Srp Arh Celok Lek. 2015 Jul-Aug;143(7-8):416-422
ОРИГИНАЛНИ РАД / ORIGINAL ARTICLE
DOI: 10.2298/SARH1508416D
UDC: 616.36-001.3-089

Severe Blunt Hepatic Trauma in Polytrauma Patient – Management and Outcome

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SUMMARY

Introduction Despite the fact that treatment of liver injuries has dramatically evolved, severe liver traumas in polytraumatic patients still have a significant morbidity and mortality.

Objective The purpose of this study was to determine the options for surgical management of severe liver trauma as well as the outcome.

Methods In this retrospective study 70 polytraumatic patients with severe (American Association for the Surgery of Trauma [AAST] grade III–V) blunt liver injuries were operated on at the Clinic for Emergency Surgery.

Results Mean age of patients was 48.26±16.80 years; 82.8% of patients were male. Road traffic accident was the leading cause of trauma, seen in 63 patients (90.0%). Primary repair was performed in 36 patients (51.4%), while damage control with perihepatic packing was done in 34 (48.6%). Complications related to the liver occurred in 14 patients (20.0%). Liver related mortality was 17.1%. Non-survivors had a significantly higher AAST grade (p=0.0001), higher aspartate aminotransferase level (p=0.01), lower hemoglobin level (p=0.0001), associated brain injury (p=0.0001), perioperative complications (p=0.001) and higher transfusion score (p=0.0001). The most common cause of mortality in the "early period" was uncontrolled bleeding, in the "late period" mortality was caused by sepsis and acute respiratory distress syndrome.

Conclusion Patients with high-grade liver trauma who present with hemorrhagic shock and associated severe injury should be managed operatively. Mortality from liver trauma is high for patients with higher AAST grade of injury, associated brain injury and massive transfusion score.

Keywords: blunt liver injury; damage control surgery; American Association for Surgery of Trauma; focused assessment with sonography for trauma; computed tomography; intensive care unit

INTRODUCTION

In polytraumatized patients with blunt abdominal trauma, the liver is the most frequently injured abdominal organ [1, 2, 3]. Nowadays the most common cause of blunt liver injuries are traffic accidents, in approximately 70% of all cases [4, 5].

The structure of the liver parenchyma, the size of the liver and its relatively fixed position make the liver particularly vulnerable to blunt trauma. As a result of the specifics of the liver anatomy, the right lobe is injured more commonly than the left one and the most involved segments are VI, VII, and VIII of the liver (>85%) [6]. The most accepted scoring system for traumatic liver injuries is the Moore score, which is based on the Organ Injury Scale (OIS) of the American Association for Surgery of Trauma (AAST) [7, 8] and is considered a gold standard to describe liver injuries. Severe blunt liver trauma remains a great challenge for clinicians. Hemodynamic stability is the key for the diagnostic and therapeutic approach to the severe liver injuries. The diagnostics of hepatic trauma have evolved from ultrasound (focused assessment with sonography for trauma, FAST) with the use of computerized tomography (CT), within a short time after admission to the emergency room [9, 10, 11]. CT has become the gold standard for assessing trauma patients [1]. Hepatic parenchymal injuries can be categorized by CT as contusions, subcapsular and parenchymal hematomas, linear or stellate lacerations, and hepatic fractures.

Management of a liver trauma involves a systematic sequence of actions, and non-operative management with angiographic embolization has become a reality for selected hemodynamically stable patients [3, 12, 13]. Indications for surgical treatment include progressive hemodynamic instability with CT findings of a laceration of a major hepatic vein, complex perihilar injuries, progression of a hepatic injury on follow-up examinations or persistent hemoperitoneum [3, 14]. In unstable patients with severe physiological derangement, surgical procedures such as direct vessel repair of juxtahepatic venous injuries or early perihepatic packing (damage control surgery, DCS) have led to improved outcome [15, 16, 17]. The decision for an emergency laparotomy is usually taken based upon the presence of the "lethal triad", consisting of coagulopathy, acidosis and hypothermia. In such cases a complex, long-lasting, definitive surgical procedure such as liver resection leads

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to time wasting. In those patients DCS is necessary to control the bleeding and prevent biliary complications [18].

Complex hepatic injuries have a high morbidity rate [19, 20]. Liver-related complications occur in approximately 20% of patients and include hemobilia, arteriovenous fistula, pseudo-aneurysm, biloma, bile leak and abscess formation [21, 22]. CT and ultrasound can be used in diagnosing post-traumatic postoperative complications such as hepatic or perihepatic abscesses or bilomas. The main cause of death related to liver injury is uncontrolled bleeding, and it is associated with a mortality rate of 54% [23].

OBJECTIVE

The purpose of this study was to determine the options for surgical management of severe liver trauma as well as the outcome.

METHODS

This is a retrospective study of 70 trauma patients with severe blunt liver trauma who had been admitted and managed at Clinic of Emergency Surgery, Clinical Center of Serbia, Belgrade, during a three-year period. Liver injuries were graded according to the AAST [7, 8]. Patients with stable blood pressure, adequate urine output and insignificant changes in laboratory findings, AAST grade 1–2, were managed conservatively and were not included in the study, while liver traumas AAST grade III, IV and V were included.

Data were collected on age, sex, mechanism of trauma, grades of liver injury, management and outcome. All patients were resuscitated according to the Advanced Trauma Life Support recommendations. FAST has been used as the first tool to check for the presence or absence of hemoperitoneum and associated solid organ injury. Diagnostic peritoneal lavage was used for suspected intra-abdominal bleeding following blunt trauma in unstable patients. CT of abdomen was done in the selected group of patients who were hemodynamically stable (Figure 1A, B).

Patients with refractory hypotension not responding to resuscitation during the first hour in the presence of hemoperitoneum due to bleeding from the liver trauma were operated on. All laparotomies were performed within the first 24 hours. The decisions regarding which surgical technique should be applied had been based upon hemodynamic instability and complexity of the liver injuries with massive hemoperitoneum and signs of exsanguinations. Exploratory laparotomies were performed through the midline incision, for all patients. Blood present in the peritoneal cavity was sucked out, and the abdomen was thoroughly examined in search of liver trauma and associated injuries, with emergency care of bleeding and control of sources of infection and contamination (Figure 2A, B). The liver was mobilized by cutting triangular ligaments, and inflow vascular control (Pringle maneuver) was performed under vascular clamp before proceeding with parenchymal repair. Inflow vascular control was employed as an intermittent vascular occlusion for a period of 15–20 minutes for vascular arrest, after which the clamp was released for five minutes and the liver was reexamined for any further bleeding.

Direct liver repair techniques were used alone or in combination: extensive suture (hepatorrhaphy), hepatotomy with selective vascular ligation, selective hepatic artery ligation, resectional débridement and liver resection. Major resection was used only to control extensive lacerations of the liver and extensive devitalized liver tissue (Figure 3A, B). Abdominal drains were placed in all cases.

In unstable patients with severe physiological derangement due to exsanguinating liver injuries we used the strategy of DCS. In those patients we performed packing of the liver with approximately four to six abdominal swabs as perihepatic packing technique to provide compression and bleeding control (Figure 4). Abdominal swabs were never placed directly into a laceration and bleeding arteries were suture-ligated prior to liver packing. After liver packing, the abdomen was temporarily closed. All patients

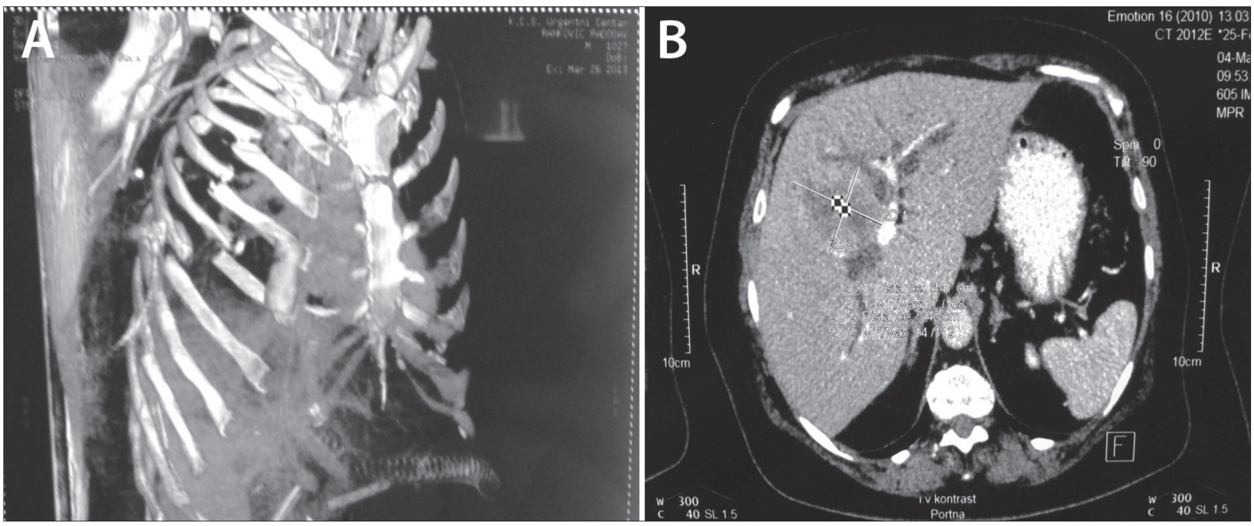

Figure 1. CT findings of severe thoracoabdominal trauma with serial rib fractures (A) and liver injury (B)

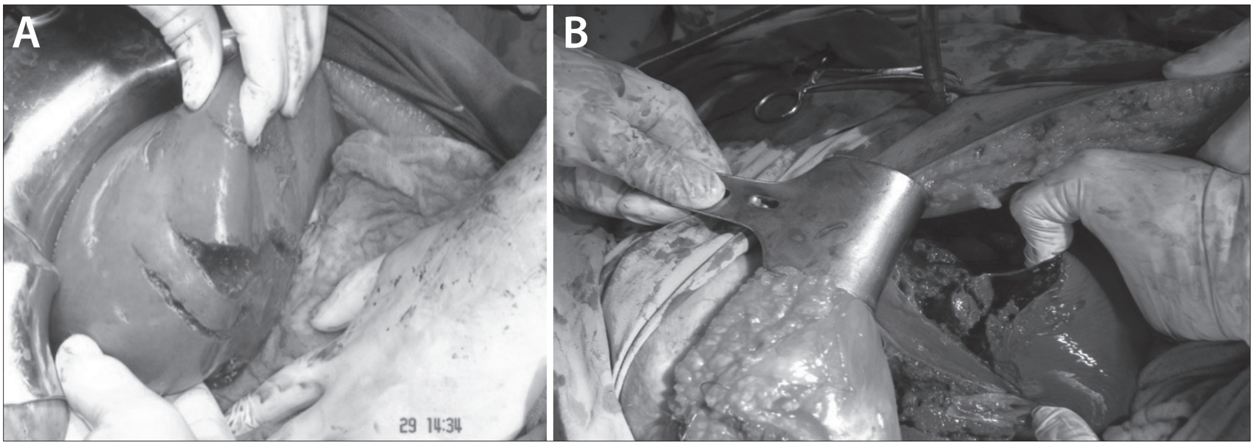

Figure 2. Intraoperative findings: liver trauma AAST grade III (A) and IV (B)

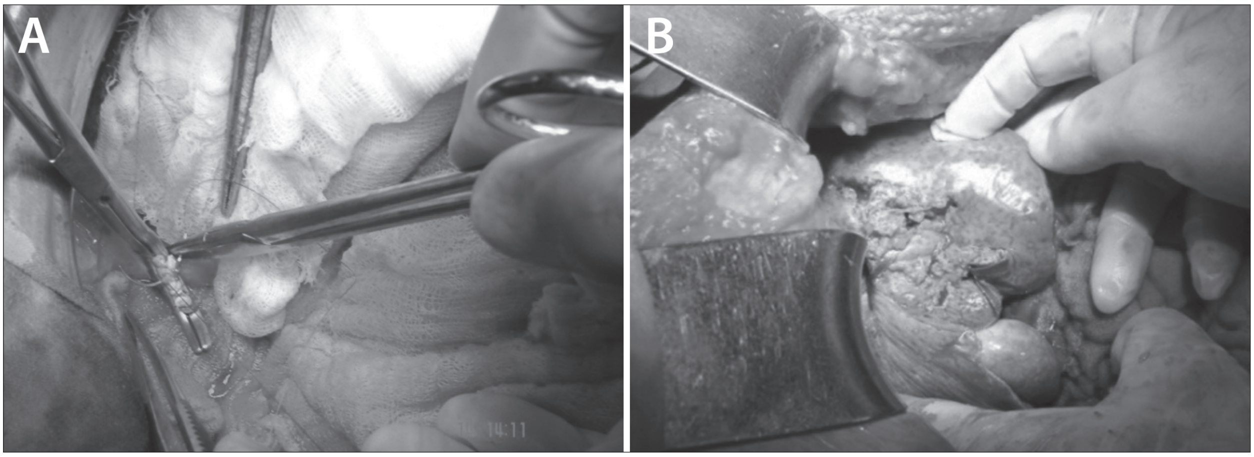

Figure 3. Direct liver repair techniques: vessel suture ligation (A) and hepatorrhaphy (B)

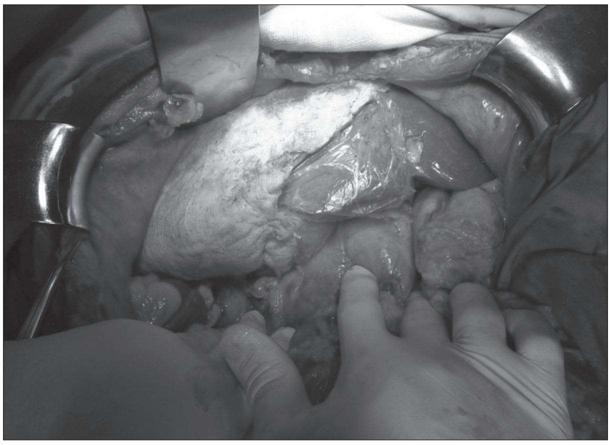

Figure 4. Liver packing in DCS approach

were then transferred to the intensive care unit for the correction of acidosis, coagulopathy, and hypothermia. A planed re-laparotomy was performed after 48 hours, when the patients' temperature had normalized, shock had been corrected, and the international normalized ratio was less than 1.5.

Liver-related mortality was calculated based on deaths due to uncontrollable and ongoing hemorrhage from the liver injures. Liver-related complications were considered to include hemorrhage, liver failure, coagulopathy, jaundice, bile leak and biloma. Abdominal sepsis was defined in cases of occurrence of peritonitis, intra-abdominal abscesses and collections, multiorgan failure secondary to intra-abdominal infection.

Statistical analysis

The data were analyzed using software package SPSS 11 (Chicago, Ill.), and are expressed as numbers (%) and mean values (SD). The Kaplan–Meier estimator was used for survival analysis and the Cox's proportional hazards model. The overall and liver injury specific morbidity rates were calculated as well. A value of $p<0.05$ was considered statistically significant.

RESULTS

In this study there were 58 males (82.8%) and 12 females (17.1%) (Table 1). Road traffic accident was the leading cause of trauma, seen in 63 patients (90.0%) (Table 1). Blood pressure, laboratory results, associated injury and clinical findings at arrival were presented in Table 1.

Associated thorax injuries were serial rib fracture, hematothorax, pneumothorax and lung/cardiac contusion.

All patients in this study had a severe liver trauma grade III–V according to the AAST (Table 2).

doi: 10.2298/SARH1508416D

Table 1. Patient characteristics on admission to the hospital

Variable	Data
Age (years)	48.2±16.8
Male sex	58 (82.8%)
Driver	48 (68.6%)
Pedestrian	10 (14.3%)
Passenger	5 (7.1%)
Fall from roof	5 (7.1%)
Hit by assailant	1 (1.4%)
Suicidal jump	1 (1.4%)
Systolic blood pressure (mm Hg)	92.1±21.3
White blood cells (10^9/L)	19.2±5.4
Hemoglobin (g/L)	89.7±13.7
AST (U/L)	685.1±235.7
Associated injury	70 (100.0%)
Thorax injury	53 (75.7%)
Bone fracture	40 (57.1%)
Brain/head/face injury	26 (37.1%)
Spleen injury	23 (32.8%)
Stomach/bowel injury	18 (25.7%)
Kidney/pancreas/abdominal aorta injury	8 (11.4%)
VCI injury	6 (8.6%)

Data are presented as mean value ± standard deviation or the number of patients with percentage.

VCI – vena cava inferior; AST – aspartate aminotransferase

Primary repair was performed in 36 (51.4%) patients (Table 3). DCS and liver packing with subsequent relaparotomy and removal of packs after 48 hours was used in 48.6% of patients (Table 3). Three of these patients required re-packing of the liver due to bleeding that occurred after the removal of the packs. Thirty-nine patients required suturing of the liver injury to obtain hemostasis. Liver resection was performed in 10 (14.3%) patients. This consisted of non-anatomic resection in six (8.6%) patients and major resection in four (5.7%). Overall there were 55 (78.6%) associated surgical procedures, which are the following: splenectomy 30 (42.8%), bowel suture 10 (14.3%), bowel resection seven (10.0%), suture of the diaphragm five (7.1%), pancreas suture two (2.8%) and pancreas resection one (1.4%) patient. After the completion of emergency abdominal procedures, 35 (50.0%) patients were undergoing an orthopedic or neurosurgery intervention.

The following complications related to the liver occurred in 14 (20.0%) patients: biloma five (7.1%), liver failure three (4.3%), bile leak five (7.1%) and liver abscess one (1.4%) patient (Table 3). Non-related liver complications were found in 33 (47.1%) patients: pleural effusion 11 (15.7%), sepsis in 12 (17.1%) and acute respiratory distress syndrome (ARDS) in 10 (14.3%) cases.

Overall mortality rate was 40.0% (Table 3). The "early" mortality (<24 hours) was noted in 12 (17.1%) patients, two of which were on the operating table and 10 (14.3%) patients died in the intensive care unit. The predominant causes of mortality in the "early period" appeared to be massive bleeding, hemorrhage shock and multiple injuries. Sixteen patients died due to late complications, such as sepsis and ARDS. Overall liver related mortality was 17.1%, and the most common causes of death were bleeding and liver failure.

Table 2. Grade of liver injuries according to the American Association for Surgery of Trauma (AAST)

Grade of liver injuries	Number of patients
III	23 (32.8%)
IV	37 (52.8%)
V	10 (14.3%)
Total	70 (100.0%)

Table 3. Surgical procedures in severe blunt liver injuries and outcome

Variable	Data
Suturing of liver	39 (55.7%)
DCS/liver packing	34 (48.6%)
Liver resection	10 (14.3%)
Hepatic artery ligation	4 (5.7%)
Vascular repair	9 (12.8%)
Associated surgical procedure	55 (78.6%)
Massive transfusion*	50 (71.4%)
ICU stay (days)	9.23±5.67
Hospital stay (days)	19.12±13.42
Overall morbidity	46 (65.7%)
Liver-related complications	14 (20.0%)
Overall mortality	28 (40.0%)
Liver-related mortality	12 (17.1%)

Data are presented as number of patients with percentage or the mean value ± standard deviation.

* Transfusion ≥10 units of pRBCs, within first 24 hours

DCS – damage control surgery; ICU – intensive care unit

Table 4. Comparison of demographics, laboratory and clinical characteristics (at arrival) between survivors and non-survivors

Variable	Survivors (N=42)	Non-survivors (N=28)	p
Male sex	32 (76.2%)	20 (71.4%)	>0.05
Age (years)	40.16±12.80	41.03±10.90	>0.05
Road traffic accident	39 (92.8%)	24 (85.7%)	>0.05
AAST grade III	23 (54.7%)	0 (0.0%)	0.0001
AAST grade IV	18 (42.8%)	19 (67.8%)	0.0001
AAST grade V	1 (1.4%)	9 (32.1%)	0.0001
AST (U/L)	354.32±124.7	705.72±545.12	0.010
Hgb (g/L)	98.6±12.8	81.3±15.6	0.0001
Thorax injury	33 (78.6%)	20 (71.4%)	>0.05
Bone fracture	25 (59.5%)	15 (53.6%)	>0.05
Brain/head injury	9 (21.4%)	17 (60.7%)	0.0001
Spleen injury	13 (30.9%)	13 (35.7%)	>0.05

Data are presented as number of patients with percentage or the mean value ± standard deviation.

Table 5. Comparison of postoperative characteristics between survivors and non-survivors

Variable	Survivors (N=42)	Non-survivors (N=28)	p
Massive blood transfusion*	24 (57.1%)	26 (92.8%)	0.0001
Perioperative complications	18 (42.8%)	28 (100.0%)	0.001
Bile leak	3 (7.1%)	2 (7.1%)	>0.05
Prolonged bleeding	3 (7.1%)	12 (42.8%)	0.0001
Liver failure	1 (2.4%)	2 (7.1%)	0.001
Sepsis	4 (9.5%)	8 (28.6%)	0.001
ARDS	4 (9.5%)	6 (21.4%)	0.001

* Transfusion ≥10 units of pRBCs

ARDS – acute respiratory distress syndrome

The comparison with the survivors showed non-survivors to have a significantly higher AAST grade of injury (p=0.0001), higher aspartate aminotransferase (AST) level (p=0.01), lower hemoglobin level (p=0.0001), associated brain injury (p=0.0001), perioperative complications (p=0.001) and higher massive transfusion score (p=0.0001) (Tables 4 and 5).

DISCUSSION

We presented 70 patients with severe blunt liver trauma who are treated surgically due to massive bleeding and hemodynamic instability.

Severe hepatic injuries occur in 5–8% of patients sustaining blunt abdominal trauma [1, 2, 23]. Since 1908, from Pringle's [24] publication on vascular inflow control in liver, the primary focus of trauma surgeons was to find out the most appropriate technique to control the massive bleeding in patients of hepatic injuries [1, 25]. The success of non-operative management of hepatic injuries in children in the 1980s and observation that up to 85% of hepatic injuries in adults were no longer bleeding at the time of laparotomy, prompted the initiative of non-operative management in selected hemodynamically stable patients [10, 26]. With increasing acceptance of non-operative management, the primary focus becomes the selection of appropriate patients for operative management and the decision when to perform an operation [1, 14, 27]. In a prospective study of 136 patients of blunt hepatic trauma, 24 patients required emergency laparotomy and 112 patients were treated conservatively with a subsequent failure rate of 11% [28]. In this study, shock on admission, hemodynamic instability, severe liver injury with massive bleeding and associated injury were related to the need of early laparotomy. In a study of 214 patients with a hepatic injury the independent predictors for the need of operative treatment included intraperitoneal contrast extravasation and hemoperitoneum [29]. The contraindications to none-operative management include the hemodynamic instability, extravasation of intravenous contrast, expanding hematomas and grade IV and V liver injury [1, 14, 25, 27]. According to the study conducted by Coimbra et al. [30], non-operative management has been accepted as treatment of choice for stable patients with grade III and IV.

The mortality in patients treated non-operatively was 0%, and non-operative treatment was associated with a 23.5% reduction in mortality.

The line of management of liver trauma is primarily guided by the hemodynamic status of the patient at the time of presentation in emergency department and response to the initial fluid restitution [1, 27]. CT is the imaging modality of choice in evaluating hemodynamically stable patients with suspected hepatic injury [10, 31]. Abdominal CT accurately defines the morphology and extent of the hepatic trauma, identifies associated visceral injuries and depicts the amount of accompanying hemoperitoneum [10]. We performed CT in all initially stable patients, and FAST and/or diagnostic peritoneal lavage in hemodynamically unstable patients. The indications for laparotomy were refractory hypotension, significant fall in hematocrit, the extravasations of intravenous contrast agent, expanding hematoma on grade IV and V liver injury on CT of the abdomen. The surgical treatment of liver injuries in this study included definitive procedure (hepatorrhaphy, hepatotomy with selective vascular ligation, debridement, selective hepatic artery ligation, liver resection) and DCS with liver packing. Perihepatic packing is needed to control hepatic bleeding in patients with high-grade liver injuries and compromised physiological stage [1]. Improvements in outcome can be achieved using damage control principles and an appropriate surgical approach. It is important to recognize that liver packing will not control arterial bleeding and that any bleeding artery should be suture ligated prior to liver packing. The incidence of trauma patients requiring liver packing varies from 5% to 60% in the literature [1, 32, 33]. This higher incidence is most likely due to an increased awareness of the need to immediately perform damage control procedures in unstable patients in hemorrhagic shock.

Over half of patients surviving grade III–V liver injuries will be at risk for the development of complications including hemorrhage, intra-abdominal abscess formation and bile leaks [19]. According to the analysis of Shapiro et al. [34] the overall mortality was as high as 40%. These patients are at great risk for intra-abdominal abscess, wound infection, abdominal compartment syndrome, wound dehiscence, enterocutaneous fistula and multi organ system failure [34]. CT is helpful in evaluating post-operative complications, like intra-abdominal abscess formation and biloma [30]. A major cause of immediate death in severe liver injuries remains uncontrollable bleeding, whereas sepsis and multiple organ dysfunction are the primary causes of morbidity and late postoperative course [14, 33, 35]. In blunt liver trauma mortality also appears to be higher in older patients, those with higher grade injuries, and those with hemodynamic instability on presentation [35]. In a series of 210 patients with grade III–V hepatic injuries, the overall and liver-related mortality rates were 46% and 30%, respectively [36]. Asensio et al. [1] showed that predictors for mortality in grade IV–V injuries are related to severe bleeding and include blood loss, number of red cell units transfused, hypothermia, acidosis and dysrhythmia. Our study shows that higher AAST grade of injury, higher AST level, higher massive blood transfusion score and associated brain injury had a significant association with mortality.

CONCLUSION

Road traffic accidents are the leading cause of severe hepatic injuries, while most patients suffering from them are young males. In patients with severe liver injury and hemodynamic instability or signs of continuous bleeding and associated abdominal injuries warrant an early laparotomy. In comparison with the survivors, non-survivors showed to have a significantly higher AAST grade of injury, higher AST level, higher massive transfusion score and associated brain injury.

doi: 10.2298/SARH1508416D

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Комплексне тупе повреде јетре код политрауматизованих болесника – лечење и исход

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КРАТАК САДРЖАЈ

Увод Упркос чињеници да је лечење од повреда јетре напредовало, комплексне повреде јетре и даље доводе до значајног морбидитета и морталитета болесника.

Циљ рада Циљ истраживања је био да се одреде начини хируршког лечења тешких повреда јетре и исходи оваквог лечења.

Методе рада Ретроспективна студија је обухватила 70 политрауматизованих особа с тешким тупим повредама јетре (*AAST III–V* степен) које су оперисане на Клиници за ургентну хирургију Клиничког центра Србије.

Резултати Болесници су у просеку били стари 48,26±16,80 година, а 82,8% су били мушкарци. Саобраћајне несреће су биле водећи узрок повређивања, а забележене су код 63 испитаника (90,0%). Примарно хируршко збрињавање повреда јетре учињено је код 36 испитаника (51,4%). Етапна контрола оштећења с перихепатичним паковањем изведена је код 34 болесника (48,6%). Специфичне компликације везане за повреду јетре забележене су код 14 болесника (20,0%). Стопа морталитета директно повезаног с комплексном повредом јетре била је 17,1%. Преминули су имали значајно већи *AAST* степен повреде (p=0,0001), више вредности *AST* (p=0,01), ниже вредности хемоглобина (p=0,0001), удружене повреде мозга (p=0,0001), периоперационе компликације (p=0,001) и виши скор трансфузије крви (p=0,0001). Најчешћи узрок умирања у тзв. раном периоду било је неконтролисано крварење, док су сепса и синдром акутног респираторног дистреса били водећи узроци морталитета у каснијем периоду.

Закључак Болеснике с тешком повредом јетре који су у хеморагичном шоку и с тешким удруженим повредама потребно је хируршки лечити. Морталитет од повреда јетре је висок за повреде тежег *AAST* степена уколико постоје удружене повреде мозга и масивна трансфузија крви.

Кључне речи: тупа повреда јетре; хируршка контрола оштећења; Америчко удружење за хируршког лечење повреда (*AAST*); циљана процена повреда ултразвуком; компјутеризована томографија; јединица интензивне неге

Примљен • Received: 10/07/2014 **Прихваћен • Accepted:** 08/12/2014

doi: 10.2298/SARH1508416D