Case Report

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# Penetrating liver injury caused by a metal fragment from a blast accident in a factory: a case report

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Penetrating abdominal injuries are rare in countries that do not allow legal possession of firearms by the public. We report a case of a 27-year-old male patient with a penetrating liver injury caused by metal fragments released in a blast accident. On the day of the accident, there was a metal explosion, and multiple fragments of the metal lodged in the patient's abdomen. The metal fragments were widely distributed over the abdomen and limited to the subcutaneous layer. A computed tomography scan showed that one metal fragment had penetrated near the right upper quadrant. First, we tried exploratory laparoscopy to accurately locate and remove the presumed metal fragment under the liver, on the side of the gallbladder, and near the duodenum. However, we could not find the metal fragment and converted the procedure to open laparotomy. The metal fragment was found to be completely lodged in segment 4, the quadrate lobe to the left of the gallbladder. To remove the fragment, a 2-cm incision was made on the liver surface where the metal fragment was found. The patient's general postoperative condition was satisfactory, with no findings of bile leakage or bleeding. In conclusion, clinicians who do not have experience with these injuries can still provide adequate treatment by selecting a treatment method based on the patient's condition as well as the velocity of trauma. The laparoscopic approach, as a less invasive procedure, may be worthwhile for treating penetrating trauma. Additionally, laparoscopic exploratory laparotomy may be considered in selected cases.

**Keywords:** Blast injuries; Hemoperitoneum; Metal fragment; Penetrating liver injury; Case reports

## INTRODUCTION

Abdominal trauma can be categorized as blunt and penetrating trauma. In blunt abdominal trauma, the liver is the most commonly damaged organ [1]. Until 30 years ago, exploratory laparotomy was performed for blunt abdominal trauma if there was a possibility of damage to the solid organs. Subsequent advances in diagnostic techniques and radiologic interventions have led to the development of nonoperative management (NOM) as an important treatment approach for blunt abdominal trauma [2]. However, penetrating abdominal trauma caused by stab and gunshot wounds still require surgical treatment, despite the developments in NOM [3,4].

Stab and gunshot wounds are the main causes of penetrating abdominal trauma in the United States and many countries worldwide. However, in Asian countries, where access to fire-

arms is not legal, clinicians lack experience in treating penetrating abdominal trauma [5–7]. In Korea, only a limited number of medical staff at trauma centers have experience in treating penetrating abdominal trauma, particularly wounds (e.g., gunshot wounds) that are caused by abdominal penetration of foreign bodies [6]. Additionally, there are limited reports in the literature describing penetration of metal fragments into the liver due to blast effects of explosions in factories; as described in this case report, such wounds are unlike typical gunshot wounds. Therefore, we present a rare case of penetrating liver injury caused by metal fragments released in an explosion accident.

This case report was approved by the Institutional Review Board of Keimyung University Dongsan Medical Center (No. DSMC 2021-10-015). Data were collected and analyzed in an ethical manner while protecting the patient's right to privacy. The requirement for informed consent was waived because this was a retrospective study conducted using medical records.

## CASE REPORT

A 27-year-old male patient was admitted to the hospital with wounds caused by multiple metal fragments that became lodged at his abdomen while pressing metals in a factory. The patient was a worker in an automobile parts factory and performed the task of pressing large pieces of metals with a high-pressure compression machine (Video S1). The patient had no notable medical and surgical history. On the day of the accident, the metal exploded and multiple fragments of the metal lodged in the patient's abdomen. He visited a local private clinic close to the factory immediately after the accident. The metal fragments were widely distributed over the abdomen and limited to the subcutaneous layer. Most of the fragments were removed at the local private clinic. However, one metal fragment near the right upper quadrant (RUQ) had penetrated the abdominal wall and entered the peritoneal cavity. This fragment could not be removed at the local clinic, and the patient was transferred to Keimyung University Dongsan Medical Center. In the emergency room, the patient was clearly conscious and complained of slight epigastric pain. Approximately 10 or more anterior abdominal penetrating wounds less than 1 cm in size were distributed throughout the abdomen (Fig. 1). All abdominal wounds except the penetrating 1-cm wound near the RUQ area were in the subcutaneous layer. Metal fragments were removed from these wounds. For local wound exploration, forceps were inserted into the penetrating wound, approximately 5 cm deep, at an oblique angle into the abdominal cavity. The skin margins of this penetrating wound were similar to those of a laceration wound from a char burn. An abdominal physical examination revealed mild pain and tenderness in the upper abdomen due to multiple wounds. However, the abdomen was soft and flat with no abdominal distention or rebound tenderness.

At the time of admission, the patient's vital signs were relatively stable, with a temperature of 36.8°C, heart rate of 88 beats/ min, blood pressure of 130/70 mmHg, respiratory rate of 20 breaths/min, and oxygen saturation of 99%. His hemoglobin level, platelet count, prothrombin time, and activated partial thromboplastin time were 14.6 g/dL, $321.0 \times 10^3$ cells/μL, 11.4 seconds, and 28.2 seconds, respectively. Arterial blood gas anal-

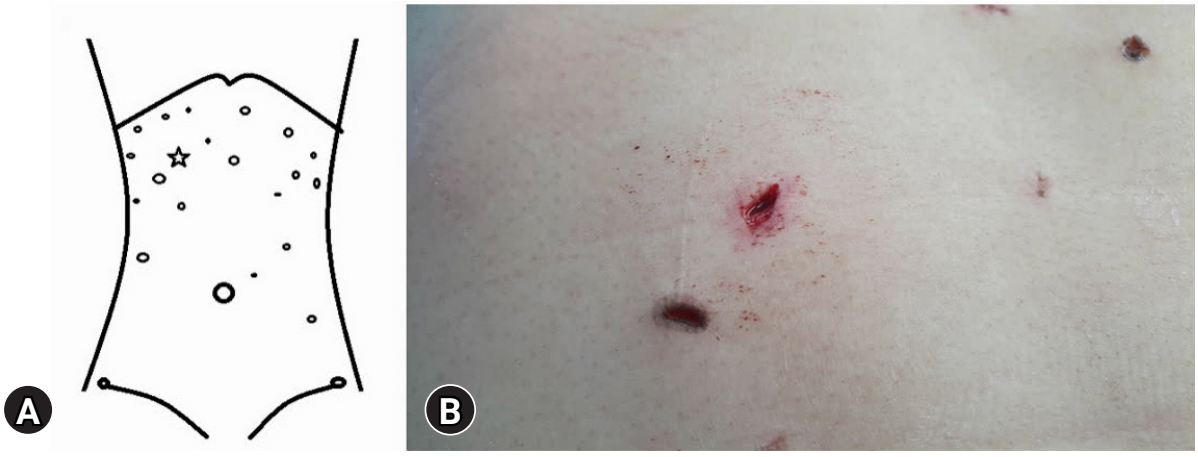


**Fig. 1.** Abdominal external wound. (A) Abdominal external penetrating wound (star) and other external wound (circles) where the foreign body had already been removed at the local clinic. (B) External penetrating wound in the right upper quadrant of the abdomen observed in the emergency room.

ysis showed a pH of 7.372, an $HCO_3^-$ level of 29.9 mmol/L, and a lactic acid level of 0.7 mmol/L. No abdominal findings were observed in other laboratory examinations. Abdominal radiography revealed an area of radiopaque material measuring 1 cm in the RUQ (Fig. 2A). Similarly, abdominal computed tomography (CT) showed a 1-cm dense radiopaque material in the subhepatic area near the lesser sac. No free intraperitoneal air was observed (Fig. 2B). Injuries to the subcutaneous layer, muscle, and peritoneum from the abdominal wall under the RUQ wound were observed. Minimal hemoperitoneum was observed; however, no active hemorrhage signs, such as contrast extravasation, were noted. According to the emergency reports of the CT scans, hollow viscus injuries could not be completely excluded. No other findings of organ damage in the abdominal cavity were observed, and chest CT showed no abnormal findings. The patient was notified of the findings, and after discussion, exploratory laparoscopy was conducted to remove the metal fragment.

The patient had stable vital signs with no active hemorrhage, and the preoperative evaluation showed no damage to the gastrointestinal tract in the peritoneal cavity. However, we decided to perform surgery to completely rule out the possibility of injury to other organs and the removal of a foreign body that could cause infection. We thought that the laparoscopic approach, as a less invasive surgical procedure, would be able to remove the foreign body and identify injuries in the surrounding organs. Thus, the treatment decision was made after full consultation with the patient. Exploratory laparoscopy was conducted to accurately locate and remove the presumed metal fragment under the liver, on the side of the gallbladder, and near the duodenum. The peritoneal cavity contained approximately 500 mL of hemoperitoneum, which was more than that observed on CT; however, no significant active bleeding was observed (Fig. 3A, B). In the laparoscopic visual field, oozing of blood was observed in the RUQ penetrating wound of the damaged peritoneum, with blood flowing down the peritoneum (Fig. 1B, 3C). An approximately 1-cm laceration on the anterior surface of the liver caused by foreign body penetration was observed; however, there was no bleeding from the surface into the abdominal cavity (Fig. 3D). Although abdominal CT images and laparoscopic exploration findings were continuously compared during surgery, the metal fragment could not be found. There are many difficulties in finding foreign bodies using laparoscopic devices without palpating them directly with one's hands. Furthermore, compared to open laparotomy, the laparoscopic approach has limitations in the range of vision. Thus, conversion to open laparotomy was performed to identify the metal fragment. After confirming that there was no damage to the entire hollow viscus and major vessels, solid organ exploration was conducted, and a hard and small mass was found between the falciform ligament and gallbladder in the quadrate lobe of the liver (Fig. 3D). Before conversion to open laparotomy, the possibility of performing C-arm fluoroscopy or intraopera-


**Fig. 2.** Preoperative image evaluation. (A) Abdominal radiography. (B) Abdominal computed tomography.


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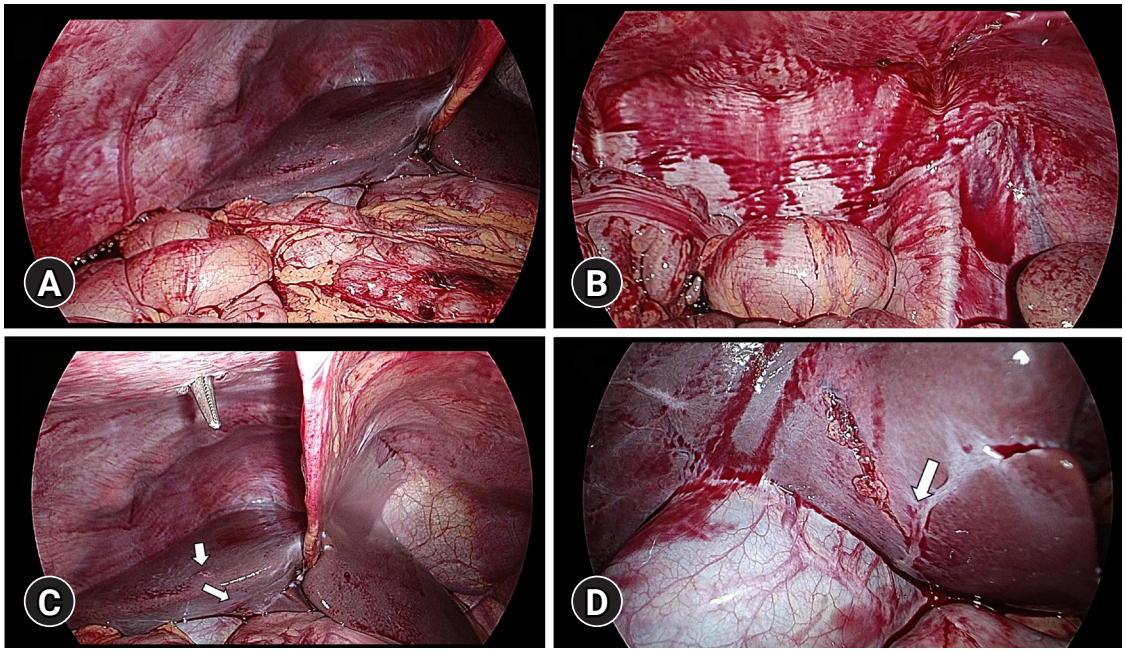


**Fig. 3.** Findings of exploratory laparoscopy. (A) Moderate amount of hemoperitoneum with a penetrating liver injury. (B) Hemoperitoneum in the pelvic cavity. (C) Depth of the penetrating wound to the intra-abdominal cavity. In the direction of the arrow, a metal fragment penetrated the surface of the liver and entered the inside. (D) The liver with a penetrating injury at the left side of the gallbladder. The arrow indicates the location of the metal fragment, although it was invisible from the outside.

tive radiography was discussed. We considered using C-arm fluoroscopy after open conversion. However, the foreign body was discovered immediately after converting to an open procedure; therefore, additional evaluation tools such as C-arm fluoroscopy were not applied. The metal fragment from the explosion accident had penetrated the abdominal wall and the liver and was completely lodged in segment 4, the quadrate lobe to the left of the gallbladder. A 2-cm incision was made on the liver surface, where the metal fragment was found, to remove the fragment (Fig. 4). The bleeding stopped after extraction and hemostasis, and primary closure of the liver was performed using black silk 3-0 sutures. A 2-cm incision was made on a lacerated wound on the anterior surface, and primary closure was performed with black braided silk 3-0 sutures after irrigation and hemostasis. No damage was observed in the gallbladder, hilum of the liver, or other solid organs. After removal of the metal fragment, intraoperative abdominal radiography was performed to confirm that the radiopaque material seen on the abdominal CT scan and radiographs before surgery was the metal fragment. To evaluate bile leakage or bleeding at the surgical site, a Jackson-Pratt silicone round channel drain was placed in the right subhepatic area, and the abdomen was closed layer-by-layer. Surgery was terminated. The patient's general postoperative

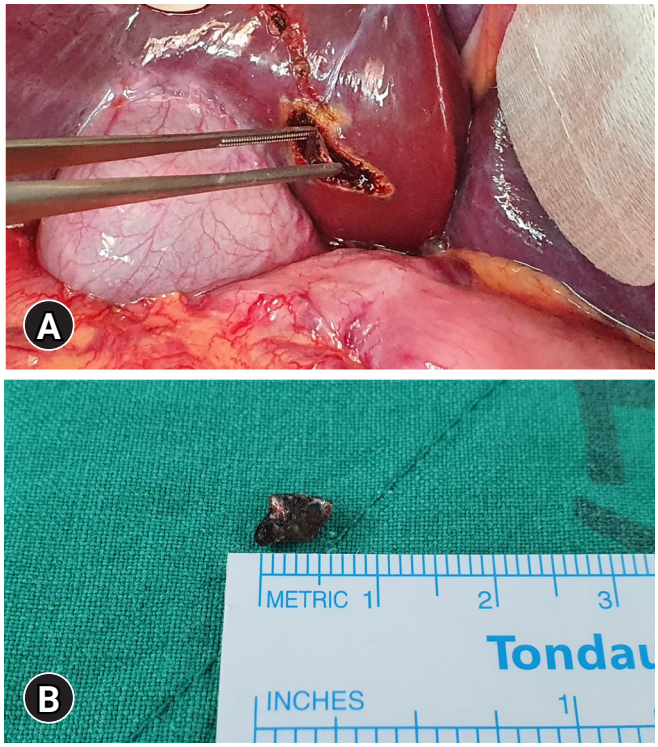


**Fig. 4.** Findings upon conversion to open laparotomy. (A) After liver incision and metal fragment extraction. (B) Metal fragment in the liver.

condition was satisfactory, with no findings of bile leakage or bleeding. His diet progressed smoothly after the operation, and he recovered without postoperative ileus. The wound with the metal fragment and the main operative wound healed without surgical site infection.

## DISCUSSION

Trauma severity may vary depending on the damaged organ. Organs that are commonly affected by explosive effects include the liver, kidney, and spleen. The severity of gunshot wounds depends on the mechanism and velocity of the accident in terms of energy strength [8,9]. The patient in our study suffered a penetrating injury caused by a metal fragment emitted with a high-velocity blast effect. The metal fragment pierced the abdominal wall and lodged in the liver. In penetrating intraperitoneal injuries, surgery is not the primary choice for the direct removal of the foreign body unless the foreign body is directly in the surgical field or view or causes life-threatening bleeding [10,11]. Moreover, active identification and removal of the foreign body can be avoided if the material causes compressive effects or is difficult to remove [12]. However, Gupta et al. [10] reported that under certain circumstances, a foreign body may cause intestinal obstruction. The purpose and principle of exploratory laparotomy should be to control life-threatening injuries such as bleeding and bowel perforation rather than to remove foreign bodies [13].

In the past, exploratory laparotomy has been considered the standard practice for penetrating abdominal trauma, such as that caused by gunshot and stab wounds. However, more recently, liver trauma has been treated according to the World Society of Emergency Surgery liver trauma management guidelines (Fig. 5) [3]. The absolute requirements for NOM are hemodynamic stability and the absence of damage to other related organs. Irrespective of the nature of the trauma injury (blunt or penetrating), NOM is recommended in hemodynamically stable patients who do not require surgery. Nonoperative treatment has been established in a selected population of patients on the basis of the condition and injury mechanisms, and many studies have evaluated the safety of NOM [14]. However, other studies have stated that NOM is not adequate for approximately 90% of high-energy gunshot wounds and other ballistic injuries [3,4]. Therefore, accurate diagnosis and follow-up of injuries are important when choosing NOM for penetrating abdominal trauma. On the basis of the operative findings, the patient in our study had stable vital signs, no abnormalities in hematological examinations, and no damage to other related organs requiring surgery. However, we had to completely eliminate the possibility of infection caused by the retained foreign body and adequately confirm the absence of injury to the surrounding organs from the penetrating injury; therefore, operative treatment was performed.

Laparoscopy, a minimally invasive technique, historically did not play a major role in the treatment of abdominal trauma, especially penetrating abdominal trauma. However, the development of laparoscopy techniques and improvements in surgeons' skills has enhanced the usefulness of exploratory laparoscopy [15]. Exploratory laparoscopy can yield satisfactory outcomes, including a shorter period of hospitalization as well as reduced wound pain and morbidity from laparoscopy. Although patients' vital signs and condition must be stable for exploratory laparoscopy, interval exploratory laparoscopy may be effective during NOM for abdominal trauma [3,13]. This technique provides important information on the progression and aggravation of the injury and can be used as a bridge strategy for subsequent laparoscopy or laparotomy after confirming other intraperitoneal organ injuries, including liver and hollow viscus injuries. Laparoscopy allows intra-abdominal observation and lavage, including an evaluation of bleeding, an assessment of the amount of bleeding, and evacuation of intraperitoneal hematoma. Although laparotomy was performed for the patient in this case, the patient had stable vital signs and no signs of peritonitis. Moreover, the metal fragment was located near the lesser sac in the peritoneal cavity, facilitating easy removal by laparoscopy. Additionally, exploration of damage to the liver, duodenum, and transverse colon around the lesser sac was feasible through laparoscopy.

Unlike in many Western countries, blunt trauma is more commonly observed than penetrating trauma in Asian countries. In particular, penetrating trauma caused by gunshot wounds has rarely been reported in these countries. In Korea, rare cases of penetrating trauma have been reported at some trauma centers [6,7]. Penetrating abdominal trauma is often life-threatening, and the injury can progress. Therefore, these injuries must be carefully managed [4]. Currently, there is no method or established protocol for follow-up evaluations during hospitalization for injuries such as penetrating abdominal trauma, and the optimal follow-up protocol remains a topic of debate. However, clinicians must always consider surgical treatment even when NOM is provided [3].

In conclusion, clinicians who do not have experience with these injuries can still provide adequate treatment by selecting a treatment method based on the patient's condition as well as the


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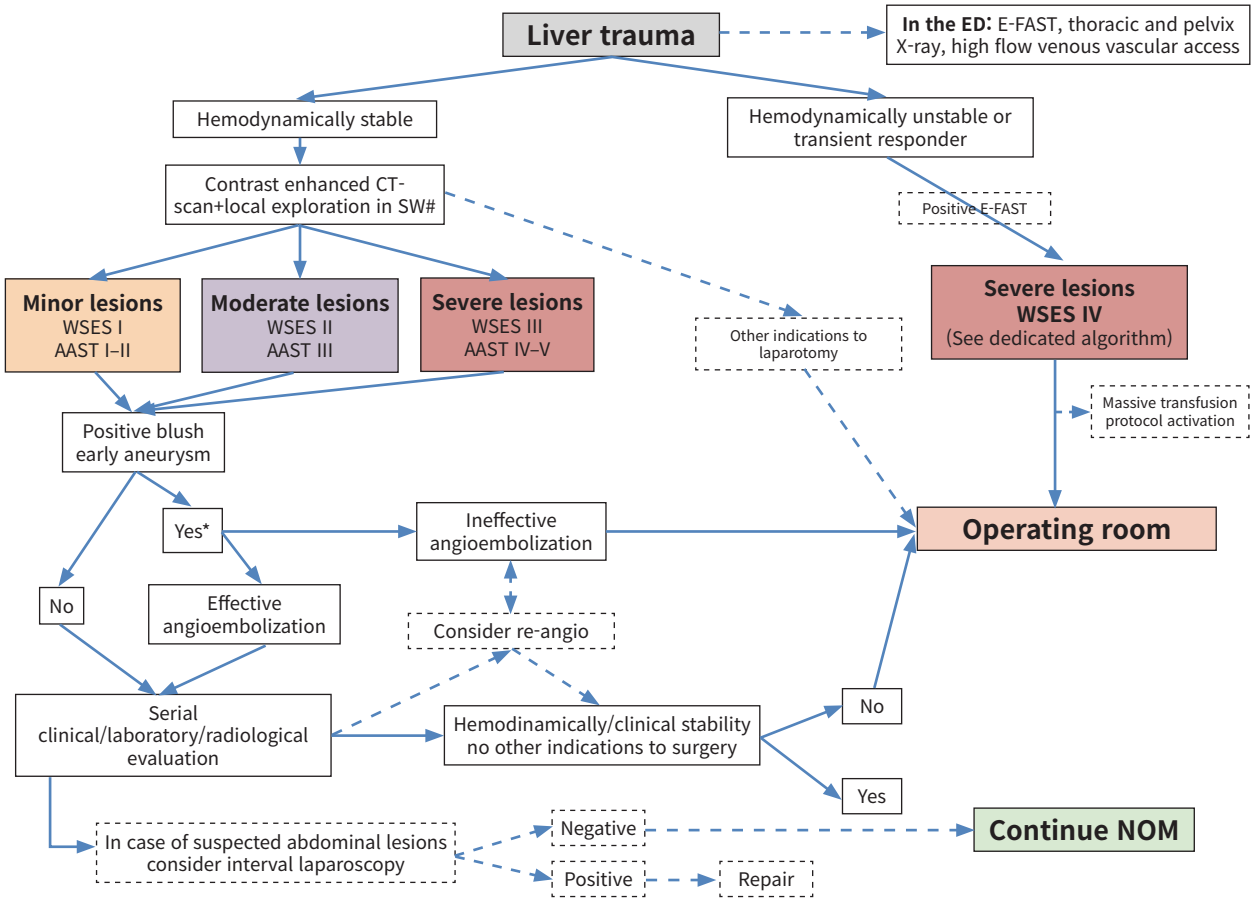
| Grade | Injury type | Injury description |
|---|---|---|
| I | Hematoma | Subcapsular <10% surface |
| | Laceration | Capsular tear <1 cm parenchymal depth |
| II | Haematoma | Subcapsular 10%–50% surface area; intraparenchymal, <10 cm diameter |
| | Laceration | 1–3 cm parenchymal depth, <10 cm in length |
| III | Hematoma | Subcapsular >50% surface area or expanding, ruptured subcapsular or parenchymal haematoma. Intraparenchymal haematoma >10 cm |
| | Laceration | >3 cm parenchymal depth |
| IV | Laceration | Parenchymal disruption 25%–75% of hepatic lobe |
| V | Laceration | Parenchymal disruption involving >75% of hepatic lobe |
| | Vascular | Juxtavenous hepatic injuries i.e retrohepatic vena cava/central major hepatic veins |
| VI | Vascular | Hepatic avulsion |

A

Advance one grade for multiple injuries up to grade III.
AAST liver injury scale (1994 revision).

| | WSES grade | AAST | Hemodynamic |
|---|---|---|---|
| Minor | I | I–II | Stable |
| Moderate | II | III | Stable |
| Severe | III | IV–V | Stable |
| | IV | I–IV | Unstable |

B




C

**Fig. 5.** Traumatic liver injury, classification, and treatment. (A) American Association for the Surgery of Trauma (AAST) liver trauma classification. (B) World Society of Emergency Surgery (WSES) liver trauma classification. (C) WSES liver trauma algorithm. Asterisk indicates angioembolization should be always considered for adults, only in selected patients and in selected centers for pediatrics. Adapted from Coccolini et al. [3], according to the creative commons license. ED, emergency department; E-FAST, extended focused assessment with sonography in trauma; CT, computed tomography; SW, stab wound; NOM, nonoperative management.

mechanism and velocity of trauma. The laparoscopic approach, as a less invasive procedure, may be worthwhile for treating penetrating trauma. Additionally, laparoscopic exploratory laparotomy may be considered in selected cases.

## SUPPLEMENTARY MATERIALS

**Video S1.** Scene of the patient's metal-casting work.
Supplementary materials are available from: https://doi.org/10.20408/jti.2021.0085.

## NOTES

### Ethical statements

The case report was approved by the Institutional Review Board of Keimyung University Dongsan Medical Center (No. DSMC 2021-10-015). Data were collected and analyzed in an ethical manner while protecting the patient's right to privacy. The requirement for informed consent was waived because this was a retrospective study conducted using medical records.

### Conflicts of interest

The authors have no conflicts of interest to declare.

### Funding

None.

### Author contributions

Conceptualization: all authors; Data curation: CP; Methodology: CP; Project administration: CP; Visualization: CP; Writing– original draft: all authors; Writing–review & editing: all authors.
All authors read and approved the final manuscript.

## REFERENCES

1. Pallett JR, Sutherland E, Glucksman E, Tunnicliff M, Keep JW. A cross-sectional study of knife injuries at a London major trauma centre. Ann R Coll Surg Engl 2014;96:23–6.
2. 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;7:49–54.
3. Coccolini F, Coimbra R, Ordonez C, et al. Liver trauma: WSES 2020 guidelines. World J Emerg Surg 2020;15:24.
4. Starling SV, de Azevedo CI, Santana AV, Rodrigues Bde L, Drumond DA. Isolated liver gunshot injuries: nonoperative management is feasible? Rev Col Bras Cir 2015;42:238–43.
5. Singh N, Hardcastle TC. Selective non operative management of gunshot wounds to the abdomen: a collective review. Int Emerg Nurs 2015;23:22–31.
6. Hwang K, Jung K, Kwon J, et al. Distribution of trauma deaths in a province of Korea: is "trimodal" distribution relevant today? Yonsei Med J 2020;61:229–34.
7. Nagata I, Abe T, Uchida M, Saitoh D, Tamiya N. Ten-year in-hospital mortality trends for patients with trauma in Japan: a multicentre observational study. BMJ Open 2018;8:e018635.
8. Santucci RA, Chang YJ. Ballistics for physicians: myths about wound ballistics and gunshot injuries. J Urol 2004;171:1408–14.
9. Oehmichen M, Meissner C, Konig HG. Brain injury after gunshot wounding: morphometric analysis of cell destruction caused by temporary cavitation. J Neurotrauma 2000;17:155–62.
10. Gupta AK, Edwards B, Vega JA. The tumbling bullet: subacute intestinal obstruction due to a retained bullet. Cureus 2020;12:e9844.
11. Dandin O, Valle EJ, Pimentha G, et al. Pyogenic liver abscess after gunshot injury: 10 years' experience at a single level 1 trauma center. Ir J Med Sci 2016;185:797–804.
12. Riehl JT, Sassoon A, Connolly K, Haidukewych GJ, Koval KJ. Retained bullet removal in civilian pelvis and extremity gunshot injuries: a systematic review. Clin Orthop Relat Res 2013;471:3956–60.
13. Bain K, Meytes V, Chang GC, Timoney MF. Laparoscopy in penetrating abdominal trauma is a safe and effective alternative to laparotomy. Surg Endosc 2019;33:1618–25.
14. Coccolini F, Montori G, Catena F, et al. Liver trauma: WSES position paper. World J Emerg Surg 2015;10:39.
15. Parrado R, Notrica DM, Garcia NM, et al. Use of laparoscopy in pediatric blunt and spleen injury: an unexpectedly common procedure after cessation of bleeding. J Laparoendosc Adv Surg Tech A 2019;29:1281–4.