JOURNAL OF
CONTEMPORARY MEDICINE

DOI:10.16899/jcm.896175
J Contemp Med 2021; 11(5): 679-684

Orjinal Araştırma / Original Article

Retrospective Evaluation of Liver Injuries in Children: Ten Years Experience of a Single Centre

Çocuklarda Karaciğer Yaralanmalarının Geriye Dönük Değerlendirilmesi: Tek Bir Merkezde On Yıllık Deneyim

Mehmet Uysal[1], Ahmet Aslan[2]

[1]Department of Pediatric Surgery, Karaman Training and Research Hospital, Karaman, Turkey
[2]Karamanoğlu Mehmetbey University School of Medicine Department of General Surgery, Karaman, Turkey

Abstract

Objective: We aimed to evaluate the causes of trauma that result in liver injury and additional solid organ injuries, management types and results of management in children referred to our clinic for liver injuries in last ten years.

Material and Method: The records of 47 patients managed for liver injuries owing to blunt abdominal trauma between July 2010 and May 2020 were reviewed retrospectively.

Results: The patients were 1-17 (7.8±5.8) years old; 30 (63.8%) were male and 17 (36.2%) were female. Causes of injuries included pedestrian and passenger traffic accidents (29, 61.7%), falls from height (12, 25.5%), bicycle accidents (4, 8.5%), objects falling on the body (1, 2.1%), after a physical assault (1, 2.1%). Isolated liver injury was present in 27 patients (62%), while 20 patients (38%) had other organ injuries. Liver injuries were grade I in 8 patients (17.3%), grade II in 12 (26%), grade III in 18 (38.2%), grade IV in 8 (17%), and grade V in 1 (2%). Thirty-nine patients (83%) were managed conservatively in these series of liver injuries, whereas 8 patients (17%) had unstable vital signs managed surgically. The mortality rate, duration of stay in intensive care and hospital, and the number of blood transfusions were higher in surgically managed patients, while hemodynamic parameters were considerably lower in surgically managed patients.

Conclusion: Conservative treatment methods should be chosen in patients with a liver injury who are hemodynamically stable. The shorter duration of hospital stay, less blood transfusion requirement, and lower morbidity, mortality percentages are indispensable reasons for this method to be preferred.

Keywords: Children, injury, liver, management, trauma

Öz

Amaç: Son on yılda kliniğimize başvuran çocuklarda karaciğer hasarı ve ek solid organ yaralanmaları ile sonuçlanan travma nedenlerini, tedavi tiplerini ve tedavinin sonuçlarını değerlendirmeyi amaçladık.

Gereç ve Yöntem: Temmuz 2010-Mayıs 2020 tarihleri arasında künt karın travmasına bağlı karaciğer yaralanmaları nedeniyle tedavi edilen 47 hastanın kayıtları retrospektif olarak incelendi.

Bulgular: Hastalar 1-17 (7,8±5,8) yaşında olup; 30 (%63,8)'u erkek, 17 (%36,2)'si kadındı. Yaralanmaların nedenleri yaya ve yolcu trafik kazaları (29, %61,7), yüksekten düşme (12, %25,5), bisiklet kazaları (4, %8,5), vücuda düşen cisimler (1, %2,1), fiziksel saldırı sonrası yaralanmadır (1, %2,1). Hastaların 27 (%62)'sinde izole karaciğer hasarı, 20 (%38)'sinde başka organ yaralanmaları vardı. Karaciğer yaralanmaları hastaların 8 (%17,3)'inde grade I, 12'sinde (%26) grade II, 18 (%38.2)'inde grade III, 8 (%17)'inde grade IV ve 1'inde (%2) grade V idi. Bu seride karaciğer yaralanması olan hastaların 39 (%83)'u konservatif olarak takip edilirken, vital bulguları stabil olmayan 8 (%17)'ine cerrahi müdahale yapıldı. Cerrahi müdahale ile takip edilen hastalarda mortalite oranı, yoğun bakım, hastanede kalış süresi ve kan transfüzyonu sayısı daha yüksekken, hemodinamik parametreler önemli ölçüde düşüktü.

Sonuç: Hemodinamik olarak stabil karaciğer yaralanması olan hastalarda konservatif tedavi yöntemi seçilmelidir. Hastanede daha kısa kalış süresi, daha az kan transfüzyonu gereksinimi ve daha düşük morbidite, mortalite yüzdeleri bu yöntemin tercih edilmesinin vazgeçilmez nedenleridir.

Anahtar Kelimeler: Çocuklar, yaralanma, karaciğer, tedavi yönetimi, travma

Corresponding *(İletişim)*: Mehmet Uysal, Karaman Training and Research Hospital Department of Pediatric Surgery, Karaman, Turkey
E-mail *(E-posta)*: drmyzuysal3@gmail.com
Received *(Geliş Tarihi)*: 14.03.2021 **Accepted *(Kabul Tarihi)*:** 31.05.2021

INTRODUCTION

Liver trauma is one of the most common abdominal lesions in severely injured trauma patients.[1] The prevalence of blunt liver injury has been reported to increase especially in the last 3 decades.[2,3] In recent years, as a result of improvements in the imaging methods used to diagnose solid organ injuries, and in the conditions of intensive care units, the treatment approach in hemodynamically stable cases with blunt liver trauma has changed from surgical intervention to non-operative therapy.[4,5] It is thought that patients with liver injury, and hemodynamically stable can be followed up with controlled ultrasonography (US) or contrast abdominal computed tomography (CT) if there is no other emergency surgical pathology.[6] Follow-up of vital signs, whether or not there are acute abdominal symptoms by physical examination, changes in hemoglobin and hematocrit, liver enzyme levels are important follow-up tools in non-operative patients.[5,6] We aimed to evaluate the causes of trauma that result in liver injury and additional solid organ injuries, management types and results of management in children referred to our clinic for liver injuries in last ten years.

MATERIAL AND METHOD

This study was conducted by ethics committee approval obtained from Karamanoğlu Mehmetbey University Faculty of Medicine (02-03/07.12.2020). The records of 47 patients managed for liver injuries owing to blunt abdominal trauma between July 2010 and May 2020 were examined. In addition to demographic features of the patients such as age and gender, duration of stay in the hospital, causes of trauma, additional organ injuries, and treatment methods were evaluated. Hemodynamic status was determined with blood pressure at referral, hemoglobin levels, and essential for blood transfusion. Contrast CT determined which solid organs were injured and the degree of injury. The amount of blood transfusion required, duration of hospital stay, and the status of injuries in the control CT were examined in the patients followed up with surgically or conservatively. All patients in the conservatively treated group were controlled by contrast abdominal CT between 7 and 10 days of hospitalization. Possible changes in lesions were controlled and the final condition of the injury was radiologically demonstrated for comparison purposes in previous findings. These patients were given 15 to 20 days rest after clinical and radiological improvement. Anatomy and severity of the injury, hemoperitoneum level, other abdominal organs, retroperitoneal structures, and the gastrointestinal system can be evaluated with contrast abdominal CT. It provides a remarkable contribution staging of trauma liver, spleen, kidney, pancreas, and digestive tract, treatment, and follow-up,[6] so after 1 and 6 months, patients were called to outpatient clinic control with contrast abdominal CT. The severity of liver injuries has been universally classified according to the American Association for the Surgery of Trauma (AAST) grading scale. In determining the optimal treatment strategy, however, the hemodynamic status and associated injuries should be considered. Thus, the management of liver trauma is ultimately based on the anatomy of the injury and the physiology of the patient.[7]

RESULTS

The patients were aged between 1-17 (7.8±5.8) years; 30 (63.8%) were male, 17(36.2%) were female involved in this study. The patients that have liver injuries were 8 (17%) grade I, 12 (25.6%) grade II, 18 (38.3%) grade III, 8 (17%) grade IV, 1 (2.1%) grade V (**Table 1**).

Table 1. Hepatic injuries according to AAST

Grade	The size of liver laceration	*n	** %
1	Small subcapsular hematoma or superficial laceration	8	17
2	Subcapsular hematoma covering 10-50% of surface area or a 1-3 cm laceration less than 10 cm in length	12	25.6
3	Large (>50%) ruptured subcapsular hematoma, an intraparenchymal hematoma >2 cm, or a laceration >3 cm in depth	18	38.3
4	Ruptured intraparenchymal hematoma or lobar parenchymal disruption involving 25-50% of the lobe	8	17
5	Lobar parenchymal disruption >50% or juxta-hepatic venous injury	1	2.1
6	Hepatic avulsion	0	

*Number of cases, **Percentage

We have assessed the liver injuries according to the AAST classification while the anatomic gravity of the associated injuries was defined the Injury Severity Score (ISS) system (**Table 2**)

The causes of injuries were involved a pedestrian and passenger traffic accidents (29, 61.7%), falls from height (12, 25.5 %), bicycle accidents (4, 8.5%), objects falling on the body (1, 2.1%), and 1 (2.1%) after a physical assault. While 8 (17%) of these patients were managed surgically, 39 (83%) of them were managed conservatively (**Table 2**).

Conservative follow-up was preferred over surgical intervention in the patients with hemodynamic instability and hollow organ injury. Twenty-eight (59.6%) of the patients had isolated liver injuries and 19 (40.4%) of them had other intraabdominal organ injuries. The patients who had liver injuries also present with 8 (42.1%) kidney, 7(36,9%) spleen, 3(15.8%) hollow organs, 1 (5.2%) pancreatic injuries. There were 7 (14.9%) head, 6 (12.8%) thorax, 4 (8.5%) limb and 3 (6.4%) multiple organs (**Table 2**).

Table 2. Frequencies of several variables for both treatment modes (conservative and laparotomy.)

Variable	Conservative	Laparotomy
Male	24 (80%)	6 (20%)
Female	15(88.2%)	2 (11.8%)
Traffic accidents	24 (82.8%)	5 (17.2%)
Falls from height	10 (83.3%)	2 (16.7%)
Bicycle accidents	3 (75%)	1 (25%)
Objects falling on the body	1 (50%)	1 (50%)
Assault	1 (100%)	0

While all the patients of grade I and II were managed conservatively, 4 patients (22.2%) grade III, 3 patients (37.5%) grade IV, and 1 patient (100%) grade V were managed surgically. There was also an ileum perforation in 2 patients in grade III, and 1 patient in grade IV undergone surgery. As a surgery we used primary repair for the laceration in 5 (62.5%) patients and pringle maneuver (portal triad blockage), local hypothermia application to the liver that we used it to our one patient in grade V. Also, perihepatic packing and planned reexploration as a part of damage control surgery. We used it it to our two patients in grade IV and V in cases of hemodynamic instability or coagulopathy. One patient died during surgery (2.1%) owing to excessive bleeding that induced respiratory and circulatory failure. One case in grade IV (2.1%) observed with delayed bleeding was treated surgically.

The data according to the grades of liver injury are summarized in **Table 3.** Thirty-nine patients (83%) were managed conservatively in this study. All of these patients survived.

Table 3. The data according to the grades of liver injury

Grade	Hemoglobin Level * (g/dl)	Blood transfusions (n)**
1	11.8 (9-12.5)	2 (25%)
2	11.5 (10.7-13)	6 (50%)
3	11 (10.7-11.8)	13 (72.7%)
4	10.2 (9-10.8)	8 (100%)
5	6.8	+

*Median (min-max), **Number of the patient

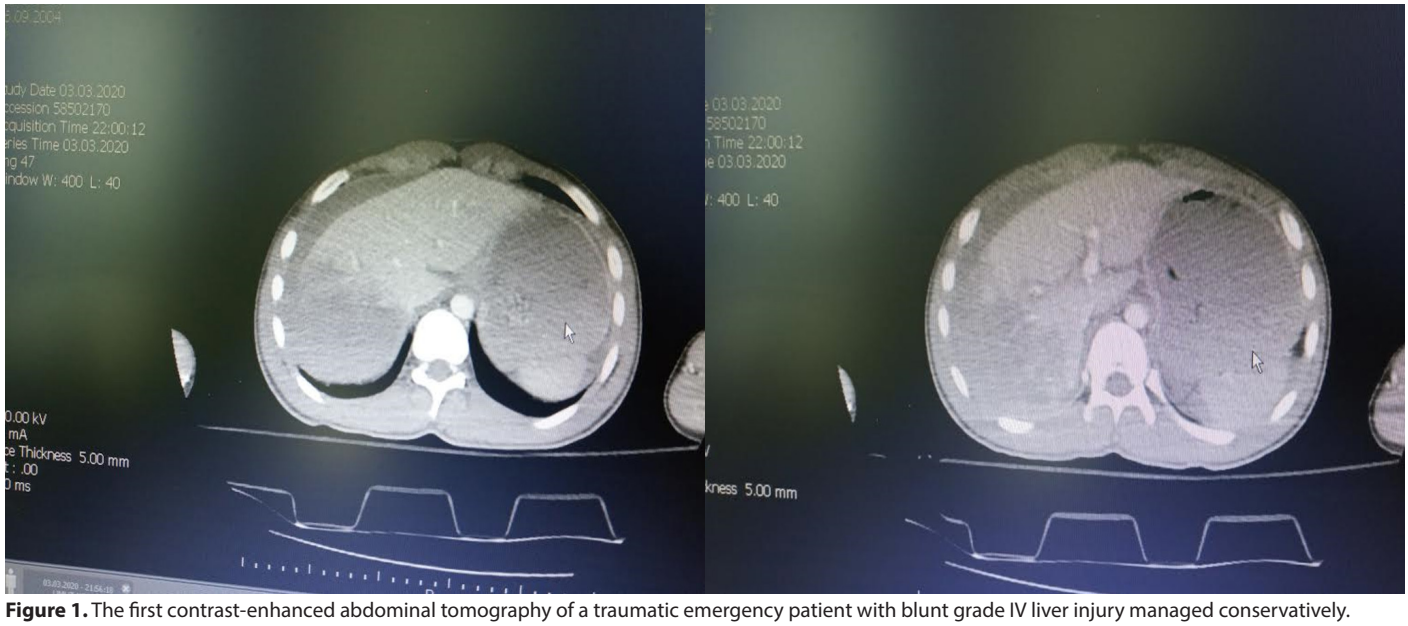

Figure 1. The first contrast-enhanced abdominal tomography of a traumatic emergency patient with blunt grade IV liver injury managed conservatively.

Figure 2. A contrast-enhanced abdominal tomography of the patient was managed conservatively with a blunt grade IV liver injury after 3 months.

In the conservatively managed group 3 (7.6%) patients had atelectasis, 1 (2.6%) developed pneumonia, 1 (2.6%) had a subhepatic abscess, 3 (7,6%) had a secondary hemorrhage and bile leakage, 1 (2.6%) had a hemobilia. Hollow organ injuries and biliary peritonitis were the most complications that treated surgically. The duration of the mean hospital stay was 7.2 days for our patients.

DISCUSSION

The liver is the second most commonly injured intraabdominal organ after abdominal traumas. The amount of liver injury after blunt abdominal traumas is 2-3%. Most liver injuries appear owing to motor vehicle accidents and falls from heights. Penetrative injuries are uncommon in children. Surgical treatment is not necessary for 70-90% of patients. The aim of non-operative management of liver injuries in children is to restrict operative morbidity and mortality.[8] As in the literature, most liver injuries were appeared owing to traffic accidents 29 (61.7%), falls from height 12 (25.5%) in this study.

The right diagnosis and treatment of liver injuries are very necessary for children because liver injury after blunt abdominal traumas is the most significant cause of mortality.[9,10] In several studies, AST and ALT levels over 150 IU/L suggested liver parenchymal damage in 43-61% of patients, but were unable to declare the degree of parenchymal damage.[11,12] However, in this study, all patients had parenchymal damage, and 8 (17%) of them had enzyme levels lower than 150 IU/L. As in the literature, there was no relation between enzyme levels and injury grade in this study. On the other hand, it has been noted that one can rule out liver parenchymal damage if enzyme levels are normal.[11,12] As in the literature, in this study, except for three patients with grade I injuries, increased AST and ALT levels were determined and all patients had liver parenchymal damage.

Abdominal contrast CT is the recommended method for finding out and grading injuries. Today, the most important criterion for patient selection for non-operative treatment of trauma centres and surgeons has been hemodynamic stability rather than visual rating.[13,14] In these patients, hemodynamic stability may break down rapidly and an emergency surgical procedure may be needed without optimal patient preparation. A difference between the liver and the spleen is that delayed bleeding is uncommon in the liver. It is noticed in less than 2% of non-operative treated patients.[15,16] As in the literature, one patient in grade IV (2.1%) was noticed with delayed bleeding, and this case was managed surgically.

Monitoring in intensive care is seen as a prudent and sensible approach so that the clinician can determine which patient will fail the non-operative treatment. Angiography and embolization should be considered if the active hemorrhage is seen or suspected during tomography if technical facilities and experience are sufficient. With an experienced, well-equipped multidisciplinary team, it is possible to achieve a success rate of over 90% by remaining non-operative. The mortality of all hepatic injuries is around 10%. Fortunately, 70-90% of hepatic injuries are minor injuries. Complicated hepatic injuries are around 10-30% and mortality has decreased to 10% in the last decade with major changes in follow-up and treatment of complicated liver injuries.[17] As in the literature, 8 (17%) patients who had unstable vital signs managed surgically. One patient (2.1%) in grade V died during the surgery due to excessive bleeding that caused the respiratory and circulatory failure. The most important changes for liver surgery are:

1. The effect of CT on non-operative treatment of the adult with blunt hepatic trauma,[18]
2. Pringle maneuver (portal triad blockage), local hypothermia application to the liver[19] that we used to our one patient;
3. Perihepatic packing and planned reexploration as part of damage control surgery in cases of hemodynamic instability or coagulopathy[20] that we used it to our two patients;
4. Treatment of juxtahepatic venous injuries with various intracaval shunts that we haven't used in any of our patients, yet.

The most important decision to be made after the first resuscitation is whether or not the patient will be operated on. After two liters of intravenous liquid substitution, it should be regarded that bleeding continues in the patient whose hemodynamic stability is not achieved. Pachter et al. in the series of 495 diseases, the success rate of this treatment was 94%. This success was achieved with an average blood transfusion of 1.9 units, 6.2% complications, of which only 2.8% were related to bleeding, and an average hospital stay of 13 days.[18] Suchlike outcomes are also seen in the series of multicentric study groups containing 404 cases.[21] In these series, 98.5% of injuries were treated non-operative and the complication rate was only 5%. Ongoing bleeding was the most common complication in 14 patients (3.5%) and only 3 (0.7%) patients were operated on to stop the bleeding. Other complications, perihepatic abscesses, and bile collections were rare and most of them regressed spontaneously, while those that did not regress spontaneously were drained accompanied by CT. Only one patient needed surgery after his intrahepatic abscess failed to be percutaneous drained. But the fact that 1 liver injury-related death (0.5%) and 2 omitted small bowel injuries (0.5%) in this study suggest that more work should be done on conservative treatment protocols. In the literature, it was reported that 50 to 80% of laparotomies due to blunt liver trauma had no active bleeding and negative laparotomy was performed.[22,23]

Many studies have been managed to define specific criteria to facilitate the application of non-operative therapy and patient selection in cases with blunt trauma.[1,24,25] These criteria were determined as hemodynamic stability, absence of peritoneal findings, less than 500 ml of hemoperitoneum. The most important critical factor here is not the degree of liver injury

or hemoperitoneum, but the hemodynamic stability of the cases after application or resuscitation.[1,26] Another factor to be considered is the presence of another intraabdominal solid or hollow organ injury that requires surgical intervention. As in the literature, there was an additional ileum perforation in 2 (11%) patients in grade III and 1(12.5%) patient in grade IV liver injuries managed surgically in our study.

After discharge, absolute bed rest for 7-10 days and limited physical activity for 4-6 weeks are recommended.[11,22] Thirty-nine of 47 (%83) patients were managed conservatively in the present study. Twenty (100%) of them were with grade I and II injuries, 14 (77.8%) with grade III injuries, and 5 (62.5%) with grade IV injuries were managed conservatively. There was a transfusion reaction in 3 patients (7%) in the follow-up period.

Surgical management of liver injury has a higher mortality rate than conservative management because liver resection increases the risk of perioperative and postoperative mortality.[11,26] Kepertis et al.[27] managed 9 of 34 patients (26%) surgically. Two of these patients had grade IV injuries, one had grade V and one had grade VI; two of the other five patients underwent surgery for splenic laceration, two for a head injury, one for diaphragmatic rupture, and one for extremity fracture. There was 1 (11%) mortality in the surgically managed patients and no incidence of mortality in the conservatively managed patients in the study of Kepertis et al.[27] Similarly, in the present study, the mortality rate was high in the surgically managed patients, as one out of eight patients (12.5%) died. The mortality rate, duration of stay in intensive care and hospital, and the number of blood transfusions were higher in surgically managed patients, while hemodynamic parameters were considerably lower in surgically managed patients.

On the other hand, there were no complications in the 6 surviving patients managed surgically. However, the lower complication rate remarked in surgically managed patients in this study was probably owing to the low patient numbers. The occurrence of intrahepatic or subhepatic abscess is 0.5-3% (11,28). As in the literature, 1 (2.6%) patient managed conservatively had a subhepatic abscess in this study.

Potential disadvantages of nonoperative treatment and early or late period complications in blunt liver traumas recovered as delayed bleeding, biliary fistula, and liver abscess, hemobilia, and extrahepatic biliary tract strictures seen in 3-5% cases.[28] Missed delayed bleeding and hollow organ injuries lead to life-threatening and negative effects on the success of non-operative therapy. Nonoperative treatment was recommended in our 5 (62.5%) cases with hemodynamically stable stage IV liver injury. We observed that there were almost no signs of trauma left after one and six months later in the contrast abdominal CT. This suggests that non-operative treatment may be more frequent, especially in selected cases, without being dependent on the degree of trauma.

In this study, the duration of stay was 1, 1.5, 2, and 3 days in intensive care and 4, 5, 6, 7 days in the hospital for grades I, II, III, and IV, respectively. There was a statistically remarkable association between grade of injuries, and duration of stay in intensive care and in-hospital ($p<0.05$). Nellensteijn et al.[29] declared that durations of stay were 0, 0, 0, and 1 day in intensive care and 2, 3, 4, and 5 days in the hospital for grades I, II, III and IV, respectively. In this study, there was also a connection between the grade of injury and duration of stay in intensive care and hospital. However, durations of stay in intensive care and hospital were longer determined in this study than Nellenstein et al.[29] This may have been owing to more severe traumas.

Although surgery is primarily considered in high-grade liver trauma, hemodynamically stable cases such as grade III and IV can be treated conservatively with close follow-up. It was determined that there was no exitus in the nonoperative treatment group. One patient died from the operated group, and that the causes of exitus were related to additional injuries. This study disclosed that the current approaches in the diagnosis and treatment of solid organ injuries determined after blunt abdominal trauma have been successfully applied in our hospital emergency surgery department.

Conclusion: Management of liver injury after blunt abdominal trauma is multidisciplinary. Conservative treatment should be preferred in children with blunt liver trauma provided that hemodynamic stability is maintained. It appears that the degree of liver damage is not as important as the hemodynamic balance in deciding non-surgical treatment. Therefore, clinical condition, degree of anatomical injury and associated injuries should be considered together in determining the best option. Conservative treatment has advantages such as shorter hospital stay, less need for blood transfusion, lower morbidity, and mortality..

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Karamanoğlu Mehmetbey University School of Medicine Ethics Committee (Permission granted: 07.12.2020, Decision no: 02-03).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Brillantino A, Iacobellis F, Festa P, et al. Non-operative management of blunt liver trauma:safety, efficacy and complications of a standardized treatment protocol. Bull Emerg Trauma 2019;7(1):49-54.
2. Richardson JD, Franklin GA, Lukan KJ, et al. Evolution in the management of hepatic trauma:a 25-year perspective. Ann Surg 2000;32:324-30.
3. Lucas CE, Ledgerwood AM. Changing times and the treatment of liver injury. Am Surg 2000;66:337-41.
4. Malhotra AK, Fabian TC, Croce MA, et al. Blunt hepatic injury:a paradigm shift from operative to nonoperative management in the 1990s. Ann Surg 2000;231:804-13.
5. Fang JF, Chen RJ, Lin BC, Hsu YB, Kao JL, Chen MF. Blunt hepatic injury:minimal intervention is the policy of treatment. J Trauma 2000;49:722-8.
6. Anadol AZ, Topgül K, Güngör B, Bilgin M, Kesim M. Künt karaciğer travmalarına konservatif yaklaşım. Ulus Travma Acil Cerrahi Derg 2007;13:222-6.
7. Coccolini F, Catena F, Moore EE, et al. WSES classification and guidelines for liver trauma. World J Emerg Surg. 2016;10 (11):50.
8. Gross M, Lynch F, Canty T Sr, Peterson B, Spear R. Management of pediatric liver injuries:a 13-year experience at a pediatric trauma center. J Pediatr Surg 1999;34:811-7.
9. Keller MS. Blunt injury to solid abdominal organs. Semin Pediatr Surg 2004;13(2):106-11.
10. Eppich WJ, Zonfrillo MR. Emergency department evaluation and management of blunt abdominal trauma in children. Curr Opin Pediatr 2007;19:265-9.
11. Management and treatment of liver injury in children. Arslan S, Güzel M, Turan C, Doğanay S, Doğan AB, Aslan A.Ulus Travma Acil Cerr Derg 2014;20(1):45-50.
12. Bouras AF, Truant S, Pruvot FR. Management of blunt hepatic trauma. J Visc Surg. 2010;147(6):e351–8.
13. Badger SA, Barclay R, Campbell P, Mole DJ, Diamond T. Management of liver trauma. World J Surg. 2009;33:2522–37.
14. Peitzman AB, Richardson JD. Surgical treatment of injuries to the solid abdominal organs:a 50-years perspective from the Journal of Trauma. J Trauma. 2010;69:1011-21.
15. Coccolini F, Montori G, Catena F, et al. Liver trauma:WSES position paper. World J Emerg Surg. 2015;10:39
16. Ordonez CA, Parra MW, Salamea JC, et al. A comprehensive five-step surgical management approach to penetrating liver injuries that require complex repair. J Trauma Acute Care Surg. 2013;75(2):207-11.
17. Ordonez CA, Herrera-Escobar JP, Parra MW, Rodriguez-Ossa PA, Puyana JC, Brenner M. A severe traumatic juxtahepatic blunt venous injury. J Trauma Acute Care Surg. 2016;80(4):674-6.
18. Gruen RL, Brohi K, Schreiber M, et al. Haemorrhage control in severely injured patients. Lancet (London, England). 2012 Sep 22;380 (9847):1099-108.
19. Ordonez CA, Badiel M, Pino LF, et al. Damage control resuscitation:early decision strategies in abdominal gunshot wounds using an easy "ABCD" mnemonic. J Trauma Acute Care Surg. 2012;73(5):1074–8.
20. Afifi I, Abayazeed S, El-Menyar A, Abdelrahman H, Peralta R, Al-Thani H. Blunt liver trauma:a descriptive analysis from a level I trauma center. BMC Surg. 2018;18(1):42.
21. Peitzman AB, Marsh JW. Advanced operative techniques in the management of complex liver injury. J Trauma Acute Care Surg. 2012;73(3):765-70.
22. Çelebi F, Balik AA, Polat KY, Yildirgan MI, Böyük A, Oren D. Hepatic injuries. Surgical treatment experience. Ulus Travma Dergisi 2001;7:185-8.
23. Carver D, Kirkpatrick AW, D'Amours S, Hameed SM, Beveridge J, Ball CG. A prospective evaluation of the utility of a hybrid operating suite for severely injured patients. Ann Surg. 2018;20:1.
24. Abbas Q, Jamil MT, Haque A, Sayani R. Use of interventional radiology in critically injured children admitted in a pediatric intensive care unit of a developing country. Cureus. 2019;11(1):e3922.
25. Van der Vlies CH, Saltzherr TP, Wilde JCH, van Delden OM, de Haan RJ, Goslings JC. The failure rate of nonoperative management in children with splenic or liver injury with contrast blush on computed tomography:a systematic review. J Pediatr Surg. 2010;45(5):1044-9.
26. Vo N-J, Althoen M, Hippe DS, Prabhu SJ, Valji K, Padia SA. Pediatric abdominal and pelvic trauma:safety and efficacy of arterial embolization. J Vasc Interv Radiol. 2014; 25(2):215-20.
27. Kepertis C, Zavitsanakis A, Filippopoulos A, Kallergis K. Liver traumain children:Our experience. J Indian Assoc Pediatr Surg 2008;13:61-3.
28. Norrman G, Tingstedt B, Ekelund M, Andersson R. Nonoperative management of blunt liver trauma:feasible and safe also in centres with a low trauma incidence. HPB (Oxford) 2009;11:50-6.
29. Nellensteijn D, Porte RJ, van Zuuren W, ten Duis HJ, Hulscher JB. Paediatricblunt liver trauma in a Dutch level 1 trauma center. Eur J Pediatr Surg 2009;19:358-6