www.jcimcr.org

JCIMCR OPEN ACCESS Journal of Clinical Images and Medical Case Reports

ISSN 2766-7820

Case Report

Open Access, Volume 6

Back to the basics: Comprehensive management of stage III penetrating liver trauma

Akhavan Ryan, BS[1]; Erdman Dan[1]; Young Jaso[2]; Saed Khaled[2]; Lozada Jose[3]

[1]St. George's University School of Medicine, USA.

[2]Larkin Community Hospital, USA.

[3]Delray Medical center, USA.

***Corresponding Author: Akhavan Ryan**

St. George's University School of Medicine, USA.

Email: rakhavan@sgu.edu

Received: Jun 19, 2025

Accepted: Jul 16, 2025

Published: Jul 23, 2025

Archived: www.jcimcr.org

DOI: www.doi.org/10.52768/2766-7820/3699

Abstract

Stage 3 liver trauma (S3PLT), characterized by parenchymal injury as well as possible vessel involvement, provides a unique challenge in trauma management. Our paper discusses the case of a 59-year-old undercover police officer who suffered a stab wound to the right upper abdomen, resulting in S3PLT. We analyzed the current understanding, diagnostic approaches, and management strategies for patients with S3PLT. We discuss the various stages of liver trauma, as well as a multidisciplinary approach involving surgical intervention, interventional radiology and intensive care. Imaging studies, including ultrasonography as well as CT angiography, demonstrated an approximate 6 cm laceration in segment IVb of the left lobe, resulting in a large subcapsular hematoma involving approximately 60% of the liver. Recent advancements in hemostatic agents and surgical approaches, as well as implications of liver-specific trauma protocols, are discussed. Our team provides a framework regarding various modalities of diagnosing and treating S3PLT, ranging from undergoing coil embolization to solely imaging studies, including abdominal ultrasound and CT scans.

Keywords: Liver trauma; Penetrating; Stab wound; Stage III; Case report.

Introduction

Abdominal trauma can have a myriad of etiologies and implications that dictate diagnosis and treatment. Depending on the area of the abdomen affected, there are a variety of steps to work up patients and dictate the proper next steps in management. The two most common forms of abdominal trauma are penetrating trauma and blunt trauma. Penetrating trauma most often refers to injuries to the peritoneum, including gunshot wounds and stabbings, while blunt trauma refers to high impact injuries, such as motor vehicle collisions [1]. Studies show that blunt abdominal traumas are more common than penetrating abdominal traumas, accounting for 70-80% of abdominal trauma injuries [2]. However, penetrating traumas usually require immediate surgical laparotomies, as vital injuries to the peritoneum and associated organs, including the liver and spleen, can put patients at increased risk of mortality.

Depending on the type of abdominal trauma, different measures are taken in diagnosis and treatment. If a patient presents with hemodynamic instability, including hypotension and tachycardia from significant bleeding, patients are immediately sent for surgical laparotomy due to imminent risk of mortality. This is also the case if patients present with signs of peritonitis,

including abdominal rigidity or severe tenderness to palpation. However, if patients present hemodynamically stable, immediate surgery is not required [3]. A Focused Assessment for Sonography and Trauma (FAST) exam can be completed, which can identify bleeding in the abdominal cavity or peritoneal sac, possibly indicating the presence of retroperitoneal fluid. If the FAST exam is positive, patients are usually rushed into surgery [4]. If the FAST exam is negative, a CT scan of the abdomen and pelvis can be conducted to rule out any injuries to vital organs, including the liver or spleen. This has become a highly used imaging technique for injuries to these organs [4].

The liver and spleen are the two most common organs impacted during abdominal trauma injuries [1]. Penetrating abdominal traumas usually injure the lower lobe of the liver, while blunt abdominal traumas usually injure the posterior lobe of the liver [5]. In assessing blunt hepatic trauma, patients do not always require surgical intervention. As mentioned above, patients without severe bleeding or signs of hemodynamic instability may simply be managed with observation, serial CT scans, and laboratory evaluations, including a complete blood count or basic metabolic panel [4]. While surgery is indicated in hemodynamically unstable patients and in those with peritonitis, it is also indicated to prevent bile leakage and in removal of necrotic tissue that can cause persistent damage to other organs [6].

Another qualifying method of treatment for hepatic trauma injuries is the use of hepatic arterial or venous embolization. These methods work by preventing persistent hemorrhage in the face of hepatic trauma injuries when nonoperative management does not sufficiently stop the bleeding with the use of coils or gels [7]. A contrast blush, which indicates pooling of fluid around an injured organ, is also a primary indication for angiographic embolization to further control hemorrhage [8]. While the liver has increased blood flow through the arterial and portal venous system, the persistent disruption of vascular structures through trauma can lead to difficulties maintaining the viability of the liver and surrounding tissues, leading to necrosis and hemodynamic instability [9]. Indications for conducting hepatic arterial vs. portal venous embolization are relative to the damaged vascular supply, and both types of embolization can lead to a myriad of complications, including hepatic necrosis, hepatic ischemia, bile leak, and even acute respiratory distress syndrome in some cases [10]. However, studies have shown that patients with blunt hepatic trauma with severe hepatic injuries up to grade III or IV have improved outcomes following angiographic embolization in comparison to those who do not undergo angiographic embolization [11].

Deciding on operative management has become a mainstay discussion in the medical field. Factors including method of injury, vital signs, and past medical history of the patient all play a vital role in designating the proper method of care for such patients. We hope our case report provides information and guidance on how to diagnose and manage persons with traumatic hepatic injuries, and on the imperative next steps in management to prevent further bleeding and hemodynamic collapse. By looking at how our patient presented and at their medical history, in addition to the literature pertaining to guidelines in management, we hope to provide a more updated approach to treatment of such injuries in the medical field and beyond.

Case report

A 59-year-old male presented to the trauma bay as a trauma alert. The patient is an off-duty police officer that was involved in an altercation at a nearby parking lot. The perpetrator produced a knife on-site and the retired police officer received several large lacerations. One laceration was to the right forearm and hand, and another was to the right chest wall (Figure 1). Initially, the patient had moderate blood loss from the upper extremity injury. At the altercation site, a primary survey was initiated. A tourniquet was placed by the police department on-site prior to Emergency Medical Services' (EMS) arrival. EMS placed a second tourniquet on the site and provided bulky dressing and compressive dressing. IV access was started and oxygen was administered intravenously. Occlusive dressing was placed on the chest wall wound and the patient was transported to the trauma center.

Figure 1: Penetrating trauma to right chest wall.

Airway was patent, and the patient was speaking freely with no acute distress. The patient was breathing, with equal bilateral air entry and with visible chest rise and no paradoxical segments and no crepitus or tenderness on palpation. There was a lower chest/upper abdomen wound 3 cm in length, but without a visible open sucking chest wound. There was no active bleeding. The wound was covered with dressing. Circulation yielded blood pressure and a heart rate within normal limits. Right upper extremity had an external source of active bleeding and was packed by the EMS. Disability yielded a glasgow coma scale (GCS) of 15, with the patient moving all 4 extremities spontaneously and with no focal neurological motor and sensory deficit. Exposure yielded no long bone deformity and showed a stable pelvis. Abdominal exposure yielded no obvious injuries and was nontender to palpation. Secondary survey was subsequently initiated by the trauma team consisting of a trauma surgical attending, trauma surgical resident, and trauma nurses. The patient has a past medical history of high cholesterol and hypertension. 16-point review of systems were insignificant, with the exception of lacerations to the chest wall and right hand. Initial physical exam (PE) is provided in Figure 2. PE was positive for diaphoresis, decreased breath sounds on the right, a 3 cm laceration to the chest wall just superior to the costal margin and right anterior axillary line. The patient was cooperative and had appropriate mood and affect and no inten-

tions of suicide or homicide. Vital signs are as charted in Figure 3. After the patient was stabilized, it was decided by the trauma team that the patient would be transferred to radiology for an urgent CT angiography.

Exam:

General: Alert, mild distress. Well nourished and well developed
Skin: Warm, profoundly diaphoretic intact. No Rash.
Head: Normocephalic, atraumatic
Eye: Extraocular movements are intact. PERRL vision unchanged.
Neck: Trachea midline, neck is supple with full range of motion
ENT: oral mucosa moist, no oral dental injury noted
Respiratory: Respirations are non-labored, Symmetrical chest wall expansion. LCTA but with decreased breath sounds on the right
Heart: Rate normal. Rhythm Regular.
Chest wall: 5 cm laceration to the chest wall just superior to the costal margin right anterior axillary line. Occlusive dressing applied prehospital
Gastrointestinal: Non distended. Soft nontender
Musculoskeletal: Normal ROM. No Deformity. Non-Tender to Palp. Distal NVI
Right upper extremity: Deep laceration starting in the distal forearm across the wrist crease into the palm of the hand into the deep palmar space. There is some vascular oozing with the release of the tourniquet. Decreased cap refill distally
Neurological: No New focal neurological deficit observed. A/O x 3. Muscle Strength Normal. CN 2-12 grossly intact.
Psychiatric: Cooperative, appropriate mood & affect. No SI/HI

Figure 2: Initial physical exam.

Vital Signs: Last Charted:
Temperature Oral 37 degC (08/27 17:18)
Heart Rate 74 bpm (08/27 17:18)
Respiratory Rate 15 breaths/min (08/27 17:18)
Systolic BP 141 mmHg (H) (08/27 17:18)
Diastolic BP 82 mmHg (08/27 17:18)
SpO2/Pulse Oximetry 98 % (08/27 17:18)

Figure 3: Initial vital signs.

The results of the CT angiography (CTA) (Figure 4) demonstrated:

1. Approximate 6 cm laceration segment IVb left lobe of liver. Large subcapsular hematoma involving approximately 60% of the liver. Findings are consistent with grade 3 injury. Trace pneumoperitoneum as well as subcutaneous emphysema in right upper abdomen near the laceration. No foreign body.

2. Moderate hemorrhage is seen around the spleen without evidence of splenic injury.

3. Soft tissue laceration in palmar aspect of the right wrist. No evidence of acute arterial injury.

4. No evidence of acute traumatic injury to the chest.

Following the results of the CTA, it was agreed that the plan would include the patient being admitted to the trauma intensive care unit (TICU). Interventional radiology would be consulted for possible arterial/venous embolization of the liver. The patient remained on NPO with maintenance IV fluids, pain control, antiemetics, and GI prophylaxis. Hematocrit and hemoglobin levels would be monitored every 6 hours. Additional management included oxygen therapy and bowel regimen, as well as getting case management involved.

Following an interventional radiology consultation, it was decided that a visceral angiogram with coil embolization of the middle hepatic artery via right common femoral artery would be indicated (Figure 5). Before the procedure was performed, the indications, alternate options, and possible complications were explained to the patient and written consent was obtained. The patient was brought to the angiography suite and placed supine on the angiographic table. No conscious sedation was administered during this procedure. A radiology nurse monitored the patient's vital signs throughout the procedure. Both groins were prepped and draped in the usual sterile fashion, creating a maximum sterile barrier. Appropriate hand hygiene was performed before the procedure.

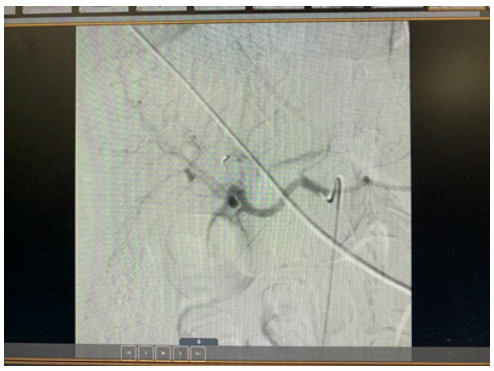

Figure 4: Angiogram of Middle hepatic artery angiogram showed the active extravasation.

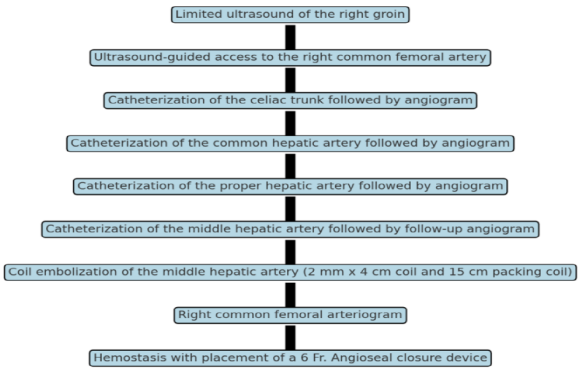

Figure 5: Embolization procedural steps.

A limited ultrasound right groin was performed. After successfully identifying a patent right common femoral artery, real time ultrasound guidance was used to puncture the right common femoral artery, using an aseptic technique. A permanent recording was created for the patient's record. After a series of exchanges, a 5 french vascular sheath connected to a continuous drip of heparinized saline was placed into the artery. Using a selective omniside winder (SOS) catheter, the celiac trunk was catheterized. Angiogram was performed. Next, a 2.8 french progreat microcatheter was advanced into the common hepatic artery over a fathom wire. An angiogram was performed. The combination was advanced into the proper hepatic artery followed by angiogram. Next, the middle hepatic artery was catheterized and an angiogram was performed. Coil embolization of the middle hepatic artery was performed, however the coil did not deploy entirely and had to be removed in entirety. After regaining access into the middle hepatic artery, coil embolization was performed using a 2 mm x 4 cm coil and 15 cm packing coil. Repeat angiograms from the common hepatic artery and celiac trunk were performed (Figure 6). The catheter was then removed over a wire. A sheath angiogram of the right common femoral artery was performed. The sheath was removed and hemostasis was obtained with deployment of a 6 french. angioseal device. The patient tolerated the procedure well and was transferred from the procedure room in stable condition. Unchanged distal pulses were noted after the procedure.

Limited ultrasound of the right groin showed a pulsatile right common femoral artery distally and a patent and compressible common femoral vein. Angiogram from the celiac trunk showed patent common hepatic, left gastric, and splenic arteries. Angiograms from the common and proper hepatic arteries showed a patent gastroduodenal artery, left hepatic artery, middle hepatic artery, and right hepatic arteries. Pooling of contrast was seen over the region of the trifurcation, raising concern for active extravasation. Middle hepatic artery angiogram showed the active extravasation which was seen previously. Post-coil embolization angiograms showed no flow through the coil pack and resolution of the previously seen extravasation. Angiogram from the right groin sheath showed appropriate access of the right common femoral artery above the bifurcation and at the level of the femoral head.

Discussion

Stage III penetrating liver trauma, as seen in this case, is a high-risk injury characterized by significant parenchymal damage and vascular involvement. Effective management requires a multidisciplinary approach involving rapid diagnosis, prompt resuscitation, and precise therapeutic interventions. This discussion aims to highlight key aspects of the clinical presentation, diagnostic tools, management strategies, and outcomes for such injuries.

Clinical presentation and diagnostic challenges

The patient's clinical presentation, including hemodynamic stability and localized right chest and upper abdomen injuries, highlights the importance of thorough initial assessment in trauma cases. While this patient's vital signs remained stable, the presence of a chest wall laceration and possible abdominal injury necessitated a focused and systematic evaluation. The FAST exam, often used as a first-line diagnostic tool, can provide critical information regarding hemoperitoneum but its sensitivity for solid organ injuries, such as liver lacerations, is limited [12]. In contrast, computed tomography angiography (CTA) offers superior detection of vascular injuries, hematomas, and active extravasation, guiding both injury classification and treatment strategy [13]. This case underscores the importance of CT angiography (CTA) in identifying the extent of organ and vascular damage, as demonstrated by the findings of a 6 cm liver laceration, subcapsular hematoma, and active hemorrhage. The detailed imaging facilitated an accurate classification of the injury as Stage III and guided the subsequent treatment plan toward an interventional approach.

Management strategies

The primary goals of managing penetrating liver trauma are to control hemorrhage, preserve hepatic function, and prevent complications [14]. Nonoperative management (NOM) has become increasingly common for stable patients with hepatic injuries; however, this patient's active bleeding and imaging findings would require intervention to address the extent of the patients liver trauma [15]. The use of visceral angiography and coil embolization exemplifies a targeted and minimally invasive method to control hepatic hemorrhage. Minimally invasive procedures have proven particularly efficacious and effective for grade III or higher hepatic injuries involving arterial extravasation,[16] as observed in this case. The careful use of embolization materials, such as coils, allowed for successful hemostasis without significant compromise to surrounding vascular structures. This aligns with existing literature, which demonstrates improved outcomes for patients undergoing angiographic embolization for severe hepatic trauma. The selection of embolization materials (e.g., coils, gelfoam, or liquid embolic agents) depends on the specific vascular involvement. Studies have demonstrated improved survival and reduced transfusion needs in penetrating liver injuries managed with embolization [17].

Hemostatic agents play a role in initial stabilization of patients with visible bleeding and less profuse internal hemorrhaging. The three most commonly used hemostatic agents can be used to address liver lacerations. However many are delivered parenterally; due to their imprecise administration they are often used to manage more moderate internal bleeding. Hemostatic agents have been proven to be efficacious and have a higher degree of clinical utility in specific use cases. Practitioners can decrease door to treatment time and mitigate risks associated with the implementation if they are aware of their utility [18].

1. Fibrin sealants (e.g., Tisseel, Evicel)

o Mechanism: Mimics the final step of the coagulation cascade by providing fibrinogen and thrombin, leading to clot formation [18].

o Use: Applied topically to the liver surface or within deep lacerations to promote clot stabilization

Contraindications:

o Hypersensitivity to human plasma-derived proteins (risk of anaphylaxis).

o Disseminated intravascular coagulation (DIC) – Can worsen thrombosis.

o Active infection – Can promote microbial growth at the application site.

Negative effects:

o Thrombosis risk: If used intravenously, it can cause thromboembolic events.

o Allergic reactions: Anaphylaxis, urticaria, fever (rare but serious).

o Poor efficacy in active arterial bleeding – Works best for oozing venous bleeding rather than high-pressure bleeding.

Indications:

o Effective for oozing or moderate bleeding when surgical suturing is difficult.

2. Topical hemostatic agents (e.g., Surgicel, Gelfoam)

Mechanism:

o Surgicel (oxidized regenerated cellulose): Creates a scaffold that promotes platelet aggregation and clot formation.

o Gelfoam (gelatin sponge): Absorbs blood and swells, promoting clotting.

o Use: Often used intraoperatively for low-pressure bleeding from liver parenchyma.

o Indications: Best for capillary or venous bleeding rather than arterial bleeding.

Contraindications:

o Infected wounds – Can trap bacteria and lead to abscess formation.

o Large arterial hemorrhage – Not effective for high-pressure bleeding.

o Hypersensitivity to materials (rare).

Negative effects:

o Foreign body reaction: Can cause granuloma formation or excessive fibrosis.

o Delayed wound healing: Due to inflammatory response.

o Neurological complications: If mistakenly placed near nerves, can lead to compression.

o Reabsorption issues: Non-absorbable agents can persist, causing chronic inflammation.

3. Tranexamic Acid (TXA)

o Mechanism: Antifibrinolytic agent that inhibits plasmin activation, preventing clot breakdown.[16]

o Use: Given systemically (IV) to reduce overall blood loss in trauma patients.

o Indications: Used in massive hemorrhage or blunt liver trauma when bleeding is significant and ongoing.

Contraindications:

o Active intravascular clotting (DVT/PE, MI, stroke history) – Can worsen thrombosis.

o Renal insufficiency – Can accumulate, increasing risk of adverse effects.

o Subarachnoid hemorrhage – Risk of cerebral infarction due to clot stabilization.

Negative effects:

o Increased thrombotic risk: Higher chances of DVT/PE, especially in high-risk patients.

o Seizures: Common in high doses due to inhibition of GABA receptors.

o Hypotension: If given too rapidly via IV.

o Nausea, vomiting, diarrhea: Mild GI disturbances.

Additional interventions in liver trauma

o Suturing or Hepatorrhaphy: Used for deeper lacerations.

o Pringle maneuver: Clamping the hepatoduodenal ligament to control hemorrhage from the hepatic artery or portal vein.

o Embolization: For arterial bleeding detected on angiography.

o Packing with laparotomy pads: Temporary measure in damage control surgery.

Clinical takeaways:

o Fibrin sealants → Avoid in DIC, infection, and hypersensitivity.

o Topical hemostatic agents → Avoid in infected wounds, arterial bleeding, and high inflammatory risk areas.

o TXA → Avoid in thrombotic disorders, renal failure, and subarachnoid hemorrhage.

Multidisciplinary approach

The case highlights the critical role of a coordinated multidisciplinary team, including trauma surgeons, interventional radiologists, and intensive care specialists, in managing complex liver injuries. The patient was admitted to the trauma intensive care unit (TICU), where close monitoring of hemoglobin, hematocrit, and hemodynamic status ensured timely detection of potential complications. Pain management, gastrointestinal (GI) prophylaxis, and fluid balance maintenance were additional supportive measures that contributed to the patient's stability. These strategies align with current evidence-based guidelines for managing traumatic liver injuries in the intensive care setting [19].

Complications and risk mitigation

Although hepatic embolization is generally considered safe, it carries potential risks, including:

o Hepatic ischemia,

o Abscess formation, and

o Bile leaks [20]

In this case, the procedural success with no immediate complications underscores the importance of meticulous technique and vigilant post-procedure monitoring. Long-term follow-up is essential to identify late-onset complications, such as liver necrosis or secondary infections, which may manifest weeks to months post-intervention [21]. Studies suggest that prophylactic antibiotic therapy and early recognition of biliary complications can reduce morbidity associated with embolization-related complications [22].

Advancements in trauma care

Recent advancements in trauma care, including the development of liver-specific management protocols and the availability of advanced hemostatic agents, have significantly improved outcomes for patients with penetrating liver trauma. The use of embolization in this case reinforces its evolving role as a primary therapeutic tool in managing vascular injuries associated with hepatic trauma [23].

Future research directions and technological innovations in hepatic trauma care may include:

o Contrast-enhanced ultrasound (CEUS) for rapid, bedside assessment of hepatic injuries,

o Dual-energy CT imaging to enhance the detection and localization of vascular damage, and

o Precision hemostatic agents tailored to specific bleeding patterns [24].

These advancements are expected to enhance trauma management strategies and further improve survival rates in high-grade liver injuries [25].

Conclusion

This case demonstrates the successful management of Stage III penetrating liver trauma through a combination of diagnostic imaging, interventional radiology, and critical care. The use of CTA and subsequent coil embolization highlights the importance of precise diagnostic and therapeutic strategies in optimizing outcomes. A multidisciplinary approach and adherence to evidence-based protocols are paramount in managing such complex injuries. This case underscores the need for continued research and innovation to further refine the care of patients with penetrating liver trauma.

References

1. Naeem BK, Perveen S, Naeem N, et al. Visceral Injuries in Patients with Blunt and Penetrating Abdominal Trauma Presenting to a Tertiary Care Facility in Karachi, Pakistan. Cureus. 2018; 10(11): e3604. Published 2018 Nov 17. doi: 10.7759/cureus.3604
2. Gottlieb M. Abdominal and Flank Trauma. In: Koyfman A, Long B, eds. The Emergency Medicine Trauma Handbook. Cambridge University Press; 2019: 213-231.
3. Dalton BGA, Dehmer JJ, Gonzalez KW, Shah SR. Blunt Spleen and Liver Trauma. J Pediatr Intensive Care. 2015; 4(1): 10-15. doi: 10.1055/s-0035-1554983
4. Taghavi S, Askari R. Liver Trauma. [Updated 2023 Jul 17]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https: //www.ncbi.nlm.nih.gov/books/NBK513236/
5. UpToDate. www.uptodate.com. https: //www.uptodate.com/contents/management-of-hepatic-trauma-in-adults
6. Alanezi T, Altoijry A, Alanazi A, Aljofan Z, Altuwaijri T, Iqbal K, AlSheikh S, Molla N, Altuwaijri M, Aloraini A, et al. Management and Outcomes of Traumatic Liver Injury: A Retrospective Analysis from a Tertiary Care Center Experience. Healthcare. 2024; 12(2): 131. https: //doi.org/10.3390/healthcare12020131
7. Green CS, Bulger EM, Kwan SW. Outcomes and complications of angioembolization for hepatic trauma: A systematic review of the literature. J Trauma Acute Care Surg. 2016; 80(3): 529-537. doi: 10.1097/TA.0000000000000942
8. Ingram MC, Siddharthan RV, Morris AD, et al. Hepatic and splenic blush on computed tomography in children following blunt abdominal trauma: Is intervention necessary?. J Trauma Acute Care Surg. 2016; 81(2): 266-270. doi: 10.1097/TA.0000000000001114
9. Segalini E, Morello A, Leati G, Di Saverio S, Aseni P. Primary angioembolization in liver trauma: major hepatic necrosis as a severe complication of a minimally invasive treatment-a narrative review. Updates Surg. 2022; 74(5): 1511-1519. doi: 10.1007/s13304-022-01372-9
10. Roh S. Endovascular embolization of persistent liver injuries not responding to conservative management: a narrative review. J Trauma Inj. 2023; 36(3): 165-171.
11. Xu H, Jie L, Kejian S, et al. Selective Angiographic Embolization of Blunt Hepatic Trauma Reduces Failure Rate of Nonoperative Therapy and Incidence of Post-Traumatic Complications. Med Sci Monit. 2017; 23: 5522-5533. Published 2017 Nov 20. doi: 10.12659/msm.905115
12. Maung AA, Schuster KM, Kaplan LJ, et al. Selective nonoperative management of blunt liver injury: ten-year experience at a level I trauma center. Arch Surg. 2011; 146(5): 475-481. doi: 10.1001/archsurg.2011.65
13. Poletti PA, Kinkel K, Vermeulen B, et al. Blunt abdominal trauma: should US be used to detect both free fluid and organ injuries? Radiology. 2003; 227(1): 95-103. doi: 10.1148/radiol.2271020080
14. Tinkoff G, Esposito TJ, Reed J, et al. American Association for the Surgery of Trauma organ injury scale for liver: reassessment and revision. J Trauma Acute Care Surg. 2018; 84(3): 467-472. doi: 10.1097/TA.0000000000001765
15. Kozar RA, Moore FA, Moore EE, et al. Nonoperative management of blunt liver injury: evolution of a practice guideline. J Trauma. 2000; 49(4): 587-595.
16. doi: 10.1097/00005373-200010000-00008
17. Rowell SE, Fair KA, Barbosa RR, et al. The role of tranexamic acid in trauma. J Trauma Acute Care Surg. 2016; 81(3): 531-542. doi: 10.1097/TA.0000000000001089
18. Croce MA, Fabian TC, Patton JH, Minard G, Kudsk KA, Schurr MJ. Nonoperative management of blunt hepatic trauma is the treatment of choice for hemodynamically stable patients. Ann Surg. 1995; 221(6): 744-753.
19. doi: 10.1097/00000658-199506000-00008
20. Stensballe J, Ostrowski SR, Johansson PI. Viscoelastic guidance of hemostatic therapy in trauma: reality or utopia? Transfusion. 2016; 56(Suppl 2): S149-S155. doi: 10.1111/trf.13424
21. Ball CG, Kirkpatrick AW, Feliciano DV. The secondary abdominal compartment syndrome: not just another post-traumatic complication. Can J Surg. 2009; 52(5): 403-412. doi: 10.1503/cjs.019808
22. Melloul E, Denys A, Demartines N. Management of severe liver trauma. J Hepatol.
23. 2016; 64(6): 1215-1225. doi: 10.1016/j.jhep.2016.01.029
24. Badger SA, Barclay R, Campbell P, Mole DJ, Diamond T. Management of liver trauma.
25. World J Surg. 2009; 33(12): 2522-2537. doi: 10.1007/s00268-009-0185-8
26. Bala M, Gazalla SA, Faroja M, et al. Complications of high-grade liver injuries: management and outcomes with focus on bile leaks. Scand J Trauma Resusc Emerg Med. 2012; 20: 20. doi: 10.1186/1757-7241-20-20
27. van der Wilden GM, Velmahos GC, Emhoff TA, et al. Successful nonoperative management of the most severe blunt liver injuries: a multicenter study of the research consortium of New England centers for trauma. Arch Surg. 2012; 147(5): 423-428. doi: 10.1001/archsurg.2012.1
28. Yuan KC, Lee CH, Lee MC, et al. Contrast-enhanced ultrasound in the assessment of blunt abdominal trauma: accuracy of diagnosis compared with contrast-enhanced computed tomography. Clin Imaging. 2020; 62: 33-38. doi: 10.1016/j.clinimag.2019.11.009
29. Fang JF, Wong YC, Lin BC, Hsu YP, Chen MF. The CT risk factors for the need of operative treatment in initially hemodynamically stable patients after blunt hepatic trauma. J Trauma. 2006; 61(3): 547-553. doi: 10.1097/01.ta.0000221791.47334.50