA), which has been reported to improve prognosis in severe trauma refractory to initial infusion therapy.²⁶ Thus, the inclusion of REBOA in our strategy may have further improved the prognosis in the TAE group. The other option to effectively utilize TAE is the hybrid ER, where all examinations and treatments for trauma are carried out in a single station composed of a carbon-fiber fluoroscopic table with a self-propelled C-arm combined with a sliding gantry CT scanner. The hybrid ER is reported to increase the rate of IVR, shorten the time to treatment initiation, and improve the prognosis in the treatment of severe trauma,²⁷ and it is effective in shortening the time to treatment because TAE can be conducted as soon as CT scanning is completed.

Limitations of this study include the fact that it was a single-center retrospective study. Moreover, the findings of this study may not be easily generalizable as the study center was a facility with immediate access to TAE. Future prospective studies will be needed to specifically control the institutional and patient enrollment criteria for validation of the findings from this research. In addition, the long-term prognosis was not considered in this study.

Conclusion

In centers with good access to TAE facility, TAE may be an effective NOM option in hemodynamically unstable patients with severe blunt liver injury. Prospective and large-scale studies are needed to verify the specific criteria for treatment selection for the application of these research findings in the clinical setting.

Declarations

Ethics approval and consent to participate:

This the retrospective observational design study involved human participants, and it was conducted in conformance with the principles of the Declaration of Helsinki and its amendments. The study protocol was approved by the Kitasato University Hospital Ethics Committee (approval no. B20-034). This committee waived the need for informed consent because of the retrospective design.

Availability of data and materials:

The datasets generated during and analysed during the current study are not publicly available due protect personal information but are available from the corresponding author on reasonable request.

Conflicts of Interest:

None declared.

Source of Funding

None.

Author Contributions:

Study design, data acquisition, data analysis and interpretation, manuscript writing, manuscript review/critical revision. S.T., M.T., K.Y., and K.F conducted study procedures (interventional) and Y.K., T.M., and T.H. undertook study procedures (surgical management). All authors have read and approved the final manuscript.

Consent for Publication:

Not applicable

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List Of Acronyms

IR: Interventional radiology

ISS: Injury Severity Score

OIS: Organ Injury Scale

OM: Operative management

OR: Odds ratio

GCS: Glasgow Coma Scale

ICU: Intensive care unit

NOM: Nonoperative management

RBC: Red blood cells

TAE: Transcatheter arterial embolization

TRISS: Trauma and Injury Severity Score

Tables

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Tables

Table 1: Comparison between the operative management and transcatheter arterial embolization groups

	OM(n=8)	TAE(n=54)	Pvalue	All (n=62)
Mean age (IQR)	35 (20-41)	28.5 (20-55)	1.00	29.5 (20-54)
Sex, (M/F)	7/1	42/12	0.51	49/13
Mechanism, n(%)			0.02	
traffic accident	4 (50%)	46 (85%)		50 (81%)
fall	4 (50%)	5 (9%)		9 (14%)
compression	0 (0%)	3 (6%)		3 (5%)
AAST grade of liver injury, n(%)			0.21	
grade I	3 (38%)	33 (61%)		36 (58%)
grade II	3 (38%)	18 (33%)		21 (34%)
grade III	2 (25%)	3 (6%)		5 (8%)
sBP on arrival (mean)	98.3±30.2	125.9±26.7	0.01	122.7±28.2
sBP on IR/Op room (mean)	106.4±10.8	134.8±3.9	0.02	131.5±29.7
RR on arrival (mean)	27.5±4.4	25.0±6.3	0.33	25.5±6.1
GCS on arrival (median, IQR)	9.5 (6-15)	15 (14-15)	0.04	15 (13-15)
Base Excess on arrival (mean)	-7.8±4.4	-2.6±3.6	<0.01	-3.1±4.0
Fibrinogen on arrival (mean)	215.3±105.1	106.9±14.7	0.47	241.1±106.3
ISS (mean)	37.5±16.9	24.9±12.3	0.01	26.6±13.5
TRISS (median,IQR)	0.78 (0.21-0.97)	0.96 (0.86-0.99)	0.05	0.95 (0.85-0.98)
Time from Door to start OM/TAE	120±109.4	76.1±34.9	0.02	81.8±51.7
Time for OM/TAE	146.5±73.9	29.4±4.1	<0.01	65.0±49.4
Hemodynamically unstable	7 (88%)	15 (28%)	<0.01	22 (35%)
In-hospital mortality	1 (13%)	3 (6%)		4 (6%)
Duration of ICU (median,IQR)	20.5 (10-35)	5 (3-9)	0.01	5.5 (3-12)
Transfusion within first 24h				
Units RBC (median,IQR)	11 (7-42)	0 (0-4.5)	<0.01	0 (0-10)
Units FFP (median,IQR)	24 (10.5-43)	0 (0-10.5)	<0.01	0 (0-14)
Units Plt (median,IQR)	0 (0-46)	0 (0-0)	0.10	0 (0-0)
Massive transfusion	6 (75%)	12 (22%)	<0.01	18 (29%)
Overall complication	4	30	0.45	34
Biloma	1 (13%)	12 (22%)	0.51	13 (21%)
Hepatic ischemia	0 (0%)	7 (13%)	0.15	7 (11%)
Pseudoaneurysm	0 (0%)	3 (6%)	0.36	3 (5%)
Gallbladder necrosis	1 (13%)	1 (2%)	0.19	2 (3%)
AP shunt	1 (13%)	5 (10)	0.78	6 (10%)
Rebleeding	0 (0%)	1 (2%)	0.60	1 (2%)
Clinical failure	1 (13%)	1 (2%)	0.19	2 (3%)

Table 2: Comparison between unstable and stable patients who underwent transcatheter arterial

	Stable (n=39)	Unstable (n=15)	P value
Mean age (IQR)	35 (20-56)	24 (17-32)	0.08
Sex, (M/F)	30/9	12/3	0.81
Mechanism, n(%)			0.34
traffic accident	34 (87%)	12 (80%)	
fall	4 (10%)	1 (7%)	
compression	1 (3%)	2 (13%)	
AAST grade of liver injury, n(%)			0.05
grade I	27 (69%)	6 (40%)	
grade II	11 (28%)	7 (47%)	
grade III	1 (3%)	2 (13%)	
sBP on arrival (mean)	133.0±3.9	107.3±6.3	<0.01
sBP on IR/Op room (mean)	143.6±4.0	111.9±6.4	<0.01
RR on arrival (mean)	24.8±1.0	26.4±1.6	0.4
GCS on arrival (median, IQR)	15 (14-15)	14 (9-15)	0.11
Base Excess on arrival (mean)	-1.6±0.5	-4.9±0.9	<0.01
Fibrinogen on arrival (mean)	257.9±16.9	209.1±28.3	0.14
ISS (mean)	21.0±1.8	33.9±2.8	<0.01
TRISS (median,IQR)	0.98 (0.9-0.99)	0.91 (0.78-0.98)	0.02
Time from Door to start TAE	44.1±4.7	53.3±7.8	0.32
Time for TAE	73.3±5.6	83.6±9.3	0.35
Hemodynamically unstable	53.8±4.7	48.7±8.2	0.6
In-hospital mortality	2 (5%)	1 (7%)	0.83
Duration of ICU (median,IQR)	4 (3-7)	8 (5-21)	<0.01
Transfusion within first 24h			
Units RBC (median,IQR)	0 (0-0)	10 (0-12)	<0.01
Units FFP (median,IQR)	0 (0-6)	12 (2-21)	<0.01
Units Plt (median,IQR)	0 (0-0)	0 (0-20)	0.19
Massive transfusion	4 (10%)	8 (53%)	<0.01
Overall complication	21	8	0.83
Biloma	7 (18%)	5 (33%)	0.24
Hepatic ischemia	7 (18%)	0 (0%)	0.03
Pseudoaneurysm	2 (5%)	1 (7%)	0.83
Gallbladder necrosis	0 (0%)	1 (7%)	0.11
AP shunt	5 (13%)	0 (0%)	0.06
Rebleeding	0 (0%)	1 (7%)	0.11
Clinical failure	0 (0%)	1 (7%)	0.11

l embolization

Table 3: Multiple regression analysis for intergroup comparison

	In-hospital mortality		Duration of ICU \geq 7 days		Massive transfusion		Comolication	
	Odds ratio (p univariate analysis)	Odds ratio (p multivariate analysis)	Odds ratio (p univariate analysis)	Odds ratio (p multivariate analysis)	Odds ratio (p univariate analysis)	Odds ratio (p multivariate analysis)	Odds ratio (p univariate analysis)	Odds ratio (p multivariate analysis)
Age	1.05 (0.074)	1.08 (0.04)	1.00 (0.83)		0.99 (0.61)		0.99 (0.33)	
Sex female	1.28 (0.84)		1.99 (0.29)		0.90 (0.88)		0.59 (0.42)	
Severe liver injury (grade \geq III)	1.41 (0.74)		1.2 (0.73)		1.19 (0.76)		6.61 (<0.01)	8.43 (<0.01)
sBP (arrival)	1.04 (0.11)		0.99 (0.19)		0.97 (<0.01)		0.99 (0.22)	
RR (arrival)	0.91 (0.34)		1.06 (0.16)		1.05 (0.32)		1.00 (0.98)	
GCS (arrival)	0.65 (<0.01)	0.48 (<0.01)	0.83 (0.04)	0.94 (0.62)	0.79 (0.01)	0.95 (0.67)	0.99 (0.90)	
Base Excess (arrival)	0.97 (0.81)		0.77 (<0.01)		0.84 (0.02)		1.00 (0.99)	
Fibrinogen (arrival)	1.00 (0.85)		1.00 (0.11)		0.99 (0.01)	0.99 (0.13)	1.00 (0.84)	
ISS	1.05 (0.17)		1.08 (<0.01)		1.18 (<0.01)		0.99 (0.57)	
Time from Door to start OM/TAE	0.98 (0.25)		1.01 (0.09)	1.00 (0.32)	1.01 (0.28)		1.00 (0.84)	
Time for OM/TAE	0.97 (0.28)		1.01 (0.06)		1.00 (0.44)		0.99 (0.24)	
Hemodynamically unstable	1.90 (0.54)		7.03 (<0.01)	3.80 (0.05)	15.8 (<0.01)	7.25 (0.01)	0.96 (0.94)	
TAE	0.41 (0.50)	0.11 (0.31)	0.08 (<0.01)	0.25 (0.23)	0.10 (<0.01)	0.23 (0.20)	2.22 (0.33)	4.60 (0.11)

Figures

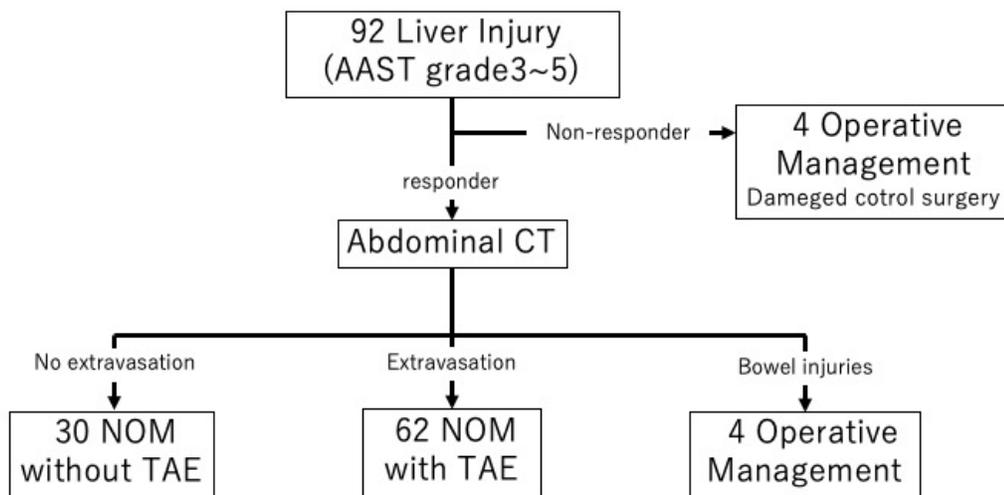


Figure 1

Management algorithm for patients with liver injury. NOM, nonoperative management; TAE, transcatheter arterial embolization.