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Aims and Scope

The *Journal of Trauma and Injury* (J Trauma Inj, JTI) is the official publication of the Korean Society of Traumatology and an international, peer-reviewed open access journal.

This journal aims to contribute to saving lives of patients who underwent traumatic events through active communication and exchange of study information on trauma and provision of education and training on trauma. Thus, the journal publishes original basic and clinical research on trauma-associated medical fields, such as surgeries (which include general surgery, chest surgery, orthopedic surgery, neurosurgery, plastic surgery, and head and neck surgery), gynecology and ophthalmology, emergency medicine, anesthesiology, neuro-psychiatrics, rehabilitation medicine, and radiology (which include interventional radiology). Due to the special circumstances Korea is under with North Korea, JTI also publishes basic and clinical research on battlefield trauma unique in Korea and has established ties with the Armed Forces Medical Command and Armed Forces Capital Hospital. Furthermore, this journal includes all items closely associated with medicine, disaster and department of emergency, emergency medical technicians and nurses, social infrastructures and systems, and government policies and supports.

JTI was launched in June 1988 with publications in Korean and English and was eventually converted to an English-only journal. The journal publishes original articles, case reports/case series, review articles, editorials, correspondences, and other articles related to basic or clinical research on trauma commissioned by the Editorial Board.

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New horizons of Flaubert: from a barber–surgeon to a modern trauma surgeon

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Ambroise Paré (1510–1590), a French barber–surgeon, is considered to have been a pioneer in the treatment of battlefield traumatic wounds. He reintroduced ligation of arteries, which had been introduced by Celsus and Galen, instead of cauterization during amputation [1].

However, medieval trauma surgeons, including Paré, did not have the legal right to treat diseases, which was the territory of physicians. Barber–surgeons were legally permitted to treat wounds, fractures, syphilis, cataracts, and gangrene. They pulled teeth and shaved, washed, and cut hair. However, the domain of diseases belonged to physicians. The ancestors of today’s medical practitioners are not university-trained, Latin-speaking medieval pedants, but humble, apprentice-trained barber–surgeons, craftsmen, and members of guilds, who provided most of the medical personnel for hospitals and armies until the 19th century [2].

The widespread introduction of firearms during the 16th century radically altered the landscape of conventional warfare in Europe. Extensive soft tissue damage, contamination from embedded projectiles, and the need for limb amputations increased dramatically. In the 16th century, the barber’s office, as a craft guild system, controlled the training of barbers and the establishment of barber shops. In the 17th century, the craft organization provided surgeons for the Army and the Navy [3].

In 1810, a French surgeon named Achille Cléophas Flaubert, better known as father of the writer Gustave Flaubert, submitted a historical dissertation (Fig. 1) [4]. We can see his confidence in the competition between surgeons (*chirurgiens*) and physicians (*médecins*). According to his work, surgeons are at a superior or at least similar level to physicians.

One becomes a true surgeon—who shows his excellence when carrying out the maneuvers necessary to perform an operation that requires precise knowledge of anatomy, dexterity of the hand, finesse with almost every sense, and strength of spirit—only by drawing upon his precious expertise, unifying the skills and knowledge of a physiologist with those of a doctor, to consider the general temperament of the patient, the specific temperament of his or her organs, and the influence of any factor that could be related to the patient’s illness, and to seek out and apply—

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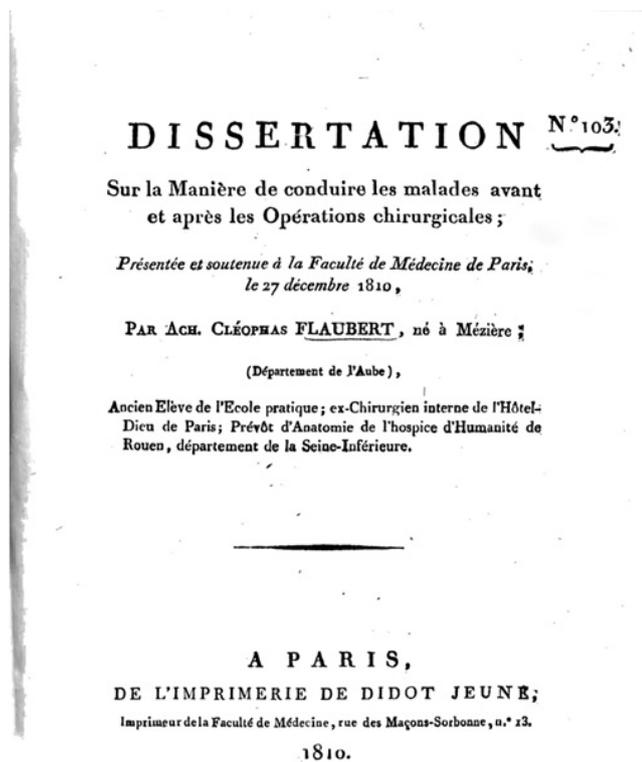


Fig. 1. Dissertation on how to manage patients before and after surgical operations (thesis defended in 1810) [4].

both before and after the operation—every possible way of achieving a successful outcome. Only then does one deserve the name of a surgeon or an operating physician; such a person unifies two sciences, medicine and surgery, that naturally go hand in hand with each other and weaken and falter as soon as they are separated. If anyone is still a partisan of the viewpoint that these two great branches of healing should be separated, let them look at the responsibilities of a surgeon and judge accordingly. The surgeon's role encompasses the periods before, during, and after the operation—in the first stage, he must be a physician; in the second stage, a surgeon; and in the third, he becomes a surgeon again. (Translated by Andrew Dombrowski, PhD).

As a trauma surgeon, I absolutely agree with the preface of Flaubert's dissertation. A good surgeon should be a good physician with some extra skills. Specifically, a good surgeon needs to learn how to operate, when to operate, and when not to operate. In addition to thorough knowledge and practical skills, a good surgeon is also expected to have common sense, which enables him or her to make sound practical judgments. In my opinion, a good trauma surgeon must first be a good surgeon, and a good surgeon must first be a good physician [5].

NOTES

Ethical statements

Not applicable.

Conflicts of interest

Kun Hwang serves on the Editorial Board of *Journal of Trauma and Injury*, but was not involved in the peer reviewer selection, evaluation, or decision process of this article. The author has no other conflicts of interest to declare.

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REFERENCES

1. Hwang K. Trauma surgery and war: a historical perspective. *J Trauma Inj* 2021;34:219–24.
2. Ackerknecht EH. From barber-surgeon to modern doctor. *Bull Hist Med* 1984;58:545–53.
3. Himmelmann L. From barber to surgeon: the process of professionalization. *Sven Med Tidskr* 2007;11:69–87.
4. Flaubert AC. How to lead patients before and after surgical operations [dissertation]. Paris: University of Paris; 1810.
5. Hwang K. A plastic surgeon should be a good physician first. *J Craniofac Surg* 2019;30:629.

Successful management of a common carotid artery injury using a Pruitt-F3 Carotid Shunt: a case report

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Penetrating neck injuries are a surgical challenge. In particular, penetrating neck injuries associated with carotid artery injuries have a high mortality rate. Overt external hemorrhage is unanimously considered as an indication for surgical exploration. The authors present a case of successful surgical management for a penetrating common carotid artery injury using a Pruitt-F3 Carotid Shunt (LeMaitre Vascular Inc., Burlington, MA, USA) in a 60-year-old male patient who was transferred to the level 1 trauma center due to a metal fragment piercing his neck while working. Active pulsatile bleeding was observed from the 3-cm-long external wound on the anterior neck in zone II. Emergent neck exploration showed near-total transection of the left common carotid artery just below the carotid bifurcation. After a Pruitt-F3 Carotid Shunt was applied to the injured carotid artery as a temporary vascular shunt, artificial graft interposition was performed for the injured common carotid artery. The patient experienced cerebral infarction as a complication caused by ischemia-reperfusion of the common carotid artery but was discharged in a suitable state for rehabilitation therapy.

Keywords: Penetrating wounds; Neck injuries; Carotid artery injuries; Cerebral infarction; Case reports

INTRODUCTION

Penetrating neck injuries are a surgical challenge because of the anatomical complexity of this region. The neck contains many important communicating structures between the head and torso, including blood vessels, the aerodigestive tract, vertebrae, and the spinal cord in a small area. In particular, penetrating neck injuries associated with carotid artery injuries are known to have a high mortality rate [1–3]. With the recent advent of selective nonoperative management for penetrating neck injuries, neck exploration is not always mandatory [3–5]. However, overt external hemorrhage is unanimously considered to be an indication for surgical exploration. Here, we present a case of successful sur-

gical management for a penetrating common carotid artery (CCA) injury caused by a metal fragment using a Pruitt-F3 Carotid Shunt (LeMaitre Vascular Inc., Burlington, MA, USA) in a 60-year-old male patient.

This study was approved by the Institutional Review Board of the Gachon University Gil Medical Center, Gachon University College of Medicine, Incheon, Korea (No. GDIRB 2022-142). The patient provided informed consent for publication of the research details and clinical images.

CASE REPORT

A 60-year-old male patient was transferred to the regional trauma

ma center of Gachon University Gil Medical Center due to a metal fragment piercing his neck while working. Active pulsatile bleeding was observed from a 3-cm-long external wound on the anterior neck (zone II). Endotracheal intubation was performed immediately with manual compression using the second finger. The initial vital signs were a blood pressure of 81/59 mmHg, a heart rate of 51 beats/min, a respiratory rate of 26 breaths/min, and a temperature of 35.6°C. The initial SpO₂ was 96%. His mental status was semicomatose.

A decision was made to perform emergent neck exploration. An oblique skin incision was made along the left sternocleidomastoid muscle. Neck exploration showed near-total transection of the left CCA just below the carotid bifurcation. The left internal jugular vein was also transected. A Pruitt-F3 Carotid Shunt was applied immediately to the injured carotid artery as a temporary vascular shunt (Figs. 1, 2). A proximal and distal occlusion balloon (blue and white) were inserted into the CCA and internal carotid artery (ICA), respectively. After applying the Pruitt-F3 Carotid Shunt as a temporary vascular shunt, each end of the transected arteries was trimmed. After trimming each end, interposition of a 3-cm-long polytetrafluoroethylene graft (8-mm diameter) was performed because the remaining ends were too short for re-anastomosis (Fig. 3). The transected internal jugular vein was ligated. A metal fragment (1.5 × 0.5 × 0.5 cm) was identified and removed from the neck (Fig. 4). Computed tomography (CT) angiography for the brain and neck was performed 1

day after the operation (Fig. 5A). The repaired carotid artery was patent (Fig. 5A). There were no abnormal findings of the brain parenchyma on CT (Fig. 5B). However, an acute infarction with diffusion restriction in the left middle-cerebral artery territory and right frontal lobe was identified on brain diffusion magnetic resonance imaging that was performed at 3 days postoperatively (Fig. 6). Aspirin and mannitol were administered for the cerebral infarction thereafter. The patient was transferred to the Department of Neurology for management of the cerebral infarction. The Korean National Institute of Health Stroke Scale (NIHSS) score was 23 points at this time. He was discharged to another hospital for rehabilitation on the 15th postoperative day, with an improved NIHSS score (13 points).

DISCUSSION

The treatment of penetrating neck injuries has changed from

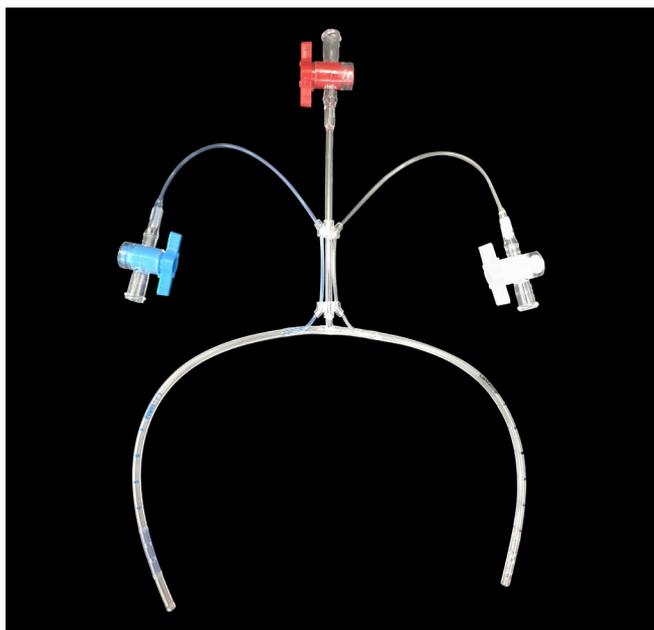


Fig. 1. A Pruitt-F3 Carotid Shunt (LeMaitre Vascular Inc., Burlington, MA, USA).

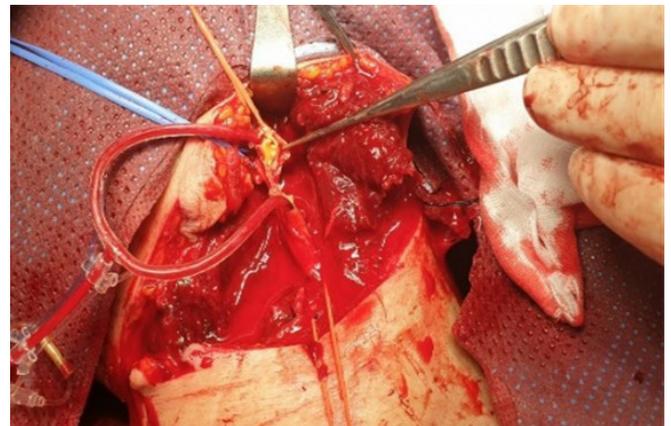


Fig. 2. A Pruitt-F3 Carotid Shunt (LeMaitre Vascular Inc., Burlington, MA, USA) was applied to the injured carotid artery.

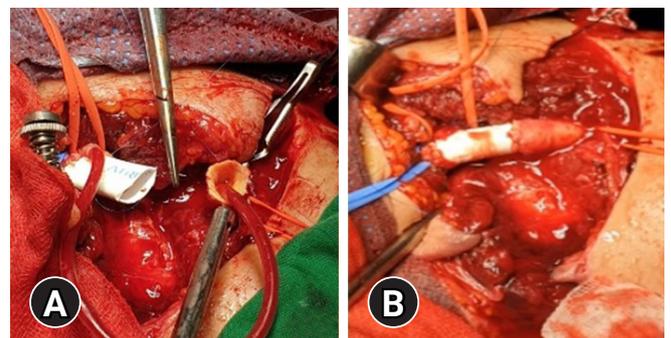


Fig. 3. Graft interposition under a carotid shunt. (A) Application of a Pruitt-F3 Carotid Shunt (LeMaitre Vascular Inc., Burlington, MA, USA) to the transected common carotid artery. (B) Polytetrafluoroethylene graft interposition was performed.



Fig. 4. A metal fragment removed from the wound.

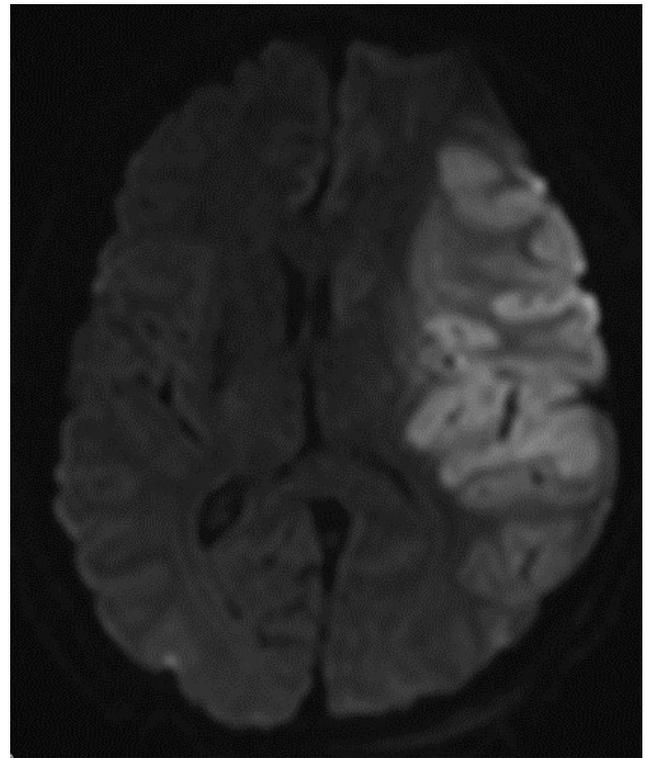


Fig. 6. Brain magnetic resonance imaging 3 days after operation. An acute infarction with diffusion restriction in the left middle-cerebral artery territory and right frontal lobe appears on brain diffusion magnetic resonance imaging performed on postoperative day 3.

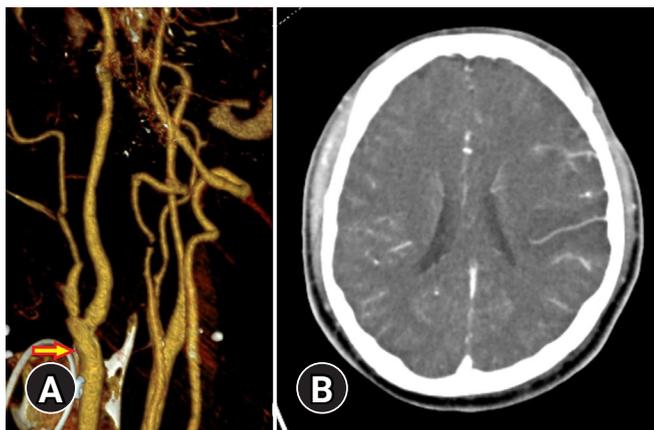


Fig. 5. Brain computed tomography angiography one day after operation. (A) Repaired left common carotid artery (arrow). (B) There are no abnormal findings of the brain parenchyma on the computed tomography scan.

mandatory neck exploration to selective nonoperative management [3–5] due to advances in diagnostic modalities. This approach prevents unnecessary complications accompanying man-

datory neck exploration [3–5]. Emergent neck exploration is indicated if there are overt symptoms or signs, including airway compromise, massive subcutaneous emphysema, active bleeding, shock, stroke, and expanding hematoma [3–5]. This patient experienced massive external bleeding with shock, which was an indication for emergent surgery.

A penetrating injury to zone II can cause a major vascular injury in up to 50% of cases [6]. Injury of the ICA or CCA is associated with high rates of mortality and central neurologic deficits [1,7].

Previous reports described poorer outcomes for the ligation of ICA or CCA injuries than for the repair of ICA or CCA injuries [3,8–14]. Patients who underwent ligation had higher rates of mortality (22% vs.10%) and stroke (88.9% vs. 33.3%) than those who underwent repair [3]. Therefore, if possible, repair of the injured carotid artery is recommended rather than ligation [3].

More than 30 studies have analyzed the use of a temporary vascular shunt during the operation [3,15]. Nonetheless, there is still no definite indication for using a temporary vascular shunt during surgery, because most of the studies were small case series

[3]. The largest retrospective study was published by Asensio et al. [3] in 2020. Their study was conducted using 32 articles performed between 1960 and 2018 [3]. The researchers found 973 patients with penetrating ICA and CCA injuries, of whom 136 (14%) underwent ligation and were excluded from the analysis [3]. Of the remaining 837 patients, 126 (15.1%) were treated with shunts (WS) and 711 (84.9%) without shunts (WOS) [3]. They concluded that patients with penetrating ICA and CCA injuries repaired with temporary shunts had a slightly lower mortality rate (WS, 5.6% vs. WOS, 11.1%; $P=0.058$) and similar or unchanged neurological outcomes versus those repaired without shunts (neurological improvement rate: WS, 14.2% vs. WOS, 13.7%; $P=0.8$; neurological worsening rate: WS, 3.4% vs. WOS, 9.0%; $P=0.038$) [3]. Summarizing the above results, a temporary intraoperative shunt is recommended for patients requiring complex vascular anastomosis. A temporary shunt should be applied according to the situation. For a tiny injury that can be repaired simply and primarily, primary repair without a shunt is considered first. However, according to our experiences, most carotid artery injuries are accompanied by atheromatous changes of the arteries and severe dissection of the intima. We think that the high pressure of the CCA coming directly from the aorta may inflict additional damage. We usually perform segmental resection and anastomosis in a short segmental injury with clean endothelium, but this patient had a long segmental injury and dirty atheromatous endothelium. We resected extensively to see a clean and healthy endothelium and interposed the graft. Therefore, surgeons should always consider using a shunt if a procedure becomes complicated.

The Pruitt-F3 Carotid Shunt is commonly used for carotid endarterectomy. There is no consensus on which shunt is best. There are two occlusion balloons in the Pruitt-F3 Carotid Shunt, which prevent additional vascular injury with no need for a vascular clamp. Identification of backflow is possible due to the presence of the middle channel in the Pruitt-F3 Carotid Shunt. We think that this shunt is usable for most peripheral artery injuries, including those affecting the carotid and femoral arteries.

The latest and largest study supports using a temporary shunt [3]; therefore, we decided to use a temporary vascular shunt during the operation. However, in our case, the patient did not avoid cerebral infarction as a complication of carotid injury, which may have been due to the ischemic time.

In conclusion, emergent surgery is mandatory for cases of a penetrating neck injury with overt signs. Repair of the injured CCA should be considered first if it is possible. The use of a tem-

porary vascular shunt during the operation is recommended for penetrating carotid artery injuries, depending on the intraoperative circumstances.

NOTES

Ethical statements

This study was approved by the Institutional Review Board of the Gachon University Gil Medical Center, Gachon University College of Medicine, Incheon, Korea (No. GDIRB 2022-142). Informed consent for publication of the research details and clinical images was obtained from the patient.

Conflicts of interest

Min A Lee is the Associate Editor and Kang Kook Choi and Jayun Cho are Editorial Board members of *Journal of Trauma and Injury*, but were not involved in the peer reviewer selection, evaluation, or decision process of this article. The authors have no other conflicts of interest to declare.

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Conceptualization: MAL, KKC, JC, YBJ; Visualization: SME, KKC, MAL; Investigation: SME, KKC, MAL; Resources: all authors; Supervision: YBJ; Writing—original draft: KKC, JC, YBJ; Writing—review & editing: JC, YBJ, SME.

All authors read and approved the final manuscript.

REFERENCES

1. Burgess CA, Dale OT, Almeyda R, Corbridge RJ. An evidence based review of the assessment and management of penetrating neck trauma. *Clin Otolaryngol* 2012;37:44–52.
2. DeBaakey ME, Simeone FA. Battle injuries of the arteries in World War II: an analysis of 2,471 cases. *Ann Surg* 1946;123:534–79.
3. Asensio JA, Kessler JJ 2nd, Kotaru TR, Kalamchi LD, Miljkovic SS, Dabestani PJ. Penetrating internal and common carotid artery injuries shunts versus no shunts during repair effect on neurological outcomes. *Injury* 2021;52:266–73.
4. Prichayudh S, Choadrachata-anun J, Sriussadaporn S, et al. Selective management of penetrating neck injuries using "no zone" approach. *Injury* 2015;46:1720–5.
5. Teixeira F, Menegozzo CA, Netto SD, et al. Safety in selective

- surgical exploration in penetrating neck trauma. *World J Emerg Surg* 2016;11:32.
6. Bladergroen M, Brockman R, Luna G, Kohler T, Johansen K. A twelve-year survey of cervicothoracic vascular injuries. *Am J Surg* 1989;157:483–6.
 7. Fox CJ, Gillespie DL, Weber MA, et al. Delayed evaluation of combat-related penetrating neck trauma. *J Vasc Surg* 2006;44:86–93.
 8. du Toit DE, van Schalkwyk GD, Wade SA, Warren BL. Neurologic outcome after penetrating extracranial arterial trauma. *J Vasc Surg* 2003;38:257–62.
 9. Fabian TC, George SM Jr, Croce MA, Mangiante EC, Voeller GR, Kudsk KA. Carotid artery trauma: management based on mechanism of injury. *J Trauma* 1990;30:953–61.
 10. Feliciano DV. Management of penetrating injuries to carotid artery. *World J Surg* 2001;25:1028–35.
 11. Lawrence KB, Shefts LM, McDaniel JR. Wounds of common carotid arteries; report of 17 cases from World War II. *Am J Surg* 1948;76:29–37.
 12. Ledgerwood AM, Mullins RJ, Lucas CE. Primary repair vs ligation for carotid artery injuries. *Arch Surg* 1980;115:488–93.
 13. Liekweg WG Jr, Greenfield LJ. Management of penetrating carotid arterial injury. *Ann Surg* 1978;188:587–92.
 14. Reva VA, Pronchenko AA, Samokhvalov IM. Operative management of penetrating carotid artery injuries. *Eur J Vasc Endovasc Surg* 2011;42:16–20.
 15. Lee TS, Ducic Y, Gordin E, Stroman D. Management of carotid artery trauma. *Craniomaxillofac Trauma Reconstr* 2014;7:175–89.

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, 321.0×10^3 cells/ μ L, 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.

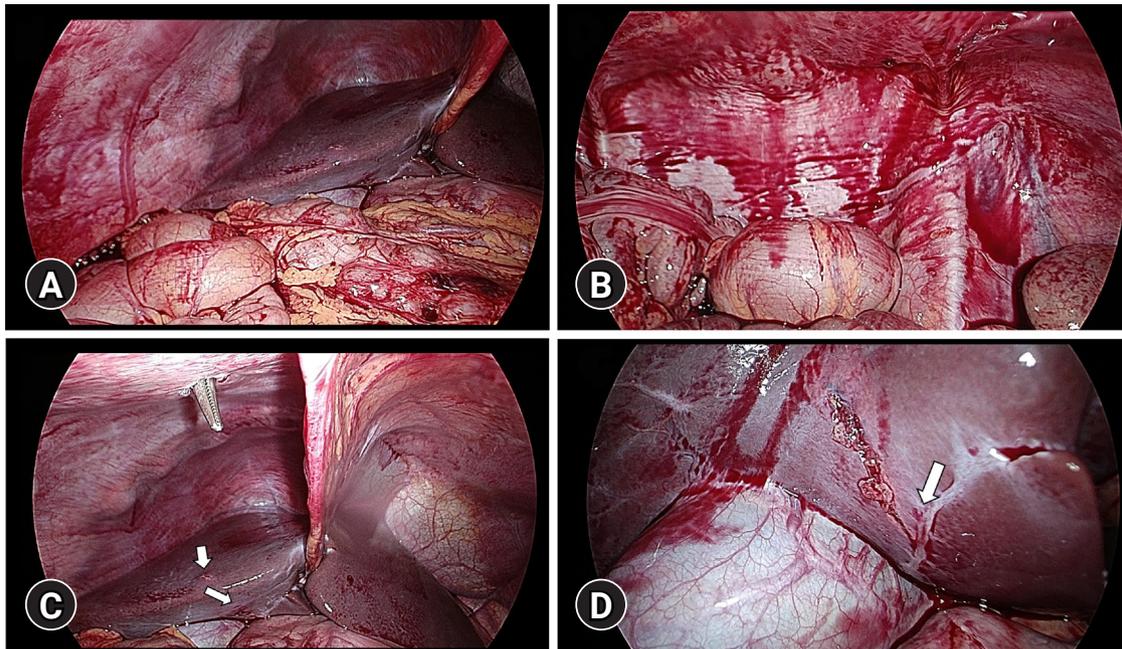


Fig. 3. Findings of exploratory laparoscopy. (A) Moderate amount of hemoperitoneum with a penetrating liver injury. (B) Hemoperitoneum in the pelvic cavity. (C) Depth of the penetrating wound to the intra-abdominal cavity. In the direction of the arrow, a metal fragment penetrated the surface of the 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

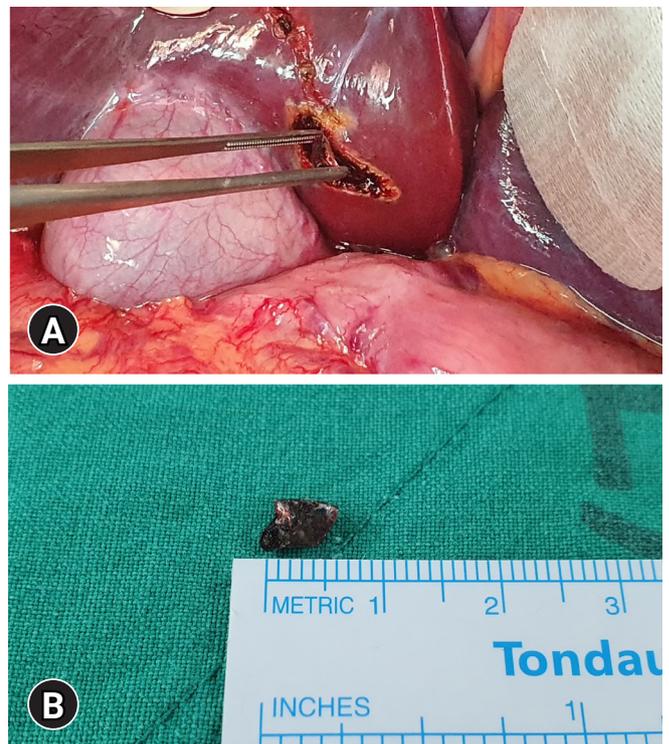


Fig. 4. Findings upon conversion to open laparotomy. (A) After liver incision and metal fragment extraction. (B) Metal fragment in the liver.

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].

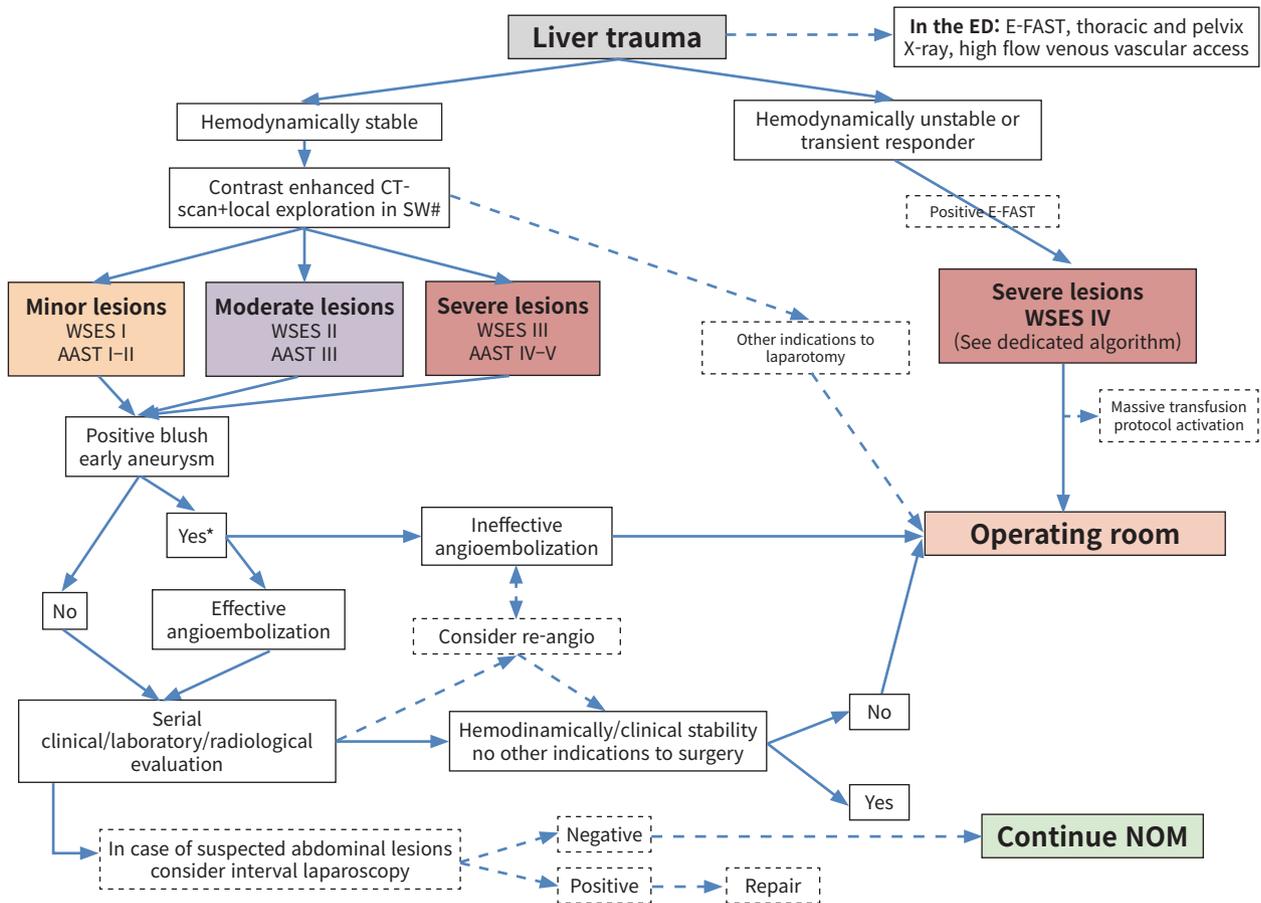
In conclusion, clinicians who do not have experience with these injuries can still provide adequate treatment by selecting a treatment method based on the patient's condition as well as the

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

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

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

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.

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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 I 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.

Acute methemoglobinemia after a blast injury: a case report

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Methemoglobin is a structurally modified form of hemoglobin incapable of binding oxygen, and elevated levels of methemoglobin cause tissue hypoxia. Occupational exposure to 2,4,6-trinitrotoluene, commonly called trinitrotoluene, causes methemoglobinemia. This case report describes a 27-year-old male sergeant who developed methemoglobinemia upon exposure to trinitrotoluene after a blast injury while welding the walls of tank shells. This is the first case of its kind in Korea. The patient had multiple burns in his abdomen and open fractures in his right leg. While his body temperature, heart rate, respiratory rate, arterial blood pressure, and chest X-ray were normal, arterial gas analysis revealed acute (methemoglobinemia concentration, 13.5%; oxygen saturation, 92.0%), probably caused by nitroglycerin exposure. Aspiration and adsorption through the skin and respiratory system were suspected to be the routes of entry. His methemoglobinemia normalized after 4 days after treating the wounds surgically, administering oxygen therapy, and performing blood transfusion.

Keywords: Methemoglobinemia; Trinitrotoluene; Blast injuries; Case reports

INTRODUCTION

Methemoglobin (MetHb) is a modified form of hemoglobin, in which Fe²⁺ (ferrous ion) is oxidized to Fe³⁺ (ferric ion). MetHb cannot bind oxygen; hence, it cannot carry oxygen. 2,4,6-trinitrotoluene (TNT) is a well-known explosive material. Methemoglobinemia induced by occupational exposure to TNT has been previously reported [1,2]. However, this is the first report describing the occurrence of methemoglobinemia in a man who was exposed to a blast injury while manipulating a TNT bomb in Korea.

This study was done in accordance with the Ethical Principles for Medical Research Involving Human Subjects outlined in the Helsinki Declaration in 1975 (revised 2013). The study was approved by the Institutional Review Board of the Armed Forces Capital Hospital (No. AFCH-21-IRB-006). The Institutional Review Board waived the requirement for written informed consent.

CASE REPORT

A previously healthy 27-year-old male sergeant was admitted be-



Fig. 1. Front surface of the right leg at admission. The patient provided written informed consent for the publication of the image.

Table 1. Arterial blood gas analysis (ABGA) on admission

ABGA	Result	Reference
pH	7.35	7.35–7.45
pCO ₂ (mmHg)	41.0	35–48
pO ₂ (mmHg)	291.0	83–108
HCO ₃ (mmol/L)	22.6	21–28
TCO ₂ (mmol/L)	23.9	20–31
O ₂ saturation (%)	99.4	94–100
Methemoglobin (%)	13.5	≤1.5

cause of a blast injury during the welding of tank shells. He had multiple burns in his abdomen and open fractures in his right leg (Fig. 1). His body temperature was 36.3°C, heart rate was 80/min, respiratory rate was 20/min, and arterial blood pressure was 159/90 mmHg. His chest X-ray was normal; however, nasal oxygen therapy was applied to deal with possible inhalation burns. His arterial blood was chocolate-colored, and the results of the arterial gas analysis are shown in Table 1. The analysis revealed acute methemoglobinemia. We could not use methylene blue for treatment since it was out of stock. Besides treating the wounds by surgery, we administered oxygen therapy and performed blood transfusion. His methemoglobinemia normalized after 4 days of hospital stay. A glucose-6-phosphate dehydrogenase (G-6-PDH) test was performed to identify the genetic cause of methemoglobinemia; the resulting (6.4 U/gHb) was within the normal range. The explosive component of the tank shells was TNT. Therefore, the patient was diagnosed with acute acquired methemoglobinemia caused by nitroglycerin exposure.

DISCUSSION

Acute methemoglobinemia may be caused by genetic factors

[3,4]. G-6-PDH deficiency and hemoglobin M disease are genetic factors that lead to methemoglobinemia, but their prevalence in the Korean population is very low [5–8]. However, the prevalence of these conditions in Korea is increasing with the increase in the number of Southeast Asian immigrants. Therefore, it should be considered in the differential diagnosis. Most cases of methemoglobinemia in Korea are due to exposure to various drugs or chemical compounds [9]. The patient in the present case did not have a family history or genetic cause other than his exposure to TNT after the blast injury. TNT is absorbed into the body via the digestive system, skin, or respiratory system [1]. In this case, it is suspected to have been absorbed via aspiration or through the skin. In the present case, the MetHb concentration was 13.5% and the ambient oxygen saturation as measured by pulse oximetry was 92.0%.

When treating patients exposed to explosives in military or industrial settings, methemoglobinemia caused by exposure to nitroglycerin should be suspected. MetHb levels should be measured early through arterial blood gas analysis. Then, the necessary tests for tissue hypoxia should be performed. Patients with methemoglobinemia often show normal pulse oxygen saturation, even when experiencing severe tissue hypoxia; this may be misinterpreted as early hypoxia [10]. Since hypoxia can persist even with intensive oxygen therapy, early ventilator care may be required. If G-6-PDH deficiency is excluded and methemoglobinemia is severe and uncorrected, methylene blue may be used as the first-line treatment if available. However, in cases of trauma, where methylene blue is unavailable, red blood cell transfusion to correct bleeding may be used for treatment for methemoglobinemia. Active correction was required in this case, with repeated MetHb follow-up tests. Regarding this case, we believed that it was important for the Armed Forces Capital Hospital to report this case of poisoning due to an explosion, since this is the first such report in Korea.

NOTES

Ethical statement

The study was approved by the Institutional Review Board of the Armed Forces Capital Hospital (No. AFCH-21-IRB-006). The Institutional Review Board waived the requirement for written informed consent.

Conflicts of interest

The authors have no conflicts of interest to declare.

Funding

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Author contributions

Conceptualization: all authors; Data curation: DK, HL; Formal analysis: all authors; Methodology: DK, HL; Project administration: all authors; Visualization: DK, HL; Writing—original draft: DK, HL; Writing—review & editing: all authors.

All authors read and approved the final manuscript.

REFERENCES

1. Hathaway JA. Subclinical effects of trinitrotoluene: a review of epidemiology studies. In: Rickert DE, editor. Toxicity of nitroaromatic compounds. Washington: Hemisphere Publishing Corporation; 1985. p. 255–74.
2. Zimmerman H. Chemical hepatic injury. In: Haddad LM, Shannon MW, Winchester JF, editors. Clinical management of poisoning and drug overdose. Philadelphia: Saunders; 1998. p. 149–74.
3. Nagel R. Disorders of hemoglobin function and stability. In: Handin RI, Lux SE, Stossel TP, editors. Blood principles and practice of hematology. Philadelphia: Lippincott; 1995. p. 1591–644.
4. Baraka AS, Ayoub CM, Kaddoum RN, Maalouli JM, Chehab IR, Hadi UM. Severe oxyhemoglobin desaturation during induction of anesthesia in a patient with congenital methemoglobinemia. *Anesthesiology* 2001;95:1296–7.
5. Saha N. Distribution of glucose-6-phosphate dehydrogenase phenotypes in five East Asian population groups. *Ann Acad Med Singap* 1984;13:494–7.
6. Blackwell RQ, Ro IH, Yen L. Low incidence of erythrocyte G-6- PD deficiency in Koreans. *Vox Sang* 1968;14:299–303.
7. Goo YK, Ji SY, Shin HI, et al. First evaluation of glucose-6-phosphate dehydrogenase (G6PD) deficiency in vivax malaria endemic regions in the Republic of Korea. *PLoS One* 2014;9:e97390.
8. Kim DS, Baek HJ, Kim BR, Yoon BA, Lee JH, Kook H. The first Korean family with hemoglobin-M Milwaukee-2 leading to hereditary methemoglobinemia. *Yonsei Med J* 2020;61:1064–7.
9. Hall AH, Kulig KW, Rumack BH. Drug- and chemical-induced methaemoglobinaemia. Clinical features and management. *Med Toxicol* 1986;1:253–60.
10. Anderson ST, Hajduczek J, Barker SJ. Benzocaine-induced methemoglobinemia in an adult: accuracy of pulse oximetry with methemoglobinemia. *Anesth Analg* 1988;67:1099–101.

Salvation of a solitary kidney in a patient with grade IV renal trauma: a case report

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There are many reasons for solitary kidney. Congenital causes include renal agenesis and dysplasia. Acquired causes include nephrectomy performed for reasons including traumatic kidney injury, disease (e.g., renal cell carcinoma), and donation for kidney transplantation. According to the European Association of Urology, the World Society of Emergency Surgery, and the American Association for the Surgery of Trauma guidelines, it is important to preserve the remaining renal function as much as possible when a solitary kidney patient has suffered a traumatic kidney injury. The authors present a case of kidney preservation in a solitary kidney patient with a traumatic grade IV renal injury through non-operative management involving superselective renal artery angioembolization.

Keywords: Renal injury; Solitary kidney; Therapeutic embolization; Case reports

INTRODUCTION

Solitary kidney, which has various causes, is a condition in which a person has a single kidney. Congenital causes include renal agenesis and renal dysplasia [1]. The major acquired cause is unilateral nephrectomy for reasons such as renal trauma, disease (e.g., renal cell carcinoma), and donation for kidney transplantation [2]. According to the annual statistics of the Korea Organ Donation Agency, the renal transplantation rate in Korea has been increasing every year and 848 kidney transplants were performed in 2020 [3]. Therefore, as the number of kidney donors increases, solitary-kidney patients are increasing.

A high-grade kidney injury is defined as an American Associ-

ation for the Surgery of Trauma (AAST) grade IV or V injury. AAST grade IV refers to parenchymal laceration extending through the renal cortex, medulla, and collecting system, and in the vascular case, it is the main renal artery or vein injury with contained hemorrhage. AAST grade V is a state of completely shattered kidney or avulsion of the renal hilum [4]. According to recent protocols, the initial management of renal trauma depends on hemodynamic status rather than the grade of the injury. For hemodynamically stable patients, conservative management, including expectant management or angioembolization, is recommended [5,6]. According to the European Association of Urology, the World Society of Emergency Surgery (WSES) and AAST, surgical management should be considered for hemodynamically unstable patients [4,7]. Unfortunately, surgical

management for unstable patients usually ends in unilateral nephrectomy [8]. For patients who have bilateral kidneys, this is not a lethal outcome, but for solitary-kidney patients, it can be a critical problem. Once nephrectomy occurs in patients who have a traumatic high-grade renal injury with solitary kidney, the patient must undergo lifelong dialysis or wait for kidney transplantation. Korea suffers from a shortage of organ donors, and long-term dialysis has the risk of various complications and mortality.

In recent studies, superselective embolization for high-grade renal trauma has been reported to show a high therapeutic success rate for hemostasis and a higher likelihood of kidney preservation than operative treatment [9,10]. Herein, we report a case of successful salvation of a solitary kidney in a patient with grade IV renal trauma by two sequential procedures of selective angioembolization and cystoscopic intra-cystic hematoma evacuation. Written informed consent for publication of the research details and clinical images was obtained from the patient.

CASE REPORT

A 52-year-old male patient who had lived with a solitary right

kidney after donating his left kidney to his father 20 years ago was transferred to a nearby hospital due to right flank pain that occurred after a motorcycle accident. An AAST grade IV right kidney injury was found on abdominal computed tomography (Fig. 1). He was transferred to Gachon University Gil Medical Center for further treatment. When he arrived, his vital signs were as follows: systolic blood pressure, 100 mmHg; diastolic blood pressure, 60 mmHg; heart rate, 73 beats/min; respiratory rate, 15 breaths/min; and body temperature, 36.0°C. His Glasgow Coma Scale score was 15. On an abdominal computed tomography scan taken at a previous hospital, the lower pole of the right kidney was shattered, accompanied by extravasation of contrast (Fig. 1). The upper pole of the right kidney was relatively preserved. After a Foley catheter was inserted, gross hematuria with blood clots was identified. Because the patient presented in a hemodynamically stable condition, we decided to preserve the remaining kidney through selective renal artery embolization. Renal angiography (Fig. 2) demonstrated a pseudoaneurysm with a diameter of 0.7 cm at the anterior superior segmental artery, a pseudoaneurysm with a diameter of 0.1 cm at the anterior inferior segmental artery, and mild irregularity of the subsegmental arteries from the posterior inferior segmental ar-

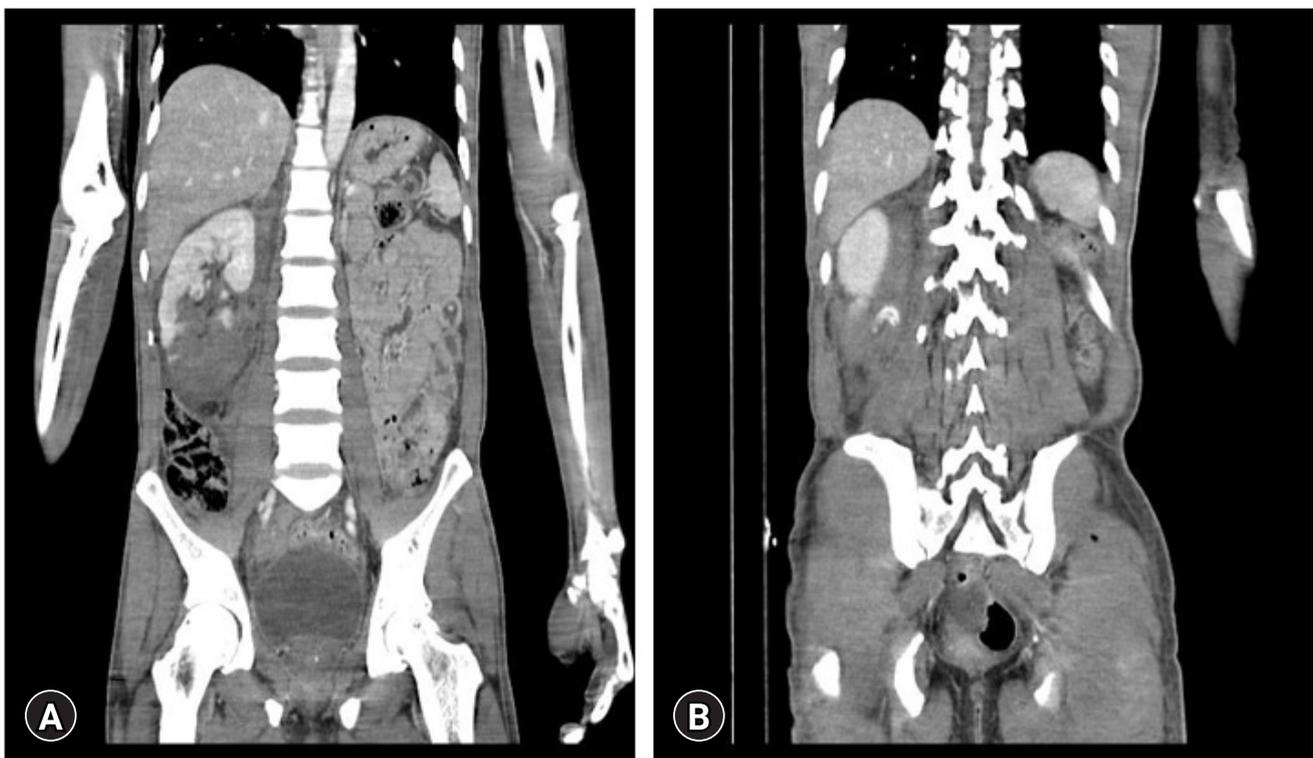


Fig. 1. Coronal view of contrast-enhanced computed tomography shows (A) a shattered low pole of the right kidney and (B) extravasation of contrast. A perirenal hematoma was also present.

tery. Embolization was performed on the pseudoaneurysm at the anterior superior segmental artery using a microcoil. Small lesions, which were suspicious for pseudoaneurysms, were observed in the anterior inferior segmental artery and the posterior inferior segmental artery, but no additional treatment was performed to preserve the viable kidney portion that would be damaged by embolization of the lesion. After embolization, the patient was transferred to the trauma intensive care unit. In the trauma intensive care unit, gross hematuria was shown. Continuous bladder irrigation (200 mL/hr) was performed. Nevertheless, the Foley catheter was frequently occluded due to clots. On the third day of hospitalization, we consulted an interventional radiologist for renal angiography to check the remnant bleeding focus. Renal angiography showed an arteriovenous fistula in the inferior pole in the right kidney (Fig. 3). Embolization with four microcoils (MicroNester with 2 mm/5 cm [Cook Medical,

Bloomington, IN, USA), Concerto with 2 mm/4 cm [Medtronic, Minneapolis, MN, USA], and two Concerto microcoils with 2 mm/8 cm [Medtronic] was done to the blood vessel. Next, we consulted a urologist for evacuation of the bladder hematoma. Ellik evacuation was done to remove the bladder hematoma. There was no definite active bleeding site in the bladder. After that, there was no definite blood clot and hematuria through the Foley catheter. Clear urine was discharged through the Foley catheter at a rate of 80 to 170 mL/hr. His initial creatinine level was 1.26 mg/dL (glomerular filtration rate by the 2021 Chronic Kidney Disease Epidemiology Collaboration equation, 69 mL/min/1.73 m²) and his creatinine levels were checked daily. The highest creatinine level in his hospital stay was 1.69 mg/dL (glomerular filtration rate, 44 mL/min/1.73 m²) on the third day of hospitalization. On the next day, the creatinine level was 1.61 mg/dL (glomerular filtration rate, 51 mL/min/1.73 m²). There was no definite pulmonary edema on a chest X-ray or pitting edema in the bilateral lower extremities. On the fifth day of hospitalization, the patient was transferred to the general ward, and on the 10th day of hospitalization, the patient was discharged uneventfully.

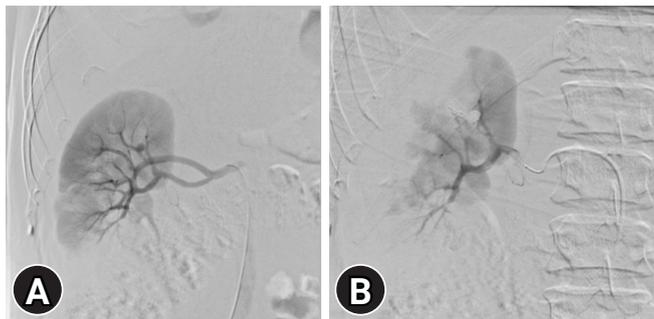


Fig. 2. Pseudoaneurysm in arteriogram of right kidney. (A) Arteriogram of the right main artery shows a pseudoaneurysm at the anterior superior segmental artery. (B) Embolization was done with a microcoil.

DISCUSSION

We saved a solitary kidney through multiple procedures in a case of high-grade renal trauma, and this experience can be helpful for the management of solitary-kidney trauma. Although the patient had a high-grade kidney injury, we could easily refer the patient to an interventional radiologist for initial therapy due to the

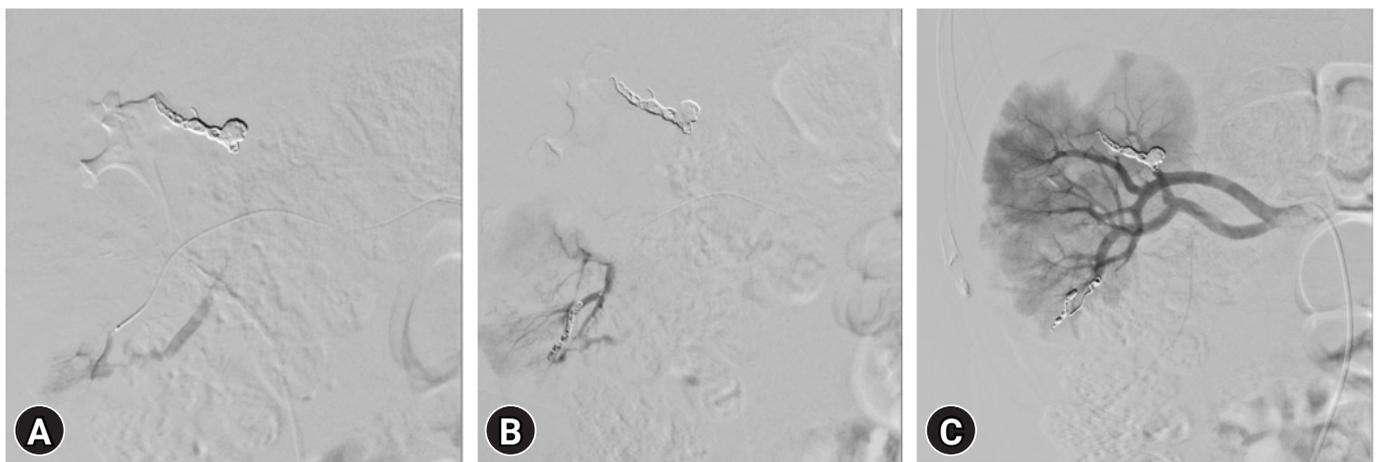


Fig. 3. Fistula in arteriogram of right kidney. (A, B) Arteriovenous fistula appears in the inferior pole of the right kidney. (C) Embolization with four microcoils (MicroNester with 2 mm/5 cm [Cook Medical, Bloomington, IN, USA], Concerto with 2 mm/4 cm [Medtronic, Minneapolis, MN, USA], and two Concerto microcoils with 2 mm/8 cm [Medtronic]) was done.

patient's hemodynamic stability. Our hospital is a regional trauma center where an interventional radiologist is available at all times. Renal artery embolization was performed in a superselective manner to preserve the remaining kidney as much as possible. After follow-up for remnant suspicious bleeding foci, embolization was additionally performed through follow-up angiography.

According to the WSES and AAST guidelines, it is recommended to consider superselective embolization in hemodynamically stable or hemodynamically stabilized solitary-kidney patients [4]. Although controversial, some recent studies have suggested that renal artery embolization be performed even in hemodynamically unstable patients [11,12]. In hemodynamically unstable solitary-kidney patients, an option could be to perform renal artery embolization accompanied with sufficient resuscitation and critical care. Even if embolization is not supported or surgery is unavoidable due to delay in embolization, renal salvation procedures such as renorrhaphy or partial nephrectomy should be tried to save the kidney as much as possible. If a salvage operation is performed, insertion of a double-J stent will be helpful for the anticipated postoperative urinary leakage.

As in the case described herein, gross hematuria may cause Foley catheter occlusion, so caution should be taken, and cystoscopic evacuation of bladder hematoma is useful. It is known that the higher the AAST renal injury grade, the lower the remnant renal function, which is also correlated with the findings of dimercaptosuccinic acid renal scans [13]. There are no guidelines on using dimercaptosuccinic acid scans to monitor residual renal function after traumatic kidney injury. Further research could provide details on the relationship between observed remnant kidney function in solitary-kidney patients through dimercaptosuccinic acid and the patient's predicted prognosis.

NOTES

Ethical statements

Written informed consent for publication of the research details and clinical images was obtained from the patient.

Conflicts of interest

Gil Jae Lee is the Editor-in-Chief, Min A Lee is the Associate Editor, and Jayun Cho and Kang Kook Choi are Editorial Board members of *Journal of Trauma and Injury* but were not involved in the peer reviewer selection, evaluation, or decision process of

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Author contributions

Conceptualization: all authors; Data curation: all authors; Formal analysis: all authors; Methodology: all authors; Project administration: all authors; Resources: all authors; Supervision: all authors; Validation: all authors; Visualization: all authors; Writing—original draft: HS, MAL, JC, GJL, BY; Writing—review & editing: KKC.

All authors read and approved the final manuscript.

REFERENCES

1. Ordon M, Welk B, McArthur E, et al. Risk of nephrectomy in previous living kidney donors. *Transplantation* 2016;100:1313–7.
2. Cochat P, Febvey O, Bacchetta J, Berard E, Cabrera N, Dubourg L. Towards adulthood with a solitary kidney. *Pediatr Nephrol* 2019;34:2311–23.
3. Korea Organ Donation Agency (KODA). Annual report [Internet]. Seoul: KODA; 2020 [cited 2021 Oct 8]. Available from: <https://www.koda1458.kr/info/transplant.do>.
4. Coccolini F, Moore EE, Kluger Y, et al. Kidney and uro-trauma: WSES-AAST guidelines. *World J Emerg Surg* 2019;14:54.
5. Liguori G, Rebez G, Larcher A, et al. The role of angioembolization in the management of blunt renal injuries: a systematic review. *BMC Urol* 2021;21:104.
6. Petrone P, Perez-Calvo J, Brathwaite C, Islam S, Joseph DK. Traumatic kidney injuries: a systematic review and meta-analysis. *Int J Surg* 2020;74:13–21.
7. Serafetinides E, Kitrey ND, Djakovic N, et al. Review of the current management of upper urinary tract injuries by the EAU Trauma Guidelines Panel. *Eur Urol* 2015;67:930–6.
8. Wessells H, Suh D, Porter JR, et al. Renal injury and operative management in the United States: results of a population-based study. *J Trauma* 2003;54:423–30.
9. van der Wilden GM, Velmahos GC, Joseph DK, et al. Successful nonoperative management of the most severe blunt renal injuries: a multicenter study of the research consortium of New England Centers for Trauma. *JAMA Surg* 2013;148:924–31.

10. Sarani B, Powell E, Taddeo J, et al. Contemporary comparison of surgical and interventional arteriography management of blunt renal injury. *J Vasc Interv Radiol* 2011;22:723–8.
11. Jairam A, King B, Berman Z, Rivera-Sanfeliz G. Non-permanent transcatheter proximal renal artery embolization for a grade 5 renal injury with delayed recanalization and preserved renal parenchymal enhancement. *J Trauma Inj* 2021; 34:198–202.
12. Desai D, Ong M, Lah K, Clouston J, Pearch B, Gianduzzo T. Outcome of angioembolization for blunt renal trauma in haemodynamically unstable patients: 10-year analysis of Queensland public hospitals. *ANZ J Surg* 2020;90:1705–9.
13. Tasian GE, Aaronson DS, McAninch JW. Evaluation of renal function after major renal injury: correlation with the American Association for the Surgery of Trauma Injury Scale. *J Urol* 2010;183:196–200.

Extraanatomic bypass grafting in a patient with an infected femoral defect caused by a rollover accident: a case report

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A 59-year-old male patient presented to the emergency department after a tractor rollover accident. His Injury Severity Score was 41 points. He had multiple pelvic bone fractures and a left common femoral artery injury with soft tissue loss. The injured arteries with skin defect were initially managed with endarterectomy and primary repair. However, the sepsis secondary to the infection from a skin defect became uncontrolled. The infected wound developed massive hemorrhage from the repaired arteries. Supportive measures were initiated to achieve hemostasis but unsuccessful. We performed an anastomosis with a prosthetic graft from the common iliac artery to the femoral artery above the knee, avoiding the wound through the lateral side of the anterior superior iliac spine. After revascularization, the patient recovered uneventfully. An extraanatomic graft reconstruction should be considered early when the autologous vein is unsuitable.

Keywords: Femoral artery; Wounds and injury; Prostheses and implants; Infections; Case reports

INTRODUCTION

Vascular injuries of the extremities can result in limb loss and functional disability [1]. Furthermore, an injury to a main artery is potentially fatal, and a soft tissue defect in a lower extremity with combined skeletal and vascular injuries can be difficult to manage. This case report describes successful reconstruction using an extraanatomic graft for recurrent bleeding in the setting of a postoperative soft tissue infection complicated with skeletal and vascular injuries.

This study was approved by the Institutional Review Board of

Dankook University Hospital (No. DKUH 2022-06-29). The requirement for informed consent was waived by the Institutional Review Board.

CASE REPORT

A 59-year-old male patient presented to the emergency department due to a tractor rollover accident. His injury severity score was 41 points based on the injury pattern: left multiple rib fractures with hemothorax, hemoperitoneum with sigmoid colon injury, multiple pelvic bone fractures with retroperitoneal hem-

orrhage, and a left common femoral artery injury with 1 × 5-cm soft tissue loss. Bluish and mottled skin was observed below the left thigh, and pulses were clearly diminished. We performed angiography with embolization, followed by emergency exploratory surgery.

Angiography revealed active bleeding of the left inferior gluteal and pudendal arteries, a cutoff sign for the left common femoral artery. After embolization, we explored the femoral artery and found a thrombus and ruptured atherosclerotic plaque. Thrombectomy through longitudinal arteriotomy (about 2 cm) with a Fogarty catheter was performed in the distal and proximal parts of the vessels, followed by endarterectomy and primary repair. After revascularization, gauze was packed onto the inguinal wound due to bleeding from a fractured acetabulum. We then performed an exploratory laparotomy. Segmental resection and anastomosis of the sigmoid colon, gauze packing, and temporary abdominal closure with a saline bag silo were done. The patient's vital signs were stable on postoperative day 1, but urine output was low. Thus, continuous renal replacement therapy was applied. We closed the abdominal and inguinal wounds 2 days later.

Exudates were observed from the inguinal wound on postadmission day 6; therefore, we irrigated the wound and applied a betadine-soaked dressing. The skin defect size increased to about 20 cm, and the repaired femoral artery was exposed (Fig. 1). In addition, he developed sustained limb edema, and his condition met the severe sepsis criteria according to the 2012 Sepsis Guidelines [2]. On postadmission day 15, the exposed vascular site was checked for integrity, and vacuum-assisted closure as primary therapy in the groin was applied after covering the exposed site with adjacent tissue.

On postadmission day 18, a massive hemorrhage occurred from the repaired femoral artery through the vacuum-assisted closure system. We repaired and reinforced the artery with a relatively fresh fasciocutaneous flap from the adjacent tissue. However, rebleeding was observed 5 days later. After bleeding control, angioplasty with a bovine patch was applied, as the previous arteriotomy edge showed friability and inflammatory changes. However, 5 days later, the sutures were reinforced with pledgets due to bleeding at the patch angioplasty site. Three days after the previous operation, recurrent bleeding resulted from inflammation and infiltration at the patch angioplasty site. Ceftriaxone as an initial empirical antibiotic was administered, a combination of piperacillin and tazobactam (Zosyn; Wyeth, Philadelphia, PA, USA) was then administered as escalation before culture, and subsequently tigecycline for multidrug-resistant *Acinetobacter baumannii*, colistin for tigecycline-resistant *A. baumannii*, and

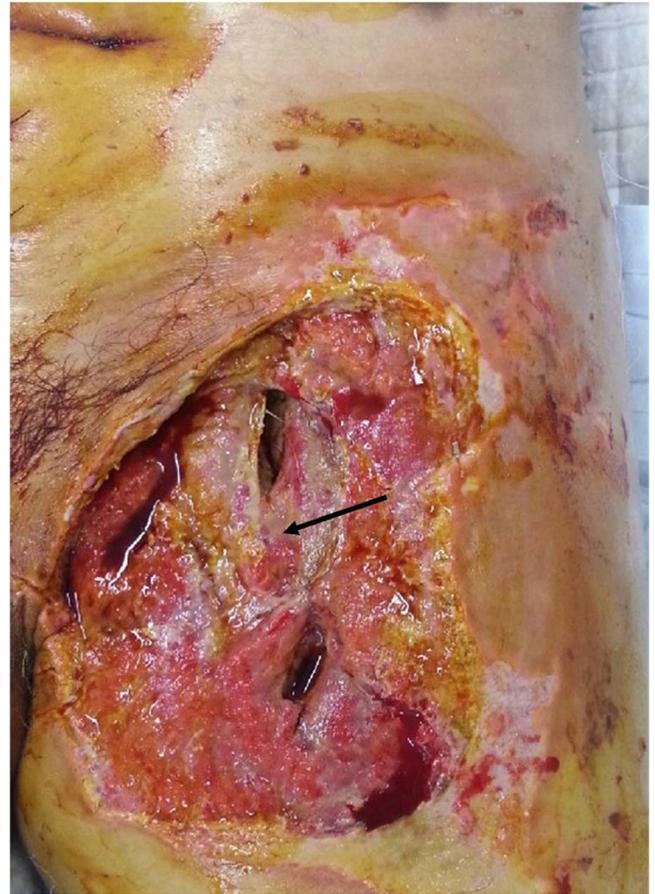


Fig. 1. Significant soft tissue defect with an uncontrolled infection. The arrow indicates the left femoral artery.

vancomycin for methicillin-resistant *Staphylococcus aureus* were consecutively given based on microbiological culture results from the wound. Despite the dressing and appropriate antibiotics based on culture sensitivity, the groin infection was uncontrolled and, according to the depth of involvement (Szilagyi classification) [3], it was defined as a grade III infection with vascular graft involvement. Therefore, we decided to perform the bypass grafting via an extraanatomic pathway.

We created an anastomosis with a ringed polytetrafluoroethylene (PTFE) graft from the common iliac artery to the femoral artery above the knee on postadmission day 36. The extraanatomic graft (like a lateral femoral bypass) was placed on the lateral side of the anterior superior iliac spine to avoid cross-contamination. The final steps of the operation included local debridement, resection of the infected artery, and oversewing the deep and superficial femoral arteries.

After revascularization, the wound was managed effectively, and the infection was controlled. Vascular computed tomography showed good graft patency (Fig. 2). A split-thickness skin



Fig. 2. Computed tomography scan of the vessel shows good patency and the graft location.

graft from the right thigh was applied on postadmission day 72, and he was discharged home on postadmission day 94 without any complaints (Fig. 3).

DISCUSSION

The optimal treatment for a patient with multiple trauma including a torso injury is difficult. In these patients, skeletal injuries complicated by vascular injuries are potentially fatal; these cases require a multidisciplinary intervention and can lead to limb loss and mortality if they are not appropriately managed. In general, after stabilization of the critical condition, the surgical procedure is based on reversing ischemia and controlling hemorrhage [4]. As a treatment for ischemia due to vascular injury, primary repair is more feasible for minor vascular injuries, whereas interposition with an autologous venous graft is more appropriate for major injuries [4].

In this case, endarterectomy and thrombectomy via arterioto-



Fig. 3. Photograph showing a split-thickness skin graft from the right thigh on posttrauma day 94.

my for reversing ischemia were performed because the injured femoral artery was grossly free and soft tissue loss was relatively small. However, despite routine antibiotic prophylaxis and using appropriate antibiotics based on culture sensitivity, severe sepsis occurred. Furthermore, reinforcement and angioplasty for hemorrhage from the repaired artery failed.

In the setting of sepsis, a prosthetic vascular graft is not commonly chosen. For patients requiring a bypass, an autologous graft is more favorable because a prosthetic graft is more susceptible to infection and thrombosis, particularly in patients with sepsis or at high risk of infection [4,5]. In addition, in cases of prosthetic infection after surgery for arterial disease, reconstruction with an autologous vein provides good potential for salvaging limbs and life [6]. Despite the risks above, in our case, a prosthetic graft was used in the setting of femoral sepsis with significant soft tissue loss because the saphenous vein had an insufficient length and diameter for graft reconstruction.

Some alternative methods exist for this condition, such as a sartorius muscle rotation flap on femoral vessels, a rifampin-soaked graft, or a cryopreserved human allograft [7–9]. Certain studies have reported that the use of a bioactive heparin-treated expanded PTFE graft could provide more favorable outcomes, with a reduced incidence of the above-mentioned

complications such as thrombosis and amputation, making it a potential alternative if an autologous saphenous vein is unavailable [10]. Vascular reconstruction by extraanatomic bypass with a ringed PTFE graft is also favorable for patients with vascular graft infection manifesting in the groin [11]. In this situation, as with inguinal-area infections, obturator bypass would be preferred [12]. Madden et al. [13] showed that lateral femoral bypass can be an alternative approach.

Extraanatomic bypass with a prosthetic vascular graft is technically challenging in the setting of sepsis, but revascularization with a synthetic graft through an extraanatomic route can be successful. Of course, an autologous vein is more favorable for bypass to avoid thrombosis and uncontrolled infection. However, if an autologous vein is unsuitable because of the patient's medical condition or the length of the vein, interpositioning an extraanatomic graft that avoids the infected surgical site can be considered early.

NOTES

Ethical statements

This study was approved by the Institutional Review Board of Dankook University Hospital (No. DKUH 2022-06-29). The requirement for informed consent was waived by the Institutional Review Board.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Author contributions

Project administration: SWC; Visualization: DSM; Writing—original draft: SWC; Writing—review & editing: all authors. All authors read and approved the final manuscript.

REFERENCES

1. Siddique MK, Bhatti AM. A two-year experience of treating vascular trauma in the extremities in a military hospital. *J Pak Med Assoc* 2013;63:327–30.
2. Dellinger RP, Levy MM, Rhodes A, et al. Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2012. *Crit Care Med* 2013;41:580–637.
3. Szilagyi DE, Smith RF, Elliott JP, Vrandečić MP. Infection in arterial reconstruction with synthetic grafts. *Ann Surg* 1972;176:321–33.
4. Akingba AG, Robinson EA, Jester AL, et al. Management of vascular trauma from dog bites. *J Vasc Surg* 2013;58:1346–52.
5. Bell CL, Ali AT, Brawley JG, et al. Arterial reconstruction of infected femoral artery pseudoaneurysms using superficial femoral-popliteal vein. *J Am Coll Surg* 2005;200:831–6.
6. Nevelsteen A, Lacroix H, Suy R. Autogenous reconstruction with the lower extremity deep veins: an alternative treatment of prosthetic infection after reconstructive surgery for aortoiliac disease. *J Vasc Surg* 1995;22:129–34.
7. Landry GJ, Carlson JR, Liem TK, Mitchell EL, Edwards JM, Moneta GL. The sartorius muscle flap: an important adjunct for complicated femoral wounds involving vascular grafts. *Am J Surg* 2009;197:655–9.
8. Oderich GS, Bower TC, Hofer J, et al. In situ rifampin-soaked grafts with omental coverage and antibiotic suppression are durable with low reinfection rates in patients with aortic graft enteric erosion or fistula. *J Vasc Surg* 2011;53:99–106.
9. Bossi M, Tozzi M, Franchin M, et al. Cryopreserved human allografts for the reconstruction of aortic and peripheral prosthetic graft infection. *Ann Vasc Dis* 2017;10:391–7.
10. Dorigo W, Di Carlo F, Troisi N, et al. Lower limb revascularization with a new bioactive prosthetic graft: early and late results. *Ann Vasc Surg* 2008;22:79–87.
11. Meyer T, Schweiger H, Lang W. Extraanatomic bypass in the treatment of prosthetic vascular graft infection manifesting in the groin. *Vasa* 1999;28:283–8.
12. Patel A, Taylor SM, Langan EM 3rd, et al. Obturator bypass: a classic approach for the treatment of contemporary groin infection. *Am Surg* 2002;68:653–8.
13. Madden NJ, Calligaro KD, Dougherty MJ, Zheng H, Troutman DA. Lateral femoral bypass for prosthetic arterial graft infections in the groin. *J Vasc Surg* 2019;69:1129–36.

A case report of field amputation: the rescue of an entrapped patient through the “doctor car” system

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In certain circumstances, invasive procedures such as creation of a surgical airway, insertion of a chest drain, intraosseous puncture, or amputation in the field are necessary. These invasive procedures can save lives. However, emergency medical service teams cannot perform such procedures according to the law in Korea. The upper arm of a 29-year-old male patient was stuck in a huge machine and the emergency medical service team could not rescue the patient. A doctor-car team was dispatched to the scene and the team performed the field amputation to extricate the patient. He was brought to the trauma center immediately and underwent formal above-elbow amputation. Here we describe a case of field amputation to rescue a patient through a “doctor car” system, along with a literature review.

Keywords: Amputation; Emergency medical services; Trauma centers; Case reports

INTRODUCTION

Prehospital care of patients who have suffered trauma is provided by emergency medical service (EMS) teams in Korea, but the procedures and the usage of medicine by EMS teams are strictly regulated by the law. Therefore, physicians could be needed on the scene in certain cases. In several studies, the presence of physician-staffed helicopters reduced both the time until contact with a physician and the transport time [1–3]. However, the use of physician-staffed helicopters is limited by the cost of operation and is affected by factors such as weather, time, and place. Physician-staffed ambulances (known as “doctor cars” in Korea) were introduced to overcome the limitations of the helicopter in Incheon, Korea. The doctor car is used only for injured patients. The medical team in a doctor car comprises a trauma surgeon, a

nurse, a paramedic, and a driver. Doctor cars are equipped with instruments for surgery (e.g., emergency thoracotomy and amputation), medications, and monitoring devices. We report a case of above-elbow amputation in the field in which a doctor car was used to rescue the patient. Written informed consent for publication of the research details and clinical images was obtained from the patient.

CASE REPORT

The arm of a 29-year-old male patient was stuck in a huge industrial machine. The EMS team that arrived at the scene found that the patient’s arm was almost completely severed above the elbow, and the remaining part of the arm was trapped between the rollers of the machine (Fig. 1). The EMS team called the regional



Fig. 1. Doctor car staffs and emergency medical service team checked the patient status.

trauma center and reported that they could not rescue the patient because the machine was too heavy to lift; moreover, they were concerned about a potential massive bleeding after rescue. The patient was alert, and his vital signs were stable; the EMS team found no arterial bleeding. Because the scene was only 17 km away from a regional trauma center and the estimated time of ground transport was approximately 30 minutes, a doctor car, rather than a helicopter, was dispatched by the trauma center to the scene. The trauma team in the car comprised a trauma surgeon, an emergency medicine resident, a trauma nurse, and a driver.

After arrival, the trauma team contacted the patient and confirmed that his vital signs were stable and that he was alert. Tramadol was administered intravenously in the noninjured arm. In the injured arm, the humerus was crushed and severed; only the part of the arm containing the triceps muscle and the brachial vessels and nerve was trapped between the rollers (Fig. 2). The trauma team explained the situation to the patient, and he agreed to undergo immediate amputation. A local anesthetic was administered, the brachial vessel and nerve were clamped and severed, and several minutes later, the part of the arm containing the triceps muscle and remaining skin was divided from the severed part of the arm by a scalpel (Fig. 2). After the procedure, the patient was extricated from the machine. No massive bleeding occurred after amputation, and the trauma team applied compression dressing. The patient was brought to the trauma center in a doctor car; his vital signs remained stable, and he was cooperative during transportation.

Upon arrival at the trauma center, the patient’s blood pressure was 198/96 mmHg, and his pulse rate was 101 beats/min. After the imaging workup, the patient was brought to the operating

room for bleeding control and debridement (Fig. 3). The skin was repaired in a second operation 2 days later. His recovery was uneventful, and he was transferred to the rehabilitation ward.

DISCUSSION

Several reports about successful field amputation and the problems present during physician involvement in rescues have been published [4]. Physicians’ discomfort with fieldwork, poor communications, hierarchy structure, media interaction, and crowd or rescue personnel control are considered problems in at-the-scene amputation [4]. Therefore, a protocol for traumatic amputation is necessary to avoid confusion. However, because of differences in medical practice and situations in different countries, establishing a universal protocol and case scenarios is difficult.

Kampen et al. [5] reported several field amputations: half of the amputations were performed by trauma surgeons, a third by emergency physicians, and the rest by paramedics or other medical professionals. In Korea, paramedics are never allowed to perform any surgical procedures. Because emergency physicians may lack surgical training, experienced trauma surgeons may be the physicians best qualified to perform field amputation in Korea. In circumstances in which airway management, anesthesia, and resuscitation are required, emergency physicians and nurses are the staff best qualified to perform those tasks. Therefore, in situations involving field amputation, the dispatch team should include a trauma surgeon, an emergency physician (or another trauma surgeon), and a trauma nurse.

In 1992, Foil et al. [6] discussed informed consent for field amputation. If the patient is conscious, the situation should be explained, and the risks, benefits, and alternatives should be de-



Fig. 2. The upper arm of the patient was entrapped between rollers and the arm was nearly amputated. Written informed consent for publication of the research details and clinical images was obtained from the patient.

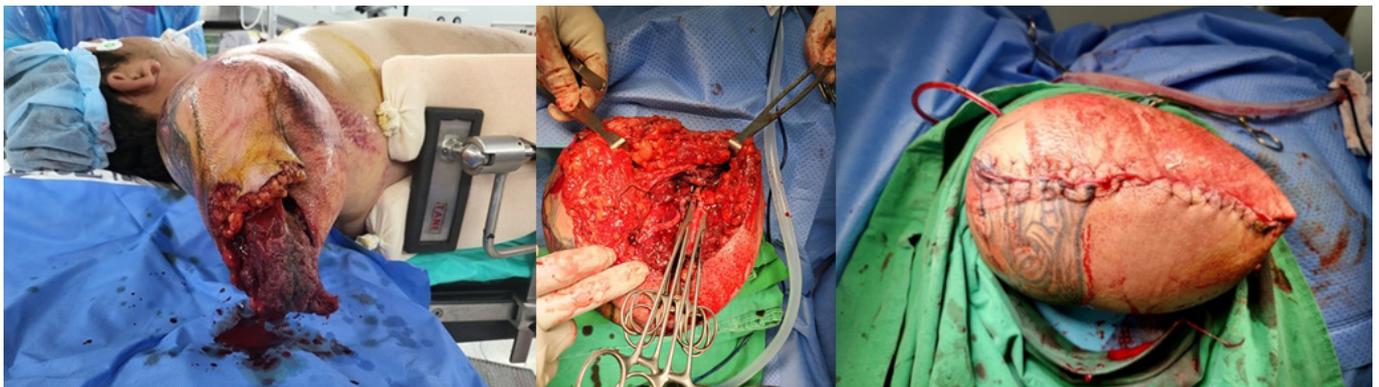


Fig. 3. The formal above-elbow amputation in the operation room. Written informed consent for publication of the research details and clinical images was obtained from the patient.

scribed; then, with the patient's consent, the amputation can be performed. If the patient is unconscious and cannot communicate, and if the patient cannot be extricated or otherwise rescued without further trauma, the procedure can be performed with the consent of two physicians. The patient in this report was conscious and immediately agreed to amputation after the trauma surgeon explained the situation; thus, no legal problem regarding the procedure arose.

In this case, equipment such as Gigli saws and bone saws were not needed, but such equipment should be available for field amputation. In addition, opiates and benzodiazepine could not be used because no appropriate protocol for bringing such medications to the field existed. Regulations for prehospital patient care and for the management of opiates should be revised so that doctor cars can be equipped with anesthetics, opiates, and even

blood products as medications in the future.

To the best of our knowledge, this is the first report of field amputation in Korea. The procedures that physicians perform at the scene of trauma can save lives. An appropriate protocol concerning trauma team members, equipment, medication, and informed consent for the procedure should be established.

NOTES

Ethical statements

Written informed consent for publication of the research details and clinical images was obtained from the patient.

Conflicts of interest

Gil Jae Lee is the Editor-in-Chief, Min A Lee is the Associate Edi-

tor, and Kang Kook Choi, Jayun Cho, Seung Hwan Lee are Editorial Board members of *Journal of Trauma and Injury*, but were not involved in the peer reviewer selection, evaluation, or decision process of this article. The authors have no other conflicts of interest to declare.

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All authors read and approved the final manuscript.

REFERENCES

1. Jung K, Huh Y, Lee JC, et al. Reduced mortality by physician-staffed HEMS dispatch for adult blunt trauma patients in Korea. *J Korean Med Sci* 2016;31:1656–61.
2. Lee JI, Lee KH, Kim OH. Comparative study on the outcome of stroke patients transferred by doctor helicopters and ground ambulances in South Korea: a retrospective controlled study. *Emerg Med Int* 2020;2020:8493289.
3. Matsumoto H, Mashiko K, Hara Y, et al. Effectiveness of a “doctor-helicopter” system in Japan. *Isr Med Assoc J* 2006; 8:8–11.
4. Sharp CF, Mangram AJ, Lorenzo M, Dunn EL. A major metropolitan “field amputation” team: a call to arms ... and legs. *J Trauma* 2009;67:1158–61.
5. Kampen KE, Krohmer JR, Jones JS, Dougherty JM, Bonness RK. In-field extremity amputation: prevalence and protocols in emergency medical services. *Prehosp Disaster Med* 1996; 11:63–6.
6. Foil MB, Cunningham PR, Hale JC, Benson NH, Treurniet S. Civilian field surgery in the rural trauma setting: a proposal for providing optimal care. *J Natl Med Assoc* 1992;84:787–9.

Portal vein embolization in intrahepatic portal vein injury after blunt trauma: a case report

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Mortality from hepatic injury has declined over the last several decades for various reasons, including nonoperative management, such as angioembolization, in more than 80% of cases. Conversely, surgical treatment is preferred in intrahepatic portal vein injury due to several reasons. Here, we report a case that treatment of blunt traumatic liver injury accompanied by intrahepatic portal vein injury through portal vein embolization. A 29-year-old female patient was transferred to our trauma center for vehicular accident injuries. Contrast-enhanced abdominal computed tomography showed a massive hemoperitoneum and liver laceration (grade IV) with contrast extravasation suspected of the right portal vein branch but no other organ injury. Since vital signs were stable, we decided to perform nonsurgical radiologic intervention. Portography showed active bleeding of the posterior branch of the right portal vein. A pseudoaneurysm in the portal vein was embolized through percutaneous transhepatic portal vein puncture. On follow-up liver dynamic computed tomography performed 2 days after embolization, the posterior branch of the right portal vein was sufficiently embolized, and no liver parenchymal necrosis was observed. The patient was discharged without any complications 2 weeks later. This report suggests portal vein embolization as a good alternative treatment method for portal vein injury in patients with stable vital signs.

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Keywords: Intrahepatic; Portal vein injury; Embolization; Case reports

INTRODUCTION

The liver is the most frequently injured abdominal organ following abdominal trauma. Fortunately, mortality from hepatic injury has declined over the past several decades for various reasons, including the evolution to the current approach of nonoperative

management of hepatic trauma in more than 80% of cases [1]. Conversely, surgical treatment is preferred in intrahepatic portal vein injury due to several reasons. This report describes the non-surgical treatment of a case involving blunt traumatic liver injury accompanied by intrahepatic portal vein injury through portal vein embolization (PVE) and establishes the characteristics of in-

trahepatic portal vein injury and indications for PVE. The patient provided informed consent for publication of the research details and clinical images.

CASE REPORT

A 29-year-old female patient with no medical history was transferred to the Trauma Center of Kyungpook National University Hospital for injuries sustained after a passenger car accident. Her initial blood pressure was 115/81 mmHg and heart rate was 112 beats/min. Hemoglobin and platelet count was 14.3 g/dL and 190,000 / μ L, respectively. Contrast-enhanced abdominal computed tomography showed a massive hemoperitoneum and liver laceration (grade IV) with contrast extravasation suspected of the right portal vein branch, but no other organ injury (Fig. 1).

Since the patient’s vital signs were stable, we decided to perform nonsurgical radiologic intervention rather than surgery.

The celiac artery angiography did not show active bleeding of the hepatic artery branch, but portography following superior mesenteric artery angiography showed a pseudoaneurysm in the posterior branch of the right portal vein (Fig. 2A). An angiography sheath was inserted through the P5 portal vein branch by percutaneous transhepatic approach to access the proximal portion rather than the injured portal vein branch, and portography showed a pseudoaneurysm at the proximal portion in posterior branch of right portal vein (Fig. 2B, C). The pseudoaneurysm was embolized using a mixture of glue (Histoacryl; B. Braun, Melsungen, Germany) and lipiodol (Lipiodol Ultra-Fluid; Guerbet, Villepinte, France). Portography performed after the procedure no longer showed active bleeding (Fig. 2D).

On follow-up liver dynamic computed tomography performed 1 month after embolization, intraabdominal hematoma was decreased, the posterior branch of the right portal vein was sufficiently embolized, and no bleeding sign or liver parenchymal ne-

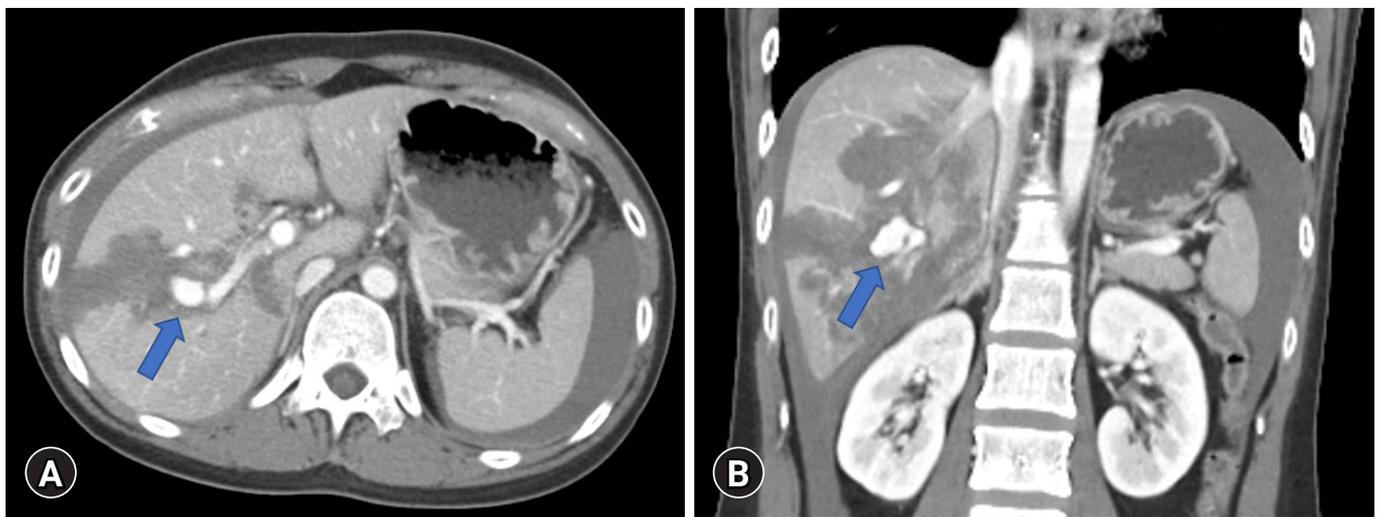


Fig. 1. Contrast-enhanced computed tomography of (A) axial and (B) coronal view, showing a massive hemoperitoneum and liver laceration (grade IV) with extravasation suspected of the right portal vein branch (arrows).



Fig. 2. Portography showed (A) active bleeding of posterior branch of right portal vein (arrow) and (B) pseudoaneurysm at proximal portion in posterior branch of right portal vein (arrow). (C) Portography performed after selection of injured portal vein branch. (D) The pseudoaneurysm was embolized and no longer showed active bleeding sign in portography (arrow).

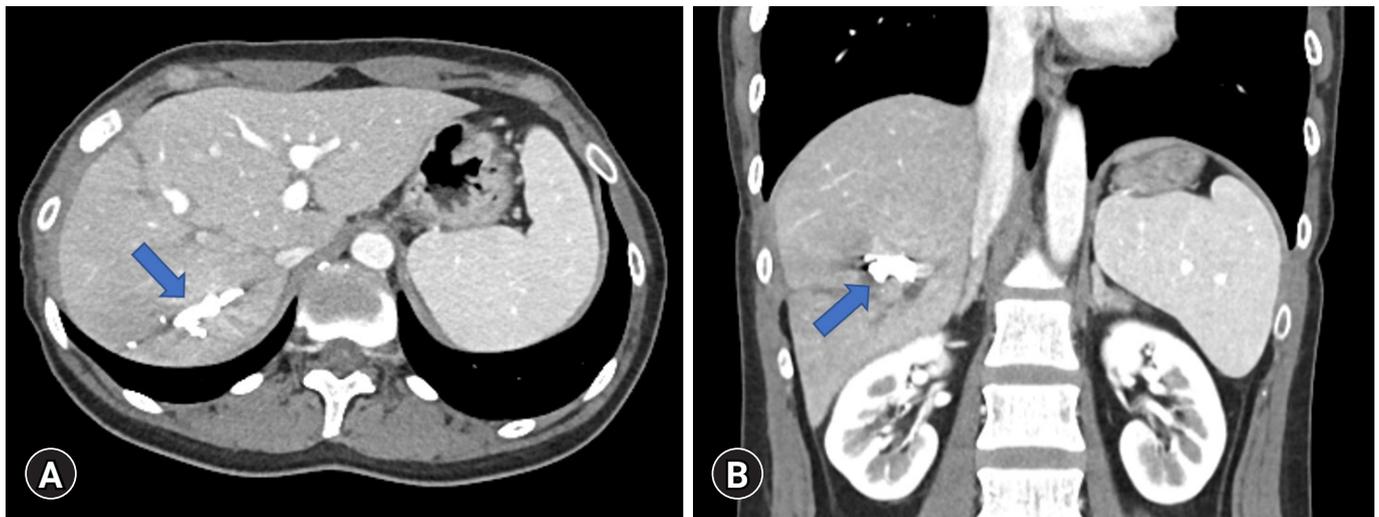


Fig. 3. Follow-up liver dynamic computed tomography of (A) axial and (B) coronal view performed 1 month after embolization. Posterior branch of the right portal vein was sufficiently embolized (arrows).

crisis was observed (Fig. 3). Additionally, the patient's aspartate aminotransferase/alanine aminotransferase were 599/550 U/L in the initial laboratory test, with the highest measurements obtained the next day at 857/802 U/L. The levels gradually decreased to 35/125 U/L after a week. The patient was discharged without any complications 2 weeks after PVE.

DISCUSSION

The liver is the most commonly injured abdominal organ following blunt abdominal trauma. However, mortality from hepatic injury has declined over the last several decades. Richardson et al. [2] proposed that the reasons for the decreased mortality from hepatic trauma over the past 25 years are improved results with gauze packing and reoperation, use of arteriography and embolization, advanced operative techniques for major hepatic injuries, and decrease in the surgical treatment of hepatic venous injuries [1,2]. Additionally, the current approach to hepatic trauma has evolved to nonoperative management in more than 80% of cases [1]. Recently, a more extensive series of angiography for control of hepatic hemorrhage has been reported with increasing success, with the identification and control of bleeding rates ranging from 68% to 87%. Therefore, angiography and embolization or stenting are considered to be very useful adjunctive techniques in stable patients and are being managed nonoperatively [3].

Hepatic arterial injury from blunt hepatic trauma is a common cause of massive hemorrhage, but significant bleeding from the portal venous system is rare because the portal venous pressure is

usually low. In addition, portal vein injuries are generally associated with severe injuries affecting adjacent organs that often require surgical treatment, such as gauze packing, vessel ligation, and venorrhaphy [4–6]. As such, angioembolization enables nonoperative management of arterial bleeding in blunt traumatic liver injury, but portal vein injury suitable to performing PVE is very rare. PVE is a preoperative treatment commonly performed to increase the volume of the remaining liver in patients undergoing major liver resection. It is a safe and effective method for inducing selective hepatic hypertrophy of the non-diseased portion of the liver and may thereby reduce morbidity and shorten hospital stays after resection [7].

In our patient, we decided to perform nonsurgical radiologic intervention because her vital signs were stable. If we decided to operate regardless, damage-control surgery, including gauze packing and reoperation, would have been performed and would have led to several postoperative complications, such as prolonged use of the mechanical ventilator, prolonged hospital stay, and even poor prognosis. Additionally, conservative treatment without intervention in this patient who with grade IV liver laceration accompanied by capsule injury, massive hemoperitoneum and active bleeding in the portal vein could worsen the condition even led to death.

According to our experience, several conditions are necessary in performing PVE in patients with intrahepatic portal vein injury. First, the most important condition is stable vital signs. Next, the patient must be cleared of any other organ injuries requiring surgery. Furthermore, unlike elective PVE, the intervention for trauma patients is urgent. An experienced radiologist must be

present for accurate identification of trauma lesions and determination of the portal vein puncture site. Anatomic variants of the portal vein are uncommon but, when present, are important to recognize because they may have profound implications for PVE [7]. Finally, the surgical team should be prepared to perform emergency surgery immediately if the procedure fails.

In summary, our report demonstrates that PVE could be a good alternative treatment for portal vein injury in patients with stable vital signs.

NOTES

Ethical statements

Informed consent for publication of the research details and clinical images was obtained from the patient.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Author contributions

Conceptualization: KHL; Project administration: SHC; Visualization: all authors; Writing—original draft: SHC; Writing—review &

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REFERENCES

1. Piper GL, Peitzman AB. Current management of hepatic trauma. *Surg Clin North Am* 2010;90:775–85.
2. David Richardson J, Franklin GA, Lukan JK, et al. Evolution in the management of hepatic trauma: a 25-year perspective. *Ann Surg* 2000;232:324–30.
3. Badger SA, Barclay R, Campbell P, Mole DJ, Diamond T. Management of liver trauma. *World J Surg* 2009;33:2522–37.
4. Sundarakumar DK, Smith CM, Lopera JE, Kogut M, Suri R. Endovascular interventions for traumatic portal venous hemorrhage complicated by portal hypertension. *World J Radiol* 2013;5:381–5.
5. Park CY, Yeom SR, Cho HM. Life-threatening traumatic rupture of an intrahepatic portal vein. *Trauma Image Proced* 2017;2:13–4.
6. Majdalany BS, Khaja MS, Sanogo ML, Saad WE. Percutaneous glue embolization for recalcitrant iatrogenic portal hemorrhage. *Diagn Interv Radiol* 2018;24:385–7.
7. Madoff DC, Hicks ME, Vauthey JN, et al. Transhepatic portal vein embolization: anatomy, indications, and technical considerations. *Radiographics* 2002;22:1063–76.

Inhalation injury after a landmine explosion: a case report

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Blast injuries are divided into four classes, and inhalation injuries are a quaternary class of blast injuries. An inhalation injury can be critical to the patient due to the possibility of related complications, such as airway obstruction resulting from upper airway edema and pneumonia. Once diagnosed, an inhalation injury should be treated with early intubation, aerosol therapy, and antibiotics as soon as possible. We should suspect this injury in circumstances involving fire and especially bomb attacks in a military setting. Antipersonnel landmines designed to damage the soldier by amputating the leg can cause blast injuries, but their power is limited to the lower extremity. However, we found an inhalation injury in a victim whose leg had been amputated by an antipersonnel landmine. As soon as we suspected an inhalation injury, we intubated the patient to preserve his airway and started acetylcysteine/heparin aerosol therapy. The patient also was treated with proper antibiotics for right lower lung pneumonia that developed as a sequela of inhalation injury. We could extubate the patient without any complications such as airway obstruction on the third day of intensive care, after which the patient was transferred to the general ward for active rehabilitation. This report presents the first known case of inhalation injury due to a landmine explosion.

Keywords: Blast injury; Inhalation injury; Military personnel; Explosive agents; Case reports

INTRODUCTION

Inhalation injuries, which can develop as a result of blast injuries, are very harmful because they cause airway obstruction, pneumonia, and acute lung injury [1]. Inhalation injuries consist of three subtypes: upper airway injuries caused by thermal heat, lower airway and lung parenchyme injuries caused by chemical irritants, and metabolic asphyxia caused by carbon monoxide and cyanide [2]. It is important for physicians to suspect inhalation injuries in cases of blast injuries; then, early

management, including intubation or aerosol therapy, to prevent airway obstruction should be performed. Herein, we would like to present the case of a patient who had been injured by an antipersonnel landmine, and we want to share how we suspected and treated the inhalation injury of this patient starting in the trauma bay with early intubation and acetylcysteine/heparin aerosol therapy.

The study was approved by the Institutional Review Board of the Armed Forces Capital Hospital (No. 2022-01-003) and was in compliance with the Declaration of Helsinki. The patient provid-

ed written informed consent for publication of the research details and clinical images.

CASE REPORT

A previously healthy 39-year-old male sergeant was transferred to the trauma bay in Armed Forces Trauma Center due to a landmine injury. He was confirmed to have an amputation at the left distal tibia joint and left thumb tip due to a landmine blast injury (Fig. 1A, B). His thigh was tightened with a tourniquet by pre-hospital medical staff. The initial arterial blood pressure was 181/112 mmHg, the heart rate was 106 beats/min, the respiratory rate was 16 breaths/min, and the body temperature was 36°C. He had multiple burn injuries, especially on the left arm, bilateral legs, and face. Bilateral sub-conjunctival hemorrhage was confirmed (Fig. 1C). His incisor was slightly sooty. The bilateral lung sounds were clear, and the initial chest X-ray was normal. The initial arterial blood gas analysis confirmed no hypoxia or hypercapnia, with a lactate level of 1.1 mmol/L. He was intubated with

video laryngoscopy for irritability and an emergent orthopedic operation was performed. Then, whole-body computed tomography was performed, and no specific injury was confirmed in the brain, chest, and abdomen. After the emergent operation was prepared, he was transferred to the operation room from the trauma bay. Because the amputated segment was not revivable and the distal tibia joint was very contaminated, the orthopedic surgeon decided to proceed with below-knee amputation and dress the amputation site and burn wound with a vacuum-assisted device. The thumb tip amputation was repaired primarily after massive irrigation and debridement. After an emergent operation, he was transferred to the intensive care unit. The day after surgery, follow-up bronchoscopy confirmed abrasions along the upper airway from the oral cavity to the upper trachea (Fig. 2), and a chest X-ray revealed increased opacity in the right lower lung field (Fig. 3). We then started heparin with acetylcysteine aerosol therapy, suspecting an inhalation burn. As *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* were confirmed in tracheal culture, levofloxacin and piperacillin/tazobactam were ad-

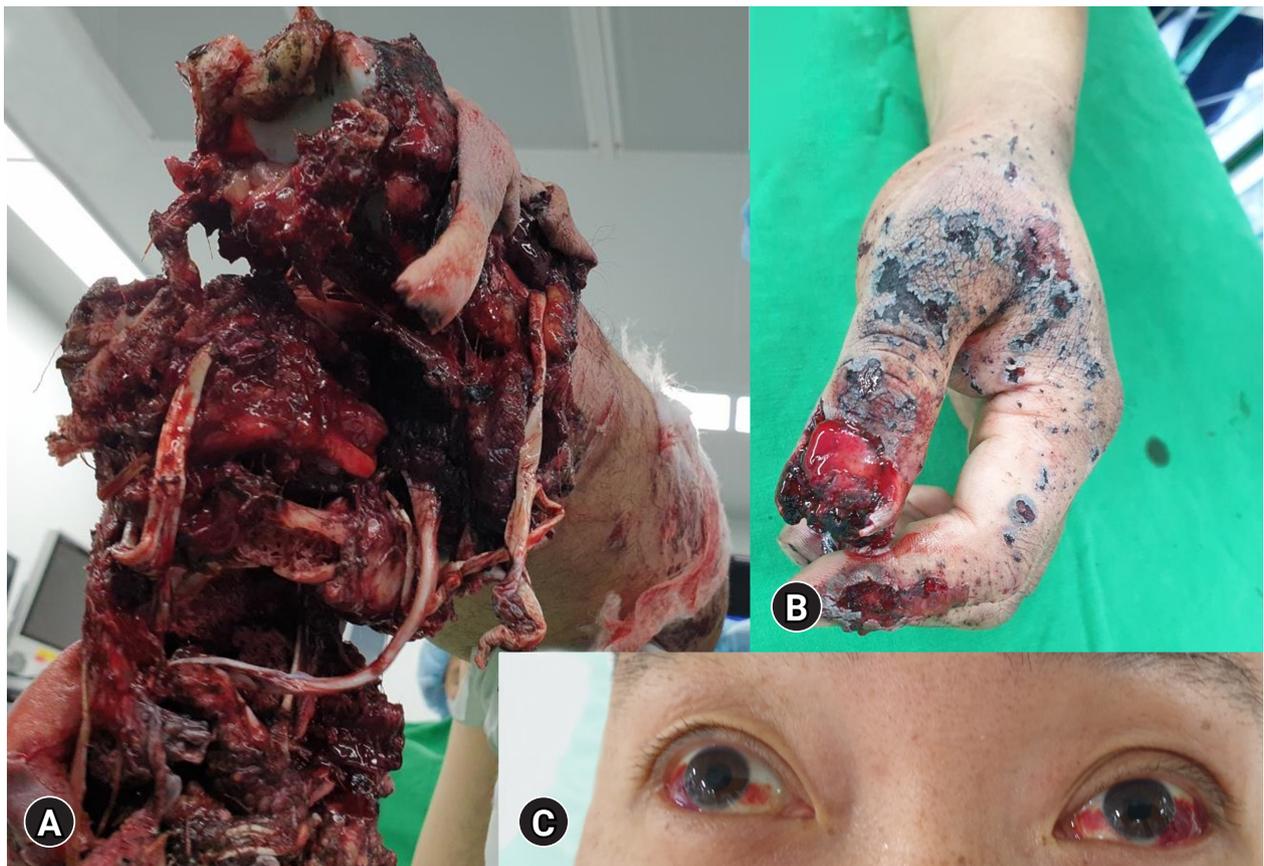


Fig. 1. Multiple trauma wounds after landmine explosion. (A) Amputated left leg and (B) left thumb tip. (C) Bilateral subconjunctival hemorrhage due to a landmine blast injury. The patient provided written informed consent for publication of the research details and clinical images.

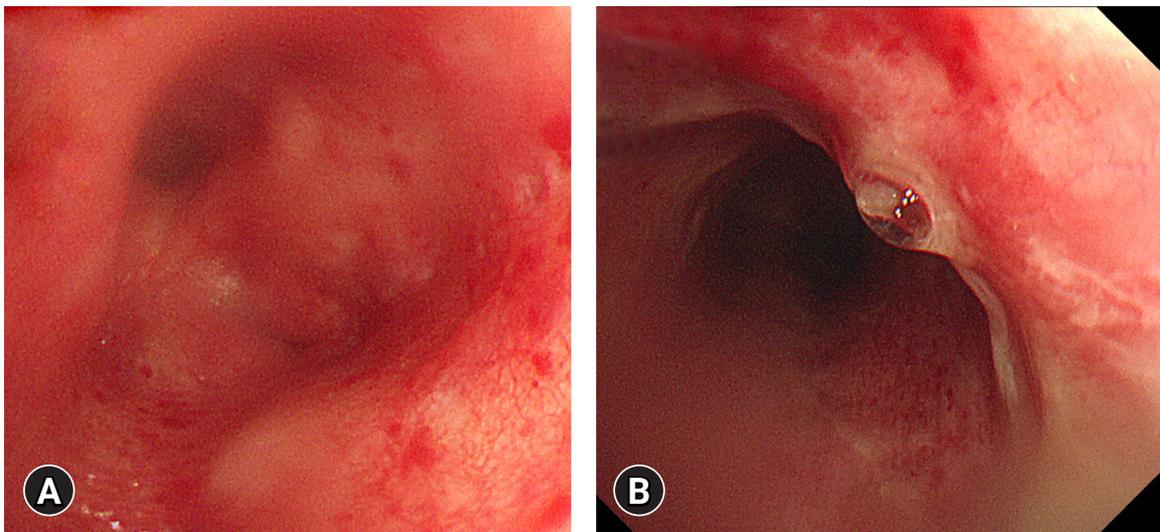


Fig. 2. Bronchoscopic examination confirmed an inhalation injury. (A) Larynx and (B) upper trachea.



Fig. 3. Chest X-ray showed right lower lung field haziness.

ministered. On the third hospital day, extubation was performed and follow-up laryngoscopy showed mild laryngeal edema and an oral cavity burn injury. During intensive care, as delirium and deep vein thrombosis developed, antipsychotics and low-molecular-weight heparin were administered. On the 19th hospital day, he was transferred to the general ward for active rehabilitation without any respiratory complications.

DISCUSSION

Inhalation burn injuries are well-known to be quaternary blast

injuries [3]. In this case, the patient's leg was amputated as the primary injury, and he had burn injuries at multiple sites as quaternary injuries. We should suspect an inhalation injury if a patient has respiratory symptoms such as stridor, wheezing, difficulty breathing, smoke debris or burn around the face, and a sooty nose, especially, in situations related to fires. Inhalation injuries are classified into three subtypes according to the anatomic site: the upper airway, the lower airway and lung parenchyme, and metabolic asphyxiation [1]. Upper airway injuries are usually caused by thermal burns from heat transfer, lower airway and lung parenchymal injuries develop from chemical and particulate irritants, and metabolic asphyxia is due to carbon monoxide and cyanide. In this case, with confirmation of the injury in the larynx and upper airway, we suspected that the cause of the inhalation injury was a thermal burn from heat transfer. We did not consider antidotes for metabolic asphyxiation in this patient because the injury occurred in an open space where cyanide is usually not problematic [4].

Inhalation injury can lead to the development of severe airway obstruction. A steam or chemical injury from the supraglottic area to the tracheobronchial tree and lung cause constriction due to the inflammatory cascade. The most important aspect of treating inhalation injuries in trauma bay is airway management. Eckert et al. [5] reported that inhalation injury led to progressive airway symptoms within 12 hours and that the majority of symptoms occurred between 6 and 12 hours after injury. He and his colleagues argued that physicians should be ready for emergent airway management for at least 18 hours, even in blast injury patients with limited severity. To prevent progression of the ob-

struction, we can consider some medications such as aerosolized heparin, epinephrine, N-acetylcysteine, or beta-2 agonists [6]. In the present case, we used aerosolized heparin/N-acetylcysteine, including heparin 10,000 IU, which is known for its safety and absence of an effect on coagulation parameters [7].

In this case, as we intubated the patient immediately after he entered the trauma bay, he had no sequelae related to the airway. However, secondary airway and pulmonary injuries can occur up to 12 hours after a blast injury [5]. An inhalation injury is a predisposing factor for pneumonia, and the combination of an inhalation injury and pneumonia increases mortality [8]. Therefore, a regular culture study is important to choose the proper antibiotics, and we obtained a specimen from a bronchoscopic exam. Since the two most common bacteria in inhalation injury-related pneumonia are *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, as in this case [9], we recommend antibiotics that can cover Gram-negative strains (e.g., piperacillin/tazobactam).

Landmines are classified into antitank mines and antipersonnel mines, and injuries due to antipersonnel mines are divided into two patterns, according to whether they are caused by blast mines or fragmentation mines [10]. Blast mines usually have small explosions that only damage the lower extremity. Fragmentation mines are relatively less explosive, but cause damage at longer distances than blast mines through multiple fragmentation. We could not confirm the type of landmine in the present case; however, the injury resembled the blast mine amputation pattern. We thought the reason why secondary and tertiary injuries were not clearly observable was the amputation caused by the blast mine injury. However, there was a report that ocular injuries could occur even with a blast mine pattern [11]. This implies that an inhalation injury could also occur. In this case, we found not only a lower extremity injury, but also bilateral subconjunctival hemorrhage, which implied that the blast wave reached the level of the face. Therefore, we also must check the condition of the nose or oral cavity and suspect smoke inhalation in landmine blasts. In Korea, it is known that there are many landmines around the demilitarized zone. We may encounter victims of landmine-related injuries in the near future, and we should always be prepared for inhalation injuries caused by landmine blasts, as in this case.

NOTES

Ethical statements

The study was approved by the Institutional Review Board of the

Armed Forces Capital Hospital (No. 2022-01-003) and was in compliance with the Declaration of Helsinki. The patient provided written informed consent for publication of the research details and clinical images.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Author contributions

Conceptualization: HL; Data curation: WK; Formal analysis: HL; Methodology: all authors; Project administration: WK; Visualization: WK; Writing—original draft: WK; Writing—review & editing: all authors.

All authors read and approved the final manuscript.

REFERENCES

1. Tanizaki S. Assessing inhalation injury in the emergency room. *Open Access Emerg Med* 2015;7:31–7.
2. Cancio LC. Airway management and smoke inhalation injury in the burn patient. *Clin Plast Surg* 2009;36:555–67.
3. Plurad DS. Blast injury. *Mil Med* 2011;176:276–82.
4. Sanders KN, Aggarwal J, Stephens JM, et al. Cost impact of hydroxocobalamin in the treatment of patients with known or suspected cyanide poisoning due to smoke inhalation from closed-space fires. *Burns* 2021 Nov 6 [Epub]. <https://doi.org/10.1016/j.burns.2021.10.017>.
5. Eckert MJ, Clagett C, Martin M, Azarow K. Bronchoscopy in the blast injury patient. *Arch Surg* 2006;141:806–11.
6. Gupta K, Mehrotra M, Kumar P, Gogia AR, Prasad A, Fisher JA. Smoke inhalation injury: etiopathogenesis, diagnosis, and management. *Indian J Crit Care Med* 2018; 22:180–8.
7. Elsharnouby NM, Eid HE, Abou Elezz NF, Aboelatta YA. Heparin/N-acetylcysteine: an adjuvant in the management of burn inhalation injury: a study of different doses. *J Crit Care* 2014;29:182.
8. Mlcak RP, Suman OE, Herndon DN. Respiratory management of inhalation injury. *Burns* 2007;33:2–13.
9. Lipovy B, Rihova H, Gregorova N, et al. Epidemiology of ventilator-associated tracheobronchitis and ventilator-associated pneumonia in patients with inhalation injury at the Burn Centre in Brno (Czech Republic). *Ann Burns Fire Di-*

- sasters 2011;24:120–5.
10. Smith S, Devine M, Taddeo J, McAlister VC. Injury profile suffered by targets of antipersonnel improvised explosive devices: prospective cohort study. *BMJ Open* 2017;7:e014697.
 11. Muzaffar W, Khan MD, Akbar MK, Malik AM, Durrani OM. Mine blast injuries: ocular and social aspects. *Br J Ophthalmol* 2000;84:626–30.

Detection of pharyngeal perforation during fiberoptic endoscopic evaluation of swallowing in a person with cervical spinal cord injury in the intensive care unit: a case report

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Endotracheal tube insertion and mechanical ventilation are indicated in spinal cord injury patients; however, dysphagia can occur after extubation. The resultant complications of dysphagia may increase the length of hospital stay and mortality. Therefore, dysphagia should be evaluated after extubation. This case report introduces a rare case of finding pharyngeal perforation during the fiberoptic endoscopic evaluation of swallowing (FEES) in patients with cervical spine injuries in the intensive care unit. A 71-year-old male patient met with a road traffic accident. The patient underwent C3–4 posterior fusion and C3–4 anterior cervical discectomy and fusion. After successful extubation, the patient underwent FEES to assess swallowing function. During FEES, the metallic plate was found to be exposed through mucosal erosion, and swelling was observed at the surgical site at the hypopharynx. The nasogastric tube was removed to prevent secondary damage and infection at the operation site and the patient was received conservative therapy. The FEES endoscope machine is portable so it can be easily applied at the bedside to intensive care unit patients. In addition, FEES allows the identification of anatomical abnormalities of the oropharynx and abnormalities of vocal cord. Thus, it is recommended to do FEES to check anatomical abnormalities as well as dysphagia in patients in the intensive care unit.

Keywords: Spinal cord injuries; Intensive care units; Dysphagia; Endoscopy; Case reports

INTRODUCTION

Patients with severe trauma are prone to respiratory failure, requiring endotracheal tube insertion and mechanical ventilation. After extubation, however, swallowing dysfunction, also known

as dysphagia, can occur frequently. The occurrence of postextubation dysphagia (PED) among patients admitted to the intensive care unit (ICU) is relatively common, and the frequency is reported to be about 93% [1].

Among patients with trauma, those with cervical spinal cord

injury (CSCI) are at a higher risk of dysphagia. A study reported that 16% of CSCI patients suffer from dysphagia during their first feeding, and the level of tetraplegia, reduction of the value of the lung volume and the subglottic pressure resulting from tracheostomy or thorax trauma, and the duration of ventilation are all significant factors in the development of dysphagia [2].

Complications of dysphagia include aspiration which has the potential to cause pneumonia, mechanical bronchial obstruction, transient hypoxemia, bronchospasm, and atelectasis. In addition, these complications may increase the length of hospital stay, delay the rehabilitation process, and increase mortality [3,4].

Therefore, after successful extubation, an evaluation of PED should be performed in the early stage of the traumatic CSCI. Both video fluoroscopic swallowing study (VFSS) and fiberoptic endoscopic evaluation of swallowing (FEES) are gold standard techniques for the assessment of dysphagia. Because FEES offers the advantages of better accessibility and direct observation of the laryngeal anatomy, it is preferred for the evaluation of patients in the ICU. Herein, we report a case demonstrating the importance of FEES after extubation in CSCI patients. What makes our case report special is that it is the first study reporting that found perforation of hypopharynx in the FEES. The patient provided written informed consent for publication of the research details and clinical images.

CASE REPORT

A 71-year-old male patient met with a road traffic accident and complained of inability to move all four limbs. On arrival, the patient was alert. On the initial physical examination, the key muscle power was found to be grade 1 out of 5 for C5, grade 0 out of 5 from C6 to C8, grade 1 out of 5 from L2 to L3, grade 0 out of 5 from L4 to L5, and grade 1 out of 5 for S1. Voluntary anal contraction was absent. Hypoesthesia was noted below the C4 dermatome, but no abnormalities were noted in the deep anal pressure, anal sensation, anal reflex, and bulbocavernosus reflex. The neurological level of injury was at C4, tetraplegia with an American Spinal Injury Association Impairment Scale grade of C. Normoactive deep tendon reflexes were present in all four limbs. The patient's cranial nerves were intact.

Cervical spine computed tomography and magnetic resonance imaging scans revealed C3/4 dislocation, prevertebral hematoma at the C2–5 level, and spinal cord contusion at the C3–4 level (Fig. 1). The patient underwent C3–4 posterior fusion and C3–4 anterior cervical discectomy and fusion (ACDF), was intubated and on mechanical ventilation due to the patient's poor respiratory function.

The patient was referred to the Department of Rehabilitation immediately after surgery, where the patient was made to un-

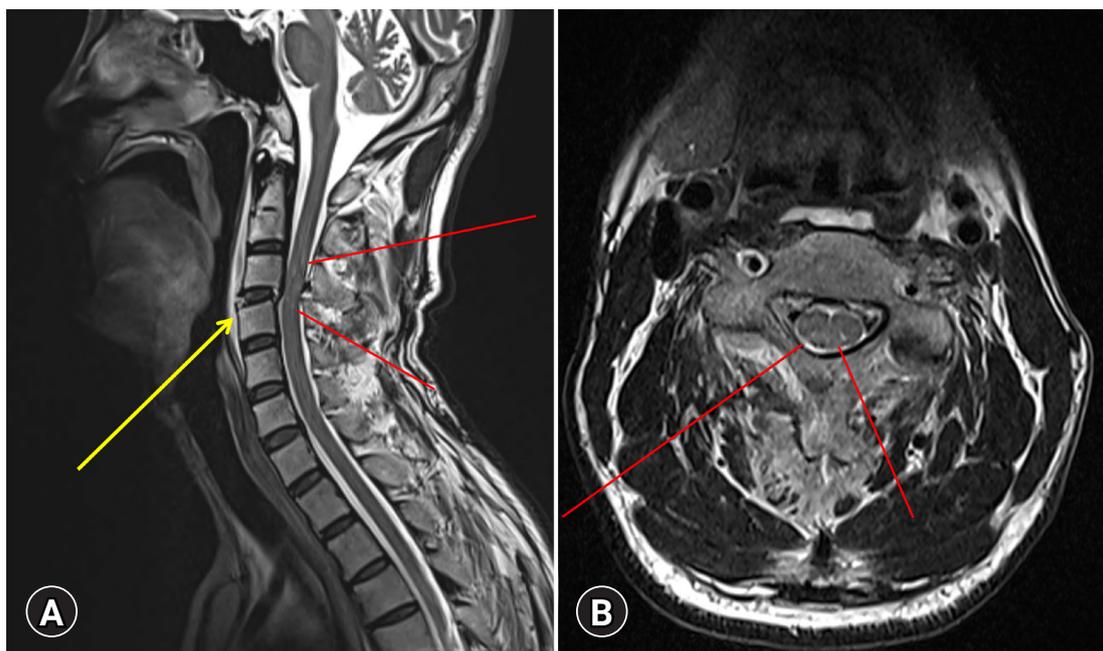


Fig. 1. Cervical spine magnetic resonance image. Magnetic resonance image scan performed when the patient was admitted to the hospital revealed C3/4 dislocation, highly suspicious anterior discoligamentous complex rupture at C3–4, (A) prevertebral soft tissue hematoma at the C2–5 level (yellow arrow), and (A, B) spinal cord contusion with hematoma at the C3–4 level (red lines).

dergo a pulmonary rehabilitation program in the intubated state, including mechanical insufflation-exsufflation, assisted coughing, postural drainage for effective sputum discharge, and air-stacking exercises for lung expansion. Owing to early pulmonary rehabilitation and intensive physical training for improved vital capacity and coughing ability, the patient's breathing pattern stabilized, and the amount of sputum decreased. The ventilator weaning was successful. The peak expiratory flow value through endotracheal tube was measured at 68 L/min. Having considered the cutoff value of peak expiratory flow for successful extubation as 60 L/min [5], we decided to attempt an extubation. However, a dental aspiration was found in the trachea on computed tomography neck on postoperative day (POD) 5. It soon moved to a peripheral bronchus, making it difficult to remove and delaying extubation. Nonetheless, the tooth was removed by bronchoscopy after a second attempt at POD 11, followed by extubation. The total period of intubation was 11 days.

A nasogastric (NG) tube had been inserted the day the patient first visited the hospital to release the gas from stomach. The ileus improved, and through NG tube, the patient started tubal feeding. In the dysphagia screening test conducted by bedside to proceed to an oral feeding, gargling voice, foul-smelling breath during exhalation, and stridor were found. Therefore, we performed FEES to investigate any anatomical abnormalities and

vocal cord function on POD 15.

During FEES, it was observed that the cervical metal plate used during ACDF to provide neck stability was found to be exposed through mucosal erosion, and swelling was observed at the ACDF surgical site at the pharynx (Fig. 2). Given the risk of infection, the NG tube was removed, and the patient was nourished with total parenteral nutrition. On POD 23, a follow-up FEES revealed that the exposed area still existed. A literature review in 1990 suggested that perforations less than 2 cm be managed conservatively [6]. Accordingly, since the exposed area was smaller than 2 cm and no signs of infection were found, the patient received conservative therapy, including meropenem, a broad-spectrum antibiotic.

An NG tube could have worsened the mucosal injury. Therefore, on POD 36, the patient underwent a percutaneous endoscopic gastrostomy procedure. While feeding through the percutaneous endoscopic gastrostomy, the patient's general condition improved. Five months after the accident, the patient was discharged. Presently, the patient is still feeding through percutaneous endoscopic gastrostomy. We have been conducting periodic assessments of pharyngeal perforation and dysphagia.

DISCUSSION

Spine surgeries with an anterior neck approach, such as ACDF,

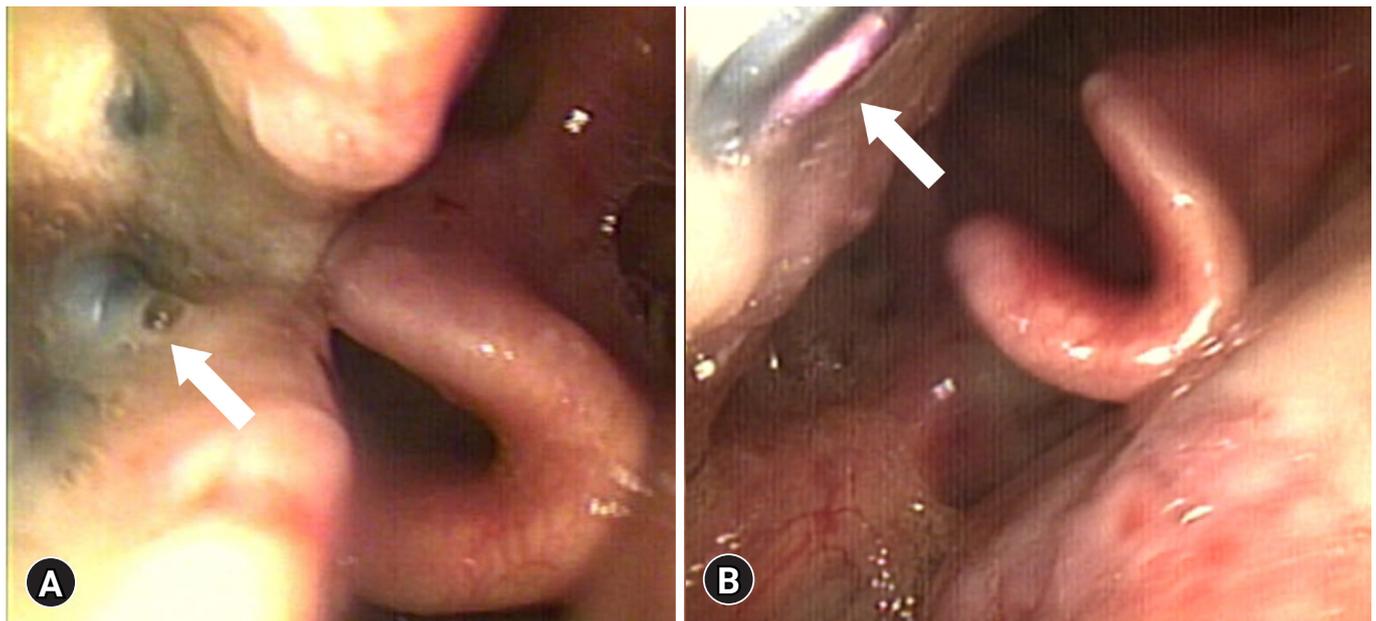


Fig. 2. Pharyngeal perforation seen on fiberoptic endoscopic evaluation of swallowing (FEES). (A) FEES on postoperative day 15. At the anterior cervical discectomy and fusion surgical site at the pharynx, the metal is exposed through mucosal erosion, and swelling is observed (arrow). (B) FEES on postoperative day 23. In the follow-up test, the exposed area is still observed (arrow).

are commonly performed and are relatively safe surgical procedures. However, the anterior neck region contains various muscles and nerves such as the recurrent laryngeal nerve, superior laryngeal nerve, sympathetic trunk, and spinal accessory nerve, as well as structures such as the thyroid gland, trachea, and esophagus. Due to the complexity of the anterior neck region, complications may occur. In a series of over 850 cases of anterior spine surgery, Cloward [7] reported a wide range of operative complications, most of them being minor and self-limiting. They can be classified into three categories: soft tissue lesions, spinal cord or root injuries, and problems related to spinal stabilization [8].

When soft tissue lesions due to spine surgery are detected, neurosurgical consultation should be obtained to assess the status of fixation and the need for revision, and removal of inciting hardware with vascularized reconstruction with a local pedicled flap. Conservative management such as drainage, broad-spectrum antibiotics, and extraoral feeding is a reasonable option if the patient is in a condition that cannot be operated on, or if the lesion is small and stable.

Major injury or surgery induces a hypermetabolic, catabolic state in which, if not supported by exogenous substrates, excessive skeletal muscle proteolysis occurs, followed by depletion of crucial visceral and circulating proteins. Therefore, early nutritional support benefits high-risk surgical patients [9]. There are many advantages of early enteral feeding in the ICU, such as lower incidence of infection, reduced length of hospital stay [10], immunocompetence, and improved wound healing. Compared to total parenteral nutrition, nutrients delivered through enteral feeding (oral or tubal feeding) are better utilized by the gut. In addition, total enteral feeding prevents gastrointestinal mucosal atrophy, attenuates the injury-stress response, maintains immunocompetence, causes lesser metabolic imbalance, and preserves normal gut flora [9]. Until now, surgeons have been reluctant to initiate early enteral feeding in CSCI patients because of concerns of ileus and other complications. However, studies have found that feeding these patients within the first 72 hours is safe [11].

However, NG tube can cause various complications: gastrointestinal (diarrhea, constipation, nausea, and vomiting), tube-related (nasal ulcers, tube clogging, and tube dislodgement), respiratory (pulmonary aspiration), metabolic (hyperglycemia, hyper or dehydration, electrolytic alterations), and so on [12]. Therefore, it is necessary to examine whether an oral diet is possible and start an oral diet at an early stage of the disease.

There are various screening tools available for dysphagia, including Gugging swallowing screen, 3-oz water test, and citric acid swallowing test in ICU. However, a gold standard test is warranted in patients at a high risk of dysphagia, such as those with CSCI. These gold standard tests include VFSS and FEES.

In patient in this report, mechanical and medical factors such as the ACDF, hematoma formation, injury to the pharynx, and pressure injury due to prolonged placement of the endotracheal tube and NG tube, could be the cause of pharyngeal perforation. A review of the patient's postoperative cervical spine X-ray (lateral view) revealed thinning of the prevertebral soft tissue (Fig. 3). Pharyngeal perforation often does not show any obvious symptoms; we were able to incidentally detect the mucosal defect through FEES, and further determine the direction of treatment and method of feeding.

FEES involves passing a fiberoptic laryngoscope trans nasally to visualize the hypopharynx, larynx, and proximal trachea for the purpose of assessing dysphagia. FEES has the disadvantage that discomfort can be induced because the fiberoptic laryngoscope enters through the patient's nose. Therefore, it is difficult to do FEES to patients who do not cooperate. In addition, it is difficult to observe the oral and upper pharyngeal phases of swallowing.

On the other hand, FEES has several advantages over VFSS. FEES is more reliable in assessing penetration than VFSS and is equally effective in discriminating between penetration and aspiration [13]. FEES allows one to observe the anatomical structure of the oropharynx and vocal cord directly. Therefore, it is possible to check for the presence of vocal cord palsy with phonation. Moreover, patients in the ICU are often difficult to shift out due to the numerous monitoring devices, the patient's poor condition, and the risk of orthostatic hypotension in patients with early SCI. VFSS is possible only when the patient can be brought to the laboratory. In contrast, the endoscope equipment used for FEES has the advantage of being portable and bedside. Therefore, FEES can be a useful test in patients admitted to the ICU with restricted mobility.

The FEES endoscope machine is portable so it can be easily applied at the bedside to patients with suspected PED in the ICU. In addition, FEES allows the identification of anatomical abnormalities of the oropharynx occurring after surgery and abnormalities of vocal cord movement that may occur after extubation. Thus, it is recommended that traumatic CSCI patients with suspected PED be evaluated through FEES.

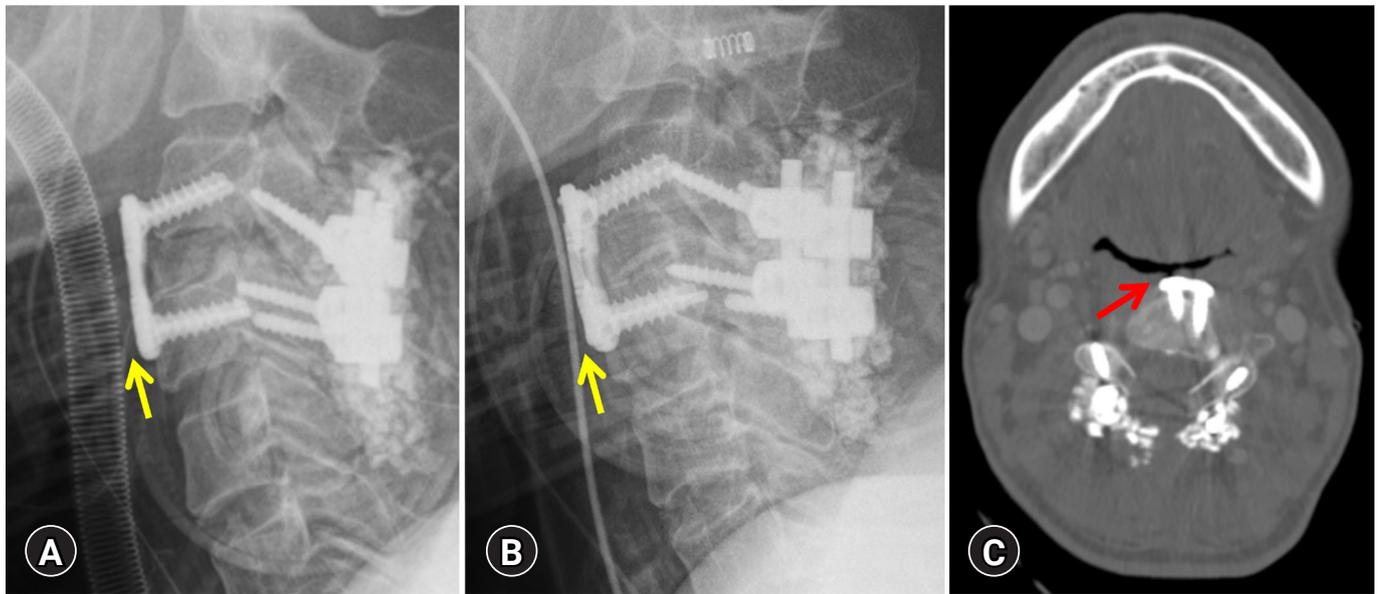


Fig. 3. Cervical spine lateral X-ray on (A) postoperative day (POD) 1 after anterior cervical discectomy and fusion surgery and (B) POD 7. The prevertebral soft tissue appears thinned in front of the surgical site (yellow arrows). (C) Horizontal view of computed tomography neck on POD 22. The cervical metal plate used during anterior cervical discectomy and fusion to provide neck stability was found to be exposed to the hypopharynx (red arrow).

NOTES

Ethical statements

Written informed consent for publication of the research details and clinical images was obtained from the patient.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Author contributions

Conceptualization: all authors; Methodology: YBS; Project administration: MHJ; Visualization: SHH; Writing–original draft: MSC; Writing–review & editing: YBS, MHJ. All authors read and approved the final manuscript.

REFERENCES

1. Macht M, King CJ, Wimbish T, et al. Post-extubation dysphagia is associated with longer hospitalization in survivors of critical illness with neurologic impairment. *Crit Care* 2013; 17:R119.
2. Seidl RO, Nusser-Muller-Busch R, Kurzweil M, Niedeggen A.

- Dysphagia in acute tetraplegics: a retrospective study. *Spinal Cord* 2010;48:197–201.
3. Kirshblum S, Johnston MV, Brown J, O’Connor KC, Jarosz P. Predictors of dysphagia after spinal cord injury. *Arch Phys Med Rehabil* 1999;80:1101–5.
4. Bath PM, Lee HS, Everton LF. Swallowing therapy for dysphagia in acute and subacute stroke. *Cochrane Database Syst Rev* 2018;10:CD000323.
5. Smina M, Salam A, Khamiees M, Gada P, Amoateng-Adjepong Y, Manthous CA. Cough peak flows and extubation outcomes. *Chest* 2003;124:262–8.
6. Niezgoda JA, McMenamin P, Graeber GM. Pharyngoesophageal perforation after blunt neck trauma. *Ann Thorac Surg* 1990;50:615–7.
7. Cloward RB. Complications of anterior cervical disc operation and their treatment. *Surgery* 1971;69:175–82.
8. Orlando ER, Caroli E, Ferrante L. Management of the cervical esophagus and hypofarinx perforations complicating anterior cervical spine surgery. *Spine (Phila Pa 1976)* 2003;28: E290–5.
9. Moore FA, Feliciano DV, Andrassy RJ, et al. Early enteral feeding, compared with parenteral, reduces postoperative septic complications. The results of a meta-analysis. *Ann Surg* 1992;216:172–83.
10. Marik PE, Zaloga GP. Early enteral nutrition in acutely ill pa-

- tients: a systematic review. *Crit Care Med* 2001;29:2264–70.
11. Dvorak MF, Noonan VK, Belanger L, et al. Early versus late enteral feeding in patients with acute cervical spinal cord injury: a pilot study. *Spine (Phila Pa 1976)* 2004;29:E175–80.
 12. Pancorbo-Hidalgo PL, Garcia-Fernandez FP, Ramirez-Perez C. Complications associated with enteral nutrition by nasogastric tube in an internal medicine unit. *J Clin Nurs* 2001; 10:482–90.
 13. Colodny N. Interjudge and intrajudge reliabilities in fiberoptic endoscopic evaluation of swallowing (FEES) using the penetration-aspiration scale: a replication study. *Dysphagia* 2002;17:308–15.

Repair of traumatic flank hernia with mesh strip suture: a case report

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Traumatic flank hernia is a relatively rare hernia. We report a case of a male patient with severe multiple trauma, including abdominal injury, who presented with flank hernia 3 years postinjury. The hernia was successfully repaired using mesh strips suture, and at the 12-month follow-up, no complications or recurrence was found. Our findings indicate that when it is difficult to secure a sufficient operative field for mesh anchoring in a traumatic flank hernia, a technique of sutured repair with mesh strips may be considered as a treatment option as it requires less dissection. Compared to the conventional planar mesh repair, this technique decreases the risk of injuries and ischemic necrosis of the surrounding tissues.

Keywords: Wounds and injuries; Ventral hernia; Herniorrhaphy; Surgical mesh; Case reports

INTRODUCTION

Flank hernias occurring after blunt abdominal trauma are rare. Approximately 500 cases have been reported in the literature [1–18]. In 2009, the European Hernia Society divided lateral hernia into four zones: L1 (subcostal), L2 (flank), L3 (iliac), and L4 (lumbar) [19]. When the hernia is located lateral to the rectal sheath in the area 3 cm above and below the umbilicus, it is defined as flank hernia [19], which is further divided into primary (spontaneous) and secondary (trauma or surgery), with an incidence of 55% for primary and 25% for secondary flank hernia [20].

Traumatic flank hernia repair has been reported only in case series; thus, surgical techniques or long-term outcomes have not been established. Kearney et al. [6] reported that primary repair of traumatic flank hernia using mesh strips provides high tension

directly to the hernia defect site and has a low recurrence rate due to force distribution at the suture site. In addition, compared to conventional hernia repair, the range of tissue dissection for repair using mesh strips is not wide, so the risk of damage to surrounding structures is low [6]. Moreover, mesh strip technique can be performed easily and quickly.

In this article, we report a case of a male patient who presented with traumatic flank hernia 3 years postinjury, which was successfully repaired using mesh strips. This is the first reported case of traumatic flank hernia repair using the mesh strip technique in Asia.

This study was approved by the Institutional Review Board of Seoul National University Hospital (No. 2201-130-1294). Written informed consent was obtained from the patient for publication of this case report and accompanying images.

CASE REPORT

A male patient with a history of intrahepatic duct stone surgery was transported to a regional trauma center after he collided with a 15-t truck while driving. His mental status was Glasgow Coma Scale 15, and he complained of severe abdominal pain. The patient was afebrile with a blood pressure of 70/40 mmHg, pulse rate of 68/min, and respiratory rate of 26/min at arrival. Focused assessment of sonography for trauma revealed a large amount of intraabdominal fluid. Shortly, the patient developed severe hypotension, which was unresponsive to resuscitation. Zone 1 resuscitative endovascular balloon occlusion of the aorta was performed, and emergency laparotomy was decided.

A large amount of hematoma due to massive bleeding from the mesenteric avulsion site and transected vessels was observed after crash laparotomy. Bleeders were controlled, and infarcted small bowel (160 cm length) due to mesenteric avulsion (30 cm length, two sites) was resected. Perforated sigmoid colon was also transected. After 2 days, small bowel anastomosis, S-colon anastomosis, and transverse colostomy were performed during second-look laparotomy.

Other accompanying injuries (left humerus fracture, multiple rib and sternum fractures, both feet fractures, and multiple trans-

verse spine fractures) were also treated. Two months later, colostomy repair was performed, and the patient was discharged 4 months after trauma.

Three years after injury, the patient newly developed left flank bulging and discomfort (Fig. 1). Computed tomography revealed abdominal wall defect and bowel herniation sized 5.6×11.6 cm above the iliac crest without signs of bowel incarceration (Fig. 2). Repair of traumatic flank hernia with mesh strip suture was planned.

The patient was placed in a right lateral decubitus position. A beanbag was placed under the patient, and negative pressure was applied to fix the posture (Fig. 3). The bed was bent to extend the space between the iliac crest and the costal margin. The incision was made in the midportion of the abdominal wall defect. The skin and subcutaneous tissue were dissected until the external oblique muscle was identified. The transversus abdominis muscle edge of the hernia defect was identified to complete the exposure of the defect. After confirming that the peritoneum was intact, monofilament polypropylene mesh (Bard Davol, Warwick, RI, USA) was cut into strips with a width of 2 cm. The end of each mesh was triangulated for easy pull-through. The transversus abdominis muscle was pierced with a sharp hemostat approximately 2 to 3 cm from the newly debrided edge of the trans-



Fig. 1. Preoperative (A) anteroposterior and (B) lateral view of a 62-year-old male patient with a traumatic flank hernia (black circles on the patient body indicate flank bulging).

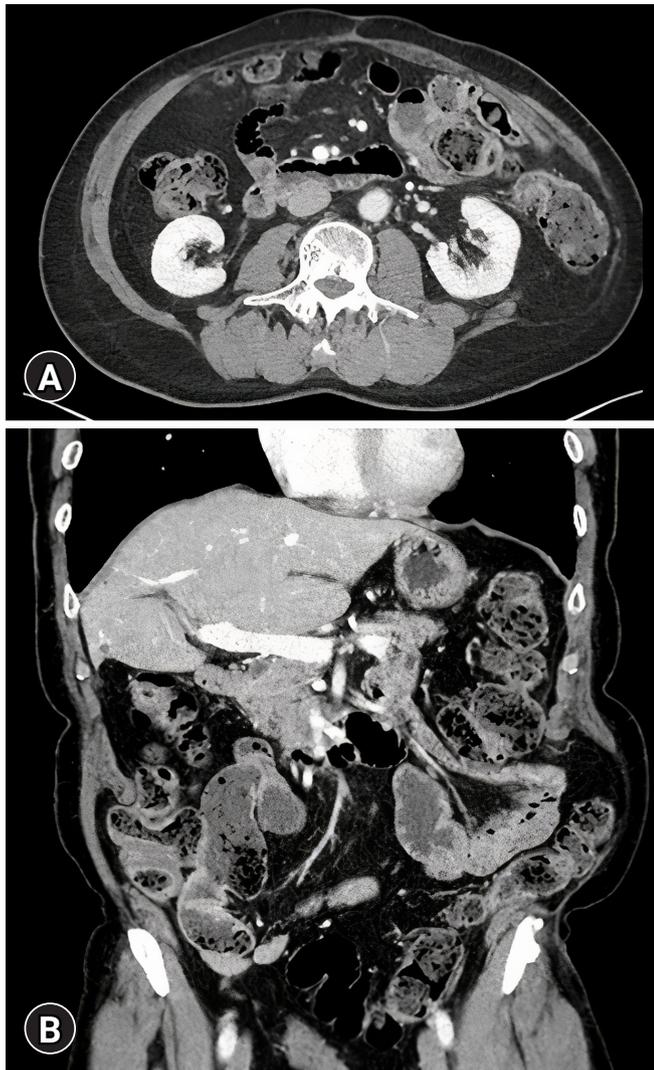


Fig. 2. Preoperative abdominal computed tomography of (A) axial and (B) coronal view show a 5.6×11.6-cm sized left abdominal wall defect above the iliac crest.

verse abdominis muscle. The mesh strip was then pulled through the muscle and tied like a suture after making the operating table flat. Eight mesh strips were applied with even distance (Figs. 4, 5). After placing the Jackson-Pratt drain over the repaired transversus abdominis muscle, the internal and external oblique muscles were repaired with 1-0 polydioxanone suture. Another Jackson-Pratt drain was placed over the external oblique muscle, and the subcutaneous tissue and skin were closed with 2-0 nylon.

No evidence of fever and surgical site infection was noted postoperatively. On the 8th postoperative day, the Jackson-Pratt drain was drained to less than 10 mL daily and removed, and the patient was discharged. Computed tomography taken 4 months postoperatively confirmed that the surgical site was intact without recurrence (Fig. 6). No recurrence was observed 12 months postoperatively (Fig. 7). The patient confirmed of having no surgical site discomfort, pain, or foreign body sensation while performing daily activities.

DISCUSSION

Traumatic flank hernia is a rare hernia, and surgical approach is difficult due to the surrounding bony structures and major neurovascular structures. Conventional methods of flank hernia repair include open, laparoscopic, and robotic approaches or a combination of these approaches. Regarding the repair technique, primary repair or planar mesh reinforcement is usually performed.

It is recommended that sufficient flap dissection be achieved as wide mesh overlap is imperative. The planar mesh should be covered 5 to 10 cm wider than the size of the hernia defect in both open and laparoscopic approach [4,10–13,15]. For mesh repair



Fig. 3. Preoperative patient position. (A, B) Right lateral decubitus position of the patient with the iliac crest at the proper flexion point. The operating table was bent for flank extension.

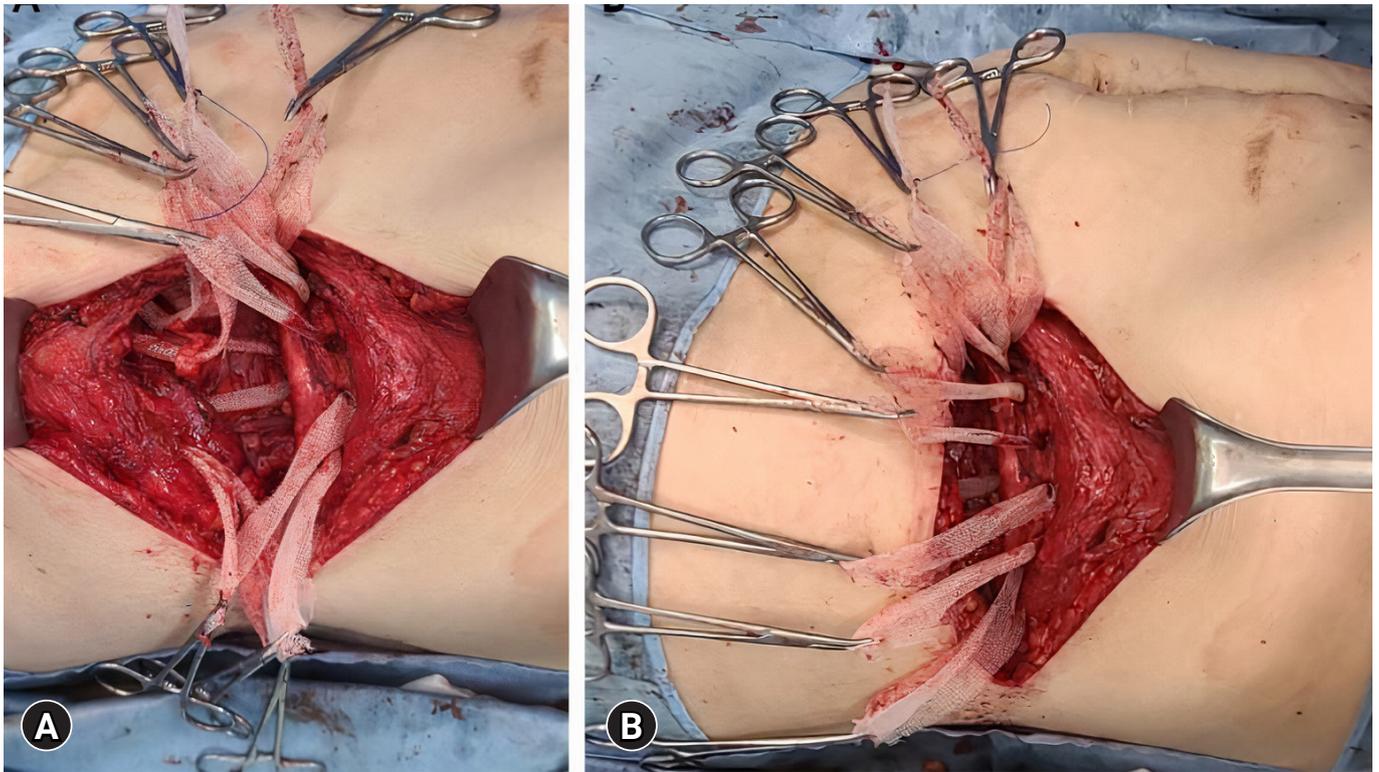


Fig. 4. The mesh strip sutures and ties. (A, B) Eight mesh strips were passed through the transversus abdominis muscle.

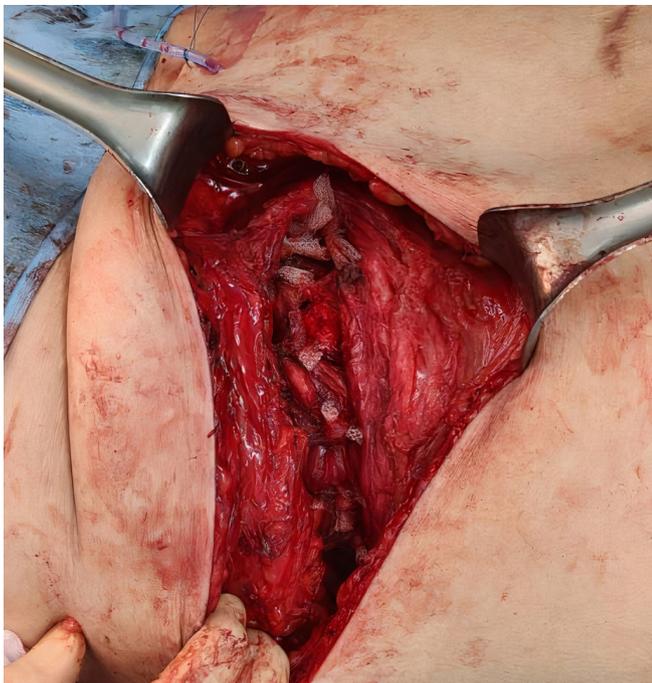


Fig. 5. The mesh strips were tied for closure of the hernia.

using the traditional open technique, the mesh should be anchored to the surrounding muscles or bony prominence, and there is a risk of bleeding or nerve injury [4,10–12,15].

In the laparoscopic approach, the rate of surgical site infection or recurrence is lower than that in open repair [4]. However, as the laparoscopic approach requires mobilization of the bowel for mesh fixation, there might be a risk of organ injury [4]. Some studies have suggested that the laparoscopic approach to repair flank hernia should be limited to smaller defects [13–15], although data on the mean hernia defect size are limited.

The most important outcome in hernia repair is the recurrence rate. Table 1 summarizes 18 case series regarding lumbar hernia (including flank hernia) repair targeting a total of 526 patients reported in the literature [1–18]. An open approach was performed in 13 studies, a laparoscopic approach in three studies, a combination of both approaches in one study, and a laparoscopic or robotic approach in one study. The overall recurrence rate of this cohort was 6.1% (0%–13.3%). The causes of lumbar (or flank) hernia recurrence included insufficient mesh overlap or fixation and mesh implantation failure due to infection [10,15,18]. Common complications that occur after hernia repair included seroma, hematoma, and infection [2,7,8,12,13,15,16,18]. Others in-

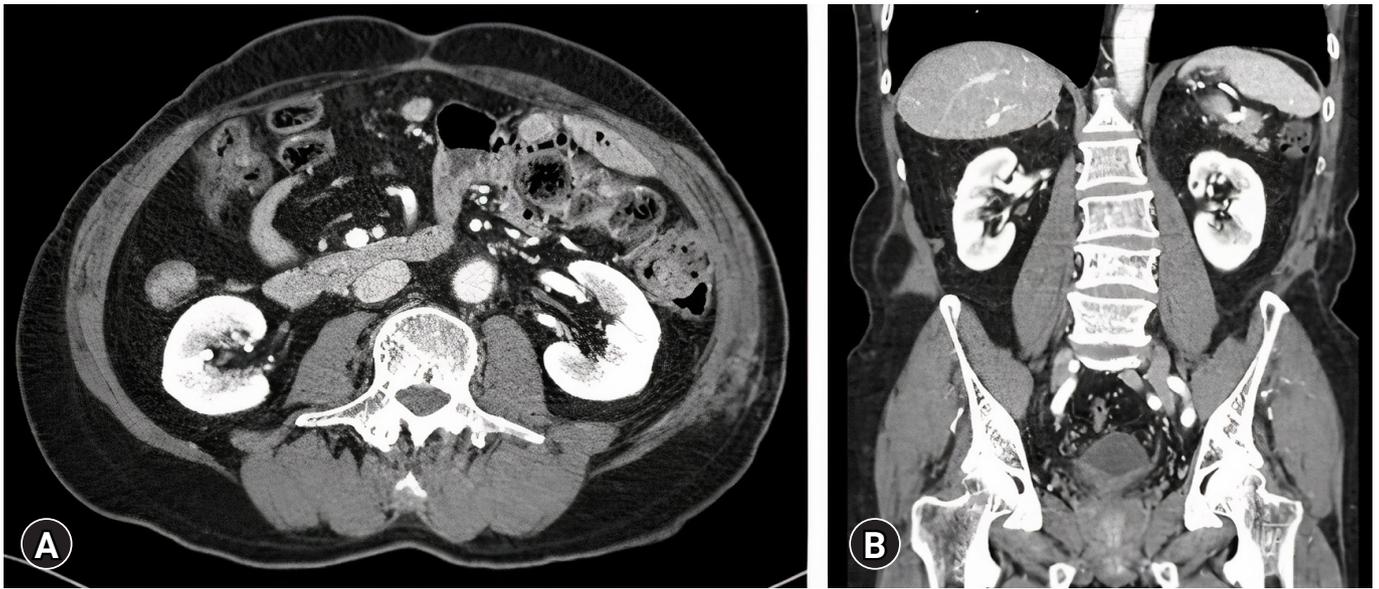


Fig. 6. Postoperative computed tomography scan of (A) axial and (B) coronal view after 4 months show an intact hernia repair site without recurrence or complications.



Fig. 7. Images of (A) anterior and (B) lateral view demonstrating intact surgical wound site 6 months postoperatively.

cluded skin dehiscence, necrosis, chronic pain, and postoperative anemia due to underlying disease or bleeding during surgery [3–5,11,12,14]. Among them, chronic pain was reported in 0% to 42% of the cases [4,5,11,12,14]. The definition of chronic pain is not clear; therefore, it might have been difficult to differentiate between chronic and postoperative pain [4]. Some studies did not assess chronic pain, which might be a reason for the wide range of prevalence of chronic pain in the cases [2,6,7,10,13,15,18].

Using the experimental pig model, a study introduced the mesh sutured repair in 2014 and compared it with standard pri-

mary suture [21]. That study demonstrated that mesh suture has higher resistance and tensile strength for pull-through than standard primary suture. According to another report on 107 mesh sutured repairs of abdominal wall defects published in 2016 [22], the recurrence rate (early mean follow-up time of 234 days) was <4%, and the incidence of surgical site occurrence (infection, seroma, hematoma, reoperation, delayed wound healing) was 17%. Another study published in 2020 reported that among four patients with traumatic flank hernia who underwent mesh strip repair [6], there were no complications such as surgical site infec-

Table 1. Outcomes of lumbar hernia repair

Study	Surgical technique	Repair technique	No. of patients	Mean defect size (cm ²)	Mean FU (mo)	Recurrence (%)	Complication (%)
Bender et al. [2]	Open	Varied	25	NC	5.7	12.0	28.0
Edwards et al. [4]	Laparoscopy	Mesh	27	188	3.6	0	0
Fei et al. [5]	Open	Extended sublay, mesh	18	NC	26.2	0	27.8
Fei et al. [5]	Open	Routine sublay, mesh	23	NC	24.5	13.0	13.0
Luc et al. [7]	Open	Retromuscular, IPOM	112	NC ^{a)}	35.0	9.8	24.1
Patel et al. [10]	Open	Varied	6 ^{b)}	78.6	15.4	11.5	49.2
Petersen et al. [11]	Open	Sublay, mesh	4	NC	33.0	0	0
Pezeshk et al. [12]	Open	Varied	29	94	21.2	3.4	31.0
Phillips et al. [13]	Open	Retromuscular, mesh	16	508	16.8	0	31.0
Purnell et al. [14]	Open	Varied, mesh	31	NC ^{c)}	27.7	9.7	6.5
Veyrie et al. [15]	Open	Retromuscular, mesh	61 ^{d)}	56	47.0	4.9	11.5
Zieren et al. [18]	Open	Retromuscular, onlay, mesh	15	NC ^{e)}	60.0	13.3	33.0
Muhkerjee et al. [8]	Open	Mesh	8	90	12.0	20.0	10.0
Novitsky et al. [9]	Laparoscopy	Mesh	14	NC ^{f)}	35.0	0	0
Amaral et al. [1]	Combining laparoscopy and open	Laparoscopic IPOM and open onlay, mesh	16	NC ^{g)}	37.0	12.5	6.3
Cavalli et al. [3]	Open	Retromuscular, mesh	22	232	44.8	4.5	9.1
Zhao et al. [17]	Laparoscopy	TAPE, mesh	19	NC ^{h)}	20.0	0	0
Wijerathne et al. [16]	Laparoscopy, robot	Varied, mesh	21	19.8	14.0	0	18.2
Kearney et al. [6]	Open	Mesh strip	4	NC	24.3	0	0

FU, follow-up; NC, not calculated; IPOM, intraperitoneal onlay mesh; TAPE, transabdominal partially extraperitoneal.

^{a)}Mean width, 8.9±11.7 cm. ^{b)}A total of 61 lumbar hernia patients (subcostal hernia, 14 patients; flank hernia, 33 patients; iliac hernia, 11 patients; lumbar hernia, 3 patients). ^{c)}Mean width, 11.1 cm. ^{d)}A total 61 lateral incisional hernia (subcostal hernia, 14 patients; flank hernia, 12 patients; iliac hernia, 35 patients). ^{e)}Mean size, 15×11 cm. ^{f)}Mean width, 6×9 cm. ^{g)}Mean width, 6.4±2.8 cm. ^{h)}Mean width, 5.8±2.1 cm.

tion, hematoma, or wound breakdown and no recurrence during the mean period of 24.3 months of follow-up. The authors suggested that targeted placement of the mesh at the repair site using strips of mesh distributes the forces of closure across a larger surface area, helping to reduce the likelihood of pull-through with improved outcomes [6]. In addition, mesh suture creates a magnified foreign body response because of its increased surface area [22]. Persistent foreign body response and associated scar formation would be important for the long-term strength of hernia defect closure [22].

There were two reasons for selecting mesh strips sutured repair for the present case. First, due to the large size of the hernia defect, extensive tissue dissection would have been required for traditional mesh application, which might have increased the risk of postoperative complications. The hernia was located at the L2–L3 boundary according to classification, and it was difficult to secure a sufficient operative field on the inferior border for planar mesh repair. Second, the tension of the surrounding tissue was anticipated to be weak compared to other types of flank hernias. As the patient had very high energy in-car traffic accident, seat-

belt might have damaged the fascia and muscles. The injured tissues may have been stretched due to long-standing exposure of intraabdominal pressure and may have progressed to an abdominal wall defect. Since the tension of surrounding tissue was anticipated to be weak, the magnified foreign body response, which is an advantage of the mesh strip suture, would be helpful. Therefore, sutured repair using mesh strips was selected so as to increase the tensile strength of the transversus abdominis muscle with less surrounding tissue dissection.

In conclusion, when it is difficult to secure a sufficient operative field for mesh anchoring in a traumatic flank hernia, a technique of sutured repair with mesh strips may be considered as a treatment option, given that this technique requires less dissection, thereby reducing the risk of injuries and ischemic necrosis of the surrounding tissue, compared to the conventional planar mesh repair. However, this technique has a limitation that it cannot be applied when there is tissue loss or edges of the hernia cannot be approximated. Further studies are warranted to evaluate the safety and efficacy of the mesh strips suture in traumatic flank hernia repair.

NOTES

Ethical statements

This study was approved by the Institutional Review Board of Seoul National University Hospital (No. 2201-130-1294). Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Author contributions

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

REFERENCES

1. Amaral PH, Tastaldi L, Barros PH, et al. Combined open and laparoscopic approach for repair of flank hernias: technique description and medium-term outcomes of a single surgeon. *Hernia* 2019;23:157–65.
2. Bender JS, Dennis RW, Albrecht RM. Traumatic flank hernias: acute and chronic management. *Am J Surg* 2008;195:414–7.
3. Cavalli M, Aiolfi A, Morlacchi A, et al. An extraperitoneal approach for complex flank, iliac, and lumbar hernia. *Hernia* 2021;25:535–44.
4. Edwards C, Geiger T, Bartow K, et al. Laparoscopic transperitoneal repair of flank hernias: a retrospective review of 27 patients. *Surg Endosc* 2009;23:2692–6.
5. Fei Y, Li L. Comparison of two repairing procedures for abdominal wall reconstruction in patients with flank hernia. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2010;24:1506–9.
6. Kearney AM, Dumanian GA. Simplified repair of traumatic iliac crest flank hernias with mesh strips. *Plast Reconstr Surg Glob Open* 2020;8:e2970.
7. Luc G, David A, Couzi L, Midy D, Collet D, Dubuisson V. Lateral incisional hernia after renal transplantation: a comparative study. *World J Surg* 2014;38:2791–6.
8. Mukherjee K, Miller RS. Flank hernia repair with suture anchor mesh fixation to the iliac crest. *Am Surg* 2017;83:284–9.
9. Novitsky YW. Laparoscopic repair of traumatic flank hernias. *Hernia* 2018;22:363–9.
10. Patel PP, Warren JA, Mansour R, Cobb WS 4th, Carbonell AM. A large single-center experience of open lateral abdominal wall hernia repairs. *Am Surg* 2016;82:608–12.
11. Petersen S, Schuster F, Steinbach F, Henke G, Hellmich G, Ludwig K. Sublay prosthetic repair for incisional hernia of the flank. *J Urol* 2002;168:2461–3.
12. Pezeshk RA, Pulikkottil BJ, Bailey SH, et al. An evidence-based model for the successful treatment of flank and lateral abdominal wall hernias. *Plast Reconstr Surg* 2015;136:377–85.
13. Phillips MS, Krpata DM, Blatnik JA, Rosen MJ. Retromuscular preperitoneal repair of flank hernias. *J Gastrointest Surg* 2012;16:1548–53.
14. Purnell CA, Park E, Turin SY, Dumanian GA. Postoperative flank defects, hernias, and bulges: a reliable method for repair. *Plast Reconstr Surg* 2016;137:994–1001.
15. Veyrie N, Poghosyan T, Corigliano N, Canard G, Servajean S, Bouillot JL. Lateral incisional hernia repair by the retromuscular approach with polyester standard mesh: topographic considerations and long-term follow-up of 61 consecutive patients. *World J Surg* 2013;37:538–44.
16. Wijerathne S, Malik S, Usmani F, Lomanto D. Minimally invasive repair for lateral ventral hernia: tailored approach from a hernia centre at a tertiary care institution. *Hernia* 2021;25:399–410.
17. Zhao Y, Zhang W, Shao X, Cheng T, Li J, Wu L. Transabdominal partial extraperitoneal repair of lateral hernias of the abdomen and flank. *J Laparoendosc Adv Surg Tech A* 2022;32:653–8.
18. Zieren J, Menenakos C, Taymoorian K, Muller JM. Flank hernia and bulging after open nephrectomy: mesh repair by flank or median approach? Report of a novel technique. *Int Urol Nephrol* 2007;39:989–93.
19. Muysoms FE, Miserez M, Berrevoet F, et al. Classification of primary and incisional abdominal wall hernias. *Hernia* 2009;13:407–14.
20. Beffa LR, Margiotta AL, Carbonell AM. Flank and lumbar hernia repair. *Surg Clin North Am* 2018;98:593–605.
21. Dumanian GA, Tulaimat A, Dumanian ZP. Experimental study of the characteristics of a novel mesh suture. *Br J Surg* 2015;102:1285–92.
22. Lanier ST, Dumanian GA, Jordan SW, Miller KR, Ali NA, Stock SR. Mesh Sutured repairs of abdominal wall defects. *Plast Reconstr Surg Glob Open* 2016;4:e1060.

Instructions for Authors

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GENERAL INFORMATION

The *Journal of Trauma and Injury* (J Trauma Inj, JTI) is an official publication of the Korean Society of Traumatology and an international, peer-reviewed open access journal. This journal is published four times per year, on the last day of March, June, September, and December. JTI was launched in June 1988 with publications in the Korean and English languages and was eventually converted to an English-only journal.

JTI aims to contribute to saving lives of patients who underwent traumatic events through active communication and exchange of study information on trauma and provision of education and training on trauma. Thus, the journal publishes original basic and clinical research on trauma-associated medical fields, such as surgeries (which include general surgery, chest surgery, orthopedic surgery, neurosurgery, plastic surgery, and head and neck surgery), gynecology and ophthalmology, emergency medicine, anesthesiology, neuro-psychiatrics, rehabilitation medicine, and radiology (which include interventional radiology). Due to the special circumstances Korea is under with North Korea, JTI also publishes basic and clinical research on battlefield trauma unique in Korea and has established ties with the Armed Forces Medical Command and Armed Forces Capital Hospital. Furthermore, this journal includes all items closely associated with medicine, disaster and department of emergency, emergency medical technicians and nurses, social infrastructures and systems, and government policies and supports.

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- Sample

1. Yeo KH, Park CY, Kim HH. Abdomino-perineal organ injuries caused by cultivators. *J Trauma Inj* 2015;28:60–6.
2. Mattox KL, Moore EE, Feliciano DV. *Trauma*. 7th ed. New York: McGraw Hill; 2013.
3. Burlew CC, Moore EE. Emergency department thoracotomy. In: Mattox KL, Moore EE, Feliciano DV, editors. *Trauma*. 7th ed. New York: McGraw Hill; 2013. p. 236–50.
4. World Health Organization (WHO). World health statistics 2021: a visual summary [Internet]. Geneva: WHO; 2021 [cited 2021 Feb 1]. Available from: <https://www.who.int/data/stories/world-health-statistics-2021-a-visual-summary>.
5. Sharma N, Sharma P, Basu S, et al. The seroprevalence and trends of SARS-CoV-2 in Delhi, India: a repeated population-based seroepidemiological study [Preprint]. Posted 2020 Dec 14. medRxiv 2020.12.13.20248123. <https://doi.org/10.1101/2020.12.13.20248123>.

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