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Original Research Article

Predictors of failure in non-operative management of blunt liver trauma

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ABSTRACT

Background: Liver is the most injured organ in abdominal trauma. Nonoperative treatment (NOM) is increasingly being adopted as the initial management strategy. The aim of this study was to evaluate the results of operative and conservative management of patients with blunt liver injury treated in a single institution.
Methods: A retrospective study, analyzing patients admitted from 2011-2015 with the diagnosis of liver trauma, was performed. The patients were classified according to the intention to treatment: Group I, NOM; Group II, operative management and Group III, fail in NOM management. We analyzed demographic data, injury classification, associated injuries, transfusions, shock, liver function test, lactate level, and mortality rates.
Results: Over the five years period, 68 patients were recorded, 45 were successful (S-NOM) and 18 were failed (F-NOM). No differences in age, sex or initial hemodynamics were found between S-NOM and F-NOM. The F-NOM patients were more seriously injured, more acidotic, required transfusion, had more fluid collection at FAST, had worse transaminase level and higher mortality rate. Grade of liver injuries was the independent risk factor of failure in nonoperating management of blunt liver trauma with the cut-off point is 3.66.
Conclusions: Non-operative management of blunt liver injuries is successful in some cases. Patients with more severe injury tend to have an operation. High-grade blunt liver injuries always present with a worse condition and require an operation.

Keywords: Blunt liver injuries, Non-Operative Management, Prognostic factors of failure

INTRODUCTION

Liver injuries are common in both blunt and penetrating trauma despite its relatively hidden location behind the subcostal region.[1] The majority of injuries are superficial or minor and require no surgical repair.[2-4] Road traffic crashes and antisocial, violent behavior account for the majority of liver injuries.[2] Liver trauma is the second most frequent event during an abdominal trauma and is the leading cause of death (20-40%) in these cases.[5] Most liver injuries (>85%) involve segments 6, 7, and 8 of the liver, due to simple compression against the fixed ribs, spine, or posterior abdominal wall. Also, pressure through the right hemithorax may propagate through the diaphragm, causing a contusion of the dome of the right lobe of the liver.[1,4,5] Furthermore, ligamentous attachment of the liver to the diaphragm and the posterior abdominal wall can act as sites of shear forces during deceleration injury.[5,6] Associated injury to other organs increases the risk of complications and death.[1]

The management of liver injury has evolved greatly over the last decade. There have been many technical advances in medicine, which now allows us to better diagnose and treat liver injuries both operatively and nonoperatively.[3,7] The recommendations on the use of CT for hemodynamically stable patients are well established, as outlined by the manual of the Advanced Trauma Life Support (ATLS) of the American College of Surgeons.[1,6,8] CT scan allows detection and classification of hepatic lesions and excludes the presence of associated injuries; especially injuries to hollow viscera, although in some cases it underestimates the findings. CT scan, due to its high sensitivity, specificity and accuracy, is an important screening and diagnostic tool for intra-abdominal injuries in hemodynamically stable patients.[8-10]

Currently, non-surgical management is the standard treatment in hemodynamically stable patients with a success rate of 85 to 98%.[11] There is no evidence to support the use of surgical management over an observation protocol for people with abdominal trauma showing no signs of bleeding or infection.[12] Surgery has been reserved for extensive lesions with condition of hemodynamic instability or for the treatment of the complications. Surgical technique has also evolved towards limited resection-debridement, selective vascular ligation and the use of perihepatic packing.[13] Studies also have shown that with the application of angioembolization the overall mortality rates in patients with severe hepatic trauma were as low as 8% to 22%. Nowadays, angioembolization has been widely accepted as a safe and effective therapeutic modality in selected patients with liver injury.[14]

The goal of this study was to determine the effectiveness of nonoperative management in liver injuries by evaluating the failure rates; need for blood transfusions; in-hospital morbidity, shock history, trauma score (ICS), associated injuries, lactate level, transaminase level, and mortality. The data will be analyzed to identify prognostic factors predicting the failure of NOM.

METHODS

We reviewed blunt liver injuries data from medical records of patients that were admitted at Hasan Sadikin General Hospital Bandung, Indonesia from January 2011 to December 2015. Hasan Sadikin General Hospital serves as a major trauma referral center in West Java, a province with population of 45 million people.[15] We treated patients with blunt liver injuries according to the established algorithm. The study protocol was reviewed and approved by our institution's research ethics board.

Patients were eligible for this analysis if they were adult (15 years or more); sustained blunt hepatic injury and were initially managed nonoperatively as per our hospital guidelines for hepatic injury. We excluded all patients who did not meet the aforementioned inclusion criteria and had no complete data the evaluation. All patients were initially resuscitated in accordance to the Advanced Trauma Life Support (ATLS) recommendation, had a Focused Assessment with Sonography in Trauma (FAST) in emergency unit and abdominal CT scan if needed. Selection criteria for nonoperative liver injuries management were hemodynamic stability after initial resuscitation with crystalloid and absence of clinical signs of peritonitis. Patients with unstable hemodynamic and with sign of peritonitis went to operating room directly. For further evaluation, patients only had a FAST examination every 2 days beside physical examination and laboratory findings. Records with incomplete CT scan data were omitted from analysis. In our hospital, we used a multi-slice CT and embolization was not available.

Patients (with or without initial fluid resuscitation) were regarded as hemodynamically stable if they had a patent airway, pulse rate <90 beats/minute with good volume and systolic blood pressure > 90 mmHg. Grade of liver injury was determined according to the chart, developed by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma like listed in Table 1.[3]

Table 1: Grade of liver injury.

Grade	Injury Type	Injury Description
I	Hematoma	Subcapsular, nonexpanding <10 cm surface area
	Laceration	Capsular tear, nonbleeding ≤1 cm parenchymal depth
II	Hematoma	Subcapsular, nonexpanding, 10-50% surface area; intraparenchymal nonexpanding ≤10 in diameter
	Laceration	Capsular tear, active bleeding; 1-3 cm parenchymal Depth <10 cm in length
III	Hematoma	Subcapsular, >50% surface area or expanding; ruptured subcapsular hematoma with active bleeding; intraparenchymal hematoma >10 cm or expanding
	Laceration	>3 cm parenchymal depth
IV	Hematoma	Ruptured intraparenchymal hematoma with active bleeding
	Laceration	Parenchymal disruption involving 25-75% of hepatic lobe or 1-3 Couinaud's segments within a single lobe
V	Laceration	Parenchymal disruption involving ≥75% of hepatic lobe or > Couinaud's segments within a single lobe
	Vascular	Juxtahepatic venous injuries (i.e., retrohepatic vena cava/ central major hepatic veins
VI	Vascular	Hepatic Avulsion

For patients who received NOM, grade of liver injury was determined with a CT scan and for those who underwent a surgery, the grade of liver injury was determined during the operation. The ISS score is an anatomical scoring system from 0-6 with a total score of 75 to determine the severity of multiple injuries patients. Calculation was based on signs that was summarized in the physical examination from head, face, chest, abdomen, extremities and external.

After reviewing the medical records, we evaluated age, gender, Glasgow Coma Scale (GCS), Injury Severity Score (ISS), shock history, blood transfusion needed, transaminase serum and lactate level, fluid collection in FAST, severity of blunt hepatic injury in abdominal CT Scan, associated injuries and mortality as the variables to evaluate. All of these numerical data were then analyzed using Kruskal Wallis test. Categorical data that were distributed normally were analyzed using χ^2 test and Fisher exact test if could not meet the χ^2's condition. P value <0.05 was regarded as statistically significant. Multivariate analysis was then performed to decide the most associated variable in NOM failure of blunt liver trauma.

RESULTS

There were 68 patients with blunt hepatic trauma in our hospital during the study period. Forty-five of them met the inclusion criteria (66%) and treated nonoperatively as listed in Figure 1. Twenty-seven patients were successfully treated conservatively (60%) and 18 of them requiring further operations (40 %). Characteristics of the subject can be seen in Table 2.

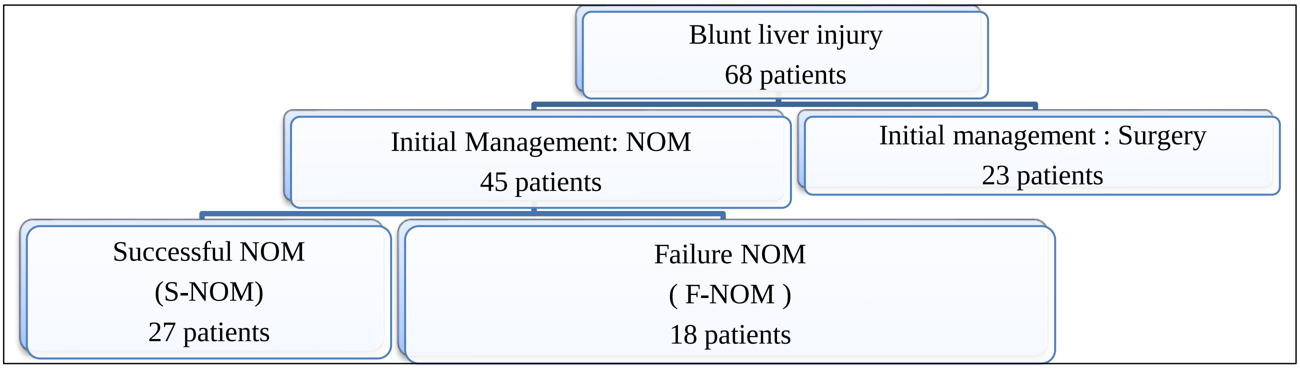

Figure 1: Study design.

Table 2: Patients Characteristics.

Variable	N= 68
Age	
Mean±STD	27.89±12.49
Median	25.00
Range (min-max)	8.00-62.00
Gender	
Male	50 (73.5%)
Female	18 (26.5%)

The mechanism of trauma was dominated by motor car accident followed by fall from height. The consciousness level of patients that were treated conservatively was alert (GCS 15). The lower of patient's consciousness level means higher possibility of failure in nonoperative management. Injury Severity Score (ISS) also shows differential value between the patients who were sent directly to operating room and who were treated conservatively. History of blood transfusion and shock were also found more significantly higher in group of patients whom were operated. Fluid collection more than 1 region in FAST were more frequent in the operated group. Higher transaminase level and lactate level of the patients on a arrival in emergency unit were found in patients who underwent surgery (Table 3). Mortality rate was lower in successful NOM group. Patients came with multiple trauma and injury of the extremities was found highzest accompanying the liver injury followed by a thoracic injury. It can be seen in Table 4. Other organ injuries accompanying a liver injury didn't show a statistically significant value to be considered in managing the patients. From all of the variables that were significantly associated with the failure of NOM in managing a liver injury, we chose 3 variables that might has the greater influence in NOM failure due to limited subject of study.

Among these variables, history of shock, history of blood transfusion and grade of liver injuries were then analyzed using a multivariate test. It showed that the grade of liver injury played a significant role in deciding the successful rate of NOM with the cutoff point is 3.66 (Table 5).

Table 3: Comparison of all variables in all patients.

Variables	Group			P value
	S-NOM	Surgery	F-NOM	
	N=27	N=23	N=18	
Gender				0,462
Male	18 (66.7%)	17 (73.9%)	15 (83.3%)	
Female	9 (33.3%)	6 (26.1%)	3 (16.7%)	
Age				0.136
Mean±STD	30.11±14.669	29.08±11.735	23.05±8.585	
GCS				
Mean±STD	15	12.95±3.125	14.55±1.33	
ISS				<0.01
Mean±STD	22.96±11.59	56.304±13.74	49.00±15.59	
Transfusion				<0.01
Without transfusion	24 (96.0%)	14 (17.4%)	8 (44.4%)	
With transfusion	1 (4.0%)	19 (82.6%)	10 (55.6%)	
Shock				<0.01
Without shock	24 (96.0%)	4 (17.4%)	7 (38.9%)	
With shock	1 (4.0%)	19 (82.6%)	11 (61.1%)	
Aast				<0.01
Mean±STD	1.740±0.764	3.478±1.201	3.666±0.485	
Fast				<0.01
No fluid collection	12 (44.4%)	0 (0,0%)	1 (5.6%)	
Fluid Collection in 1 region	15 (55.6%)	11 (47.8%)	4 (22.2%)	
Fluid Collection in 2 regions	0 (0,0%)	8 (34.8%)	10 (55.6%)	
Fluid Collection in 3 regions	0 (0,0%)	4 (17.4%)	3 (16.7%)	
AST				<0.01
Mean±STD	204.259±229.434	541.304±293.67	753.11±368.253	
Alt				<0.01
Mean±STD	197.925±221.089	512.26±288.729	814.44±373.172	
Lactate				<0.01
Mean±STD	0.944±0.352	3.882±1.474	3.911±1.180	
Mortality	0 (0,0%)	10 (43.5%)	3 (16.7%)	<0.01

Table 4: Injured organs accompanying liver injury.

Variables	Group			P value
	S-NOM	Surgery	F-NOM	
	N=27	N=23	N=18	
Spleen				0.128
(-)	26 (96.3%)	21 (91.3%)	14 (77.8%)	
(+)	1 (3.7%)	2 (8.7%)	4 (22.2%)	
Intestine				0.618
(-)	26 (96.3%)	21 (91.3%)	16 (88.9%)	
(+)	1 (3.7%)	2 (8.7%)	2 (11.1%)	
Kidney				0.193
(-)	23 (85.2%)	15 (65.2%)	15 (83.3%)	
(+)	4 (14.8%)	8 (34.8%)	3 (16.7%)	
Brain Injury				0.175
(-)	25 (92.6%)	18 (78.3%)	13 (72.2%)	
(+)	2 (7.4%)	5 (21.7%)	5 (27.8%)	
Thorax injury				0.250
(-)	20 (74.1%)	14 (60.9%)	9 (50.0%)	
(+)	7 (25.9%)	9 (39.1%)	9 (50.0%)	
Extremities Injury				0.149
(-)	20 (74.1%)	11 (47.8%)	12 (66.7%)	
(+)	7 (25.9%)	12 (52.2%)	6 (33.3%)	

DISCUSSION

The liver is the second most commonly injured abdominal organ, despite its well-protected position, because of its size and position which makes it prone to injury.[1,3,5,16] Management of liver injury depends on patient's condition, diagnosis, transfusion requirement, complication, as well as the hospital facilities to make a diagnosis and treatment. Non-operative management of liver injuries has gained wide support and adopted for approximately 80% of blunt liver injuries.[7] This non-operative approach was at first apply to pediatric patients and has been rapidly extended to adults.[2] It is contraindicated for hemodynamic instability and peritonitis. The advantages of NOM include lower hospital cost, earlier discharge, avoiding unnecessary laparotomy, fewer abdominal complication and reduced number of blood transfusion.[1,14,17]

Most prior studies concluded that the main reason for the failure of NOM is the hemodynamic instability, whereas this observation was contradicted by Mitsusada et al.[18,19] Various predictors of NOM failure have been documented in the literatures.[20-29] Literature review of Bhangu et al, reported AAST grades 4-5, the presence of moderate or large hemoperitoneum, increasing ISS and increasing age were significantly associated with increased risk factor of NOM failure in blunt liver injuries.[21]

Patients with a lower GCS and higher ISS predicts the failure of NOM that is chosen to treat the patient. This result is consistent with the study of Yanar et al, even though age and male has no role in predicting failure of NOM in blunt liver injuries.[29] Huang et al, found one of the subjects with ISS score 50 failed to be treated with non-operative management.[14]

Blood transfusion has played important role in predicting failure of NOM in blunt liver injuries, as described by many authors. Hogea et al, noted that blood transfusion more than 1 bag was a factor that can be used to predict the NOM failure.[16] Study from Hsieh et al, Carillo et al, suggested that increasing need of blood transfusion was also a sign to manage the patient operatively.[2,18]

It is in accordance with our study that blood transfusion is also a predictor failure in managing blunt liver trauma conservatively.

Polanco et al, Mingoli et al, and Hogea et al, stated that if hypotension was found in patients with blunt abdominal injuries, the rate of successful NOM is lower.[10,16,30] Nineteen patients were found shocked in the emergency unit and sent to operating immediately, while 11 patients with history of shocked were transferred to operating room later after NOM attempted.

Abdominal CT scan is widely used to evaluate intra-abdominal injuries in patients with stable hemodynamics. For a patient with unstable hemodynamic, surgery remains the first choice to treat the patients. NOM could be the choice depends on the severity of liver blunt trauma and associated injuries.[5,7] Kozar et al, in his study revealed that global complication rate of NOM is 14 % but for grade V injuries the rate was higher around 52%.[31] Grade of liver injury can reflect the degree of hepatic parenchymal damage. Grade of liver injury more than III is classified as a severe liver injury. Grade VI injuries are not salvageable.[3,5,31] She et al, present that morbidity and mortality tend to worsen with a higher grade of liver injury.[1] In our study, a higher grade of liver injury requires a surgery, but the mortality rate is also getting higher. The cut-off points in this study was 3.66. This means that a liver injury with severity more than grade III tends to be failed if treated without invasive treatment. It also because that in our hospital, angioembolization was not available to be an option in treating blunt liver injuries.

Lactate level on admission >2 is also a predictor of NOM failure in blunt liver injuries.[29] In present study lactate level >2 in emergency unit, elevation of transaminase serum level more than 10 time of normal range shows a role in predicting the failure. The lactate level results are in line with the study from Yanar et al. We found no study has been made using a transaminase serum level on admission as a predictor factor. Associated organ injuries as a predictor factor has been also proposed by Hoege et al, Boese et al, and Yanar et al. The result from these studies was different from present study. In present study, there was no relating factors between associated organ injuries with failure of NOM in blunt liver injuries.

The present study had two limitations. One was the small number of the subjects of this study and another was a retrospective single center study. Hence, it may not be an accurate reflection of the true results of the applicability of NOM to blunt liver injuries. Despite these limitations, our results provided valid information on the applicability of NOM to blunt liver injuries as the data of the study was collected with strict protocols.

CONCLUSION

Non-operative management of blunt liver injuries is successful in some cases.

Patients with a lower GCS, higher ISS score, more acidotic, ongoing transfusion requirements, have a history of transient response shock, worse liver injury and more fluid collection in FAST, have a higher likelihood of requiring operation. High-grade blunt liver injuries always present with a worse condition and require an operation.

NOM is still an effective treatment modality in most cases. Surgery is preserved for extensive lesions of liver injury with condition of hemodynamically unstable or sign of peritonitis.

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REFERENCES

1. She WH, Cheung TT, Dai WC, Chan ACY, Tong DKH, Lo CM. Outcome analysis of management of liver trauma: a 10-year experience at a trauma center. World J Hepatol. 2016;8(15):644-8.
2. Coccolini F, Montori G, Catena F, Di Saverio S, Biffl W, Moore EE, et al. Liver trauma: WSES position paper. World J Emergency Surg. 2015;10(39).
3. Timothy C, Fabian KB, Tiffany KB. liver and biliary tract. Mattox KL, Moore EE, Feliciano DV. Trauma. 7th edition. Mc Graw-Hill; 2013.
4. Brill LD, Maxwell RA. Management of abdominal trauma. Zinner MJ, Ashley SW. Maingot's Abdominal Operation. 12th edition. Mc Graw-Hill; 2013.
5. Saleh AF, Sageer EA, Elheny A. Management of Liver Trauma in Minia University Hospital, Egypt. Ind J Surg. 2016;78(6):442-7.
6. Stassen NA, Bhullar I, Cheng JD, Crandall M, Friese R, Guillamondegui O, et al. Nonoperative management of blunt hepatic injury: an eastern association for the surgery of trauma practice management guideline. J Trauma Acute Care Surg. 2012;73(5)(4):S288-93.
7. Letoublon C, Amariutei A, Taton N, Lacaze L, Abba J, Risse O, et al. Management of blunt hepatic trauma. J Visceral Surg. 2016;153:33-43.
8. Zago TM, Pereira TBM, Calderan ATR, Godinho M, Nascimento B, Fraga GP. Nonoperative management for patients with grade IV blunt hepatic trauma. World J Emerg Surg. 2012;7(1):S8.
9. Gaspar B, Negoi I, Paun S, Hostiuc S, Ganescu R, Beuran M. Selective nonoperative management of abdominal injuries in polytrauma patients: a protocol only for experienced trauma centers. Maedica (Buchar). 2014;9(2):168-72.
10. Mingoli A, Saracino A, Brachini G, Mariotta G, Migliori E, Silvestri V. Nonoperative management for major blunt hepatic trauma. A case report. Ann Ital Chir. 20156;86(ePub).
11. Noyola-Villalobos HF, Loera-Torres MA, Jiménez-Chavarría E, Nú˜nez-Cantú O, García-Nú˜nez LM, Arcaute-Velázquez FF. Non-operative treatment of hepatic lesions due to non-penetrating trauma: review article. Hector. Surgery and Surgeons. 2016;84(3):263-6.
12. Oyo-Ita A, Ugare UG, Ikpeme IA. Surgical versus non-surgical management of abdominal injury. The Cochrane database of systematic reviews. 2012;11:Cd007383.
13. Bernardo CG, Fuster J, Bombuy E, Sanchez S, Ferrer J, Loera MA. Treatment of liver trauma: operative or conservative management. Gastroenterol Res. 2010;3(1):9-18.
14. Huang YC, Wu SC, Fu CY, Chen YF, Chen RJ, Hsieh CH, et al. Tomographic findings are not always predictive of failed nonoperative management in blunt hepatic injury. Am J Surg. 2012;203(4):448-53.
15. Hartanto W. IHSN Survey Catalog. The 2010 Indonesia population census. 2010. Available at catalog.ihsn.org/index.php/catalog/4324/download/5648.
16. Hogea M, Cobelschi C, Maier A, Belecciu A, Mişarca C, Pascu A. Diagnosis and management of abdominal trauma. Bulletin of the Transilvania University of Braşov. 2016;9(58):5-12.
17. Barrie J, Jamdar S, Iniguez MF, Bouamra O, Jenks T, Lecky F, et al. Improved outcomes for hepatic trauma in England and Wales over a decade of trauma and hepatobiliary surgery centralisation. Eur J Trauma Emerg Surg. 2017: DOI 10.1007/s00068-017-0765-y.
18. Hsieh TM, Cheng Tsai T, Liang JL, Che Lin C. Non-operative management attempted for selective high grade blunt hepatosplenic trauma is a feasible strategy. World J Emergency Surg. 2014;9(1):51.
19. Lv F, Tang J, Luo Y, Nie Y, Jiao Z, Li T, et al. Percutaneous treatment of blunt hepatic and splenic trauma under contrast-enhanced ultrasound guidance. Clin Imaging. 2012;36:191-8.
20. Bala M, Gazalla SA, Faroja M, Bloom AI, Zamir G, Rivkind AI, et al. Complications of high grade liver injuries: management and outcome with focus on bile leaks. Scand J Trauma Resusc Emerg Med. 2012:20.
21. Bhangu A, Nepogodiev D, Lal N, Bowley DM. Meta-analysis of predictive factors and outcomes for failure of non-operative management of blunt splenic trauma. Injury. 2012;43:1337-46.
22. Di Saverio S, Moore EE, Tugnoli G, Naidoo N, Ansaloni L, Bonilauri S, et al. Nonoperative management of liver and spleen traumatic injuries: a giant with clay feet. World J Emerg Surg. 2012;7.
23. Fakhry SM, Watts DD, Luchette FA. EAST multi-institutional hollow viscus injury research group: east multi-institutional hollow viscus injury research group: current diagnostic approaches lack sensitivity in the diagnosis of perforated blunt small bowel injury: analysis from 275,557 trauma admissions from the EAST multi-institutional HVI trial. J Trauma Acute Care Surg. 2003;54:295-306.
24. Hashemzadeh SH, Hashemzadeh KH, Dehdilani M, Rezaei S. Non-operative management of blunt trauma in abdominal solid organ injuries: a prospective study to evaluate the success rate and predictive factors of failure. Minerva Chir. 2010;65:267-74.
25. Mitsusada M, Nakajima Y, Shirokawa M, Takeda T, Honda H. Non-operative management of blunt liver injury: a new protocol for selected hemodynamically unstable patients under

hypotensive resuscitation. J Hepatobiliary Pancreat Sci. 2014;21:202-11.
26. Robinson WP, Ahn J, Stiffler A, Rutherford EJ, Hurd H, Zarzaur BL, et al. Blood transfusion is an independent predictor of increased mortality in nonoperatively managed blunt hepatic and splenic injuries. J Trauma Acute Care Surg. 2005;58:437-45.
27. Shapiro MB, Nance ML, Schiller HJ, Hoff WS, Kauder DR, Schwab CW. Nonoperative management of solid abdominal organ injuries from blunt trauma: impact of neurologic impairment. Am Surg. 2001;67:793-6.
28. Stassen NA, Bhullar I, Cheng JD, Crandall ML, Friese RS, Guillamondegui OD, et al. Eastern Association for the Surgery of Trauma: Selective nonoperative management of blunt splenic injury: an Eastern association for the Surgery of Trauma practice management guideline. J Trauma Acute Care Surg. 2012;73:294-300.
29. Yanar H, Ertekin C, Taviloglu K, Kabay B, Bakkaloglu H, Guloglu R. Nonoperative treatment of multiple intra-abdominal solid organ injury after blunt abdominal trauma. J Trauma Acute Care Surg. 2008;64:943-8.
30. Polanco PM, Brown JB, Puyana JC, Billiar TR, Peitzman AB, Sperry JL. The swinging pendulum: a national perspective of nonoperative management in severe blunt liver injury. J Trauma Acute Care Surg. 2013;75(4):590-5.
31. Kozar RA, Moore FA, Cothren CC, Moore EE, Sena M, Bulger EM, et al. Risk factors for hepatic morbidity following nonoperative management: multicenter study. Arch Surg. 2006;141(5):451-8.

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