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Two cases of open and video-assisted thoracoscopic approaches to superior vena cava in combat trauma in Ukraine

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Aim: to analyze the clinical features and surgical outcomes of combat-related superior vena cava injuries and to determine the optimal operative strategy considering the mechanism of injury, severity of the patient's condition, and associated thoracic damage.

Materials and methods. The article presents two clinical cases of combat trauma involving injury to the superior vena cava treated in Zaporizhzhia Military Hospital, Ukraine. Both patients sustained penetrating thoracic injuries caused by explosive fragments during hostilities. Clinical data, imaging findings, intraoperative observations, surgical techniques, and postoperative outcomes were analyzed. Two different surgical approaches were used depending on the patient's clinical condition, injury characteristics, and anatomical localization of the vascular damage: open surgical repair and video-assisted thoracoscopic surgery. Particular attention was paid to the mechanism of injury, associated thoracic damage, hemodynamic stability, and the feasibility of minimally invasive intervention in combat trauma settings.

Results. In the first case, the patient underwent open surgical repair of the superior vena cava due to the severity of injury and associated thoracic damage. In the second case, a video-assisted thoracoscopic approach was successfully used for removal of the foreign body and repair of the vascular wall. Both patients survived and demonstrated favorable postoperative outcomes without major complications. These cases illustrate that modern combat injuries caused by low-velocity fragments may allow delayed surgical management due to temporary sealing of the vascular defect by the fragment itself. This phenomenon may facilitate planned surgical intervention after evacuation to a specialized medical facility.

Conclusions. Injuries of the superior vena cava in combat trauma are rare but potentially life-threatening conditions that require prompt diagnosis and individualized surgical management. Both open surgery and video-assisted thoracoscopic techniques can be effective treatment options. The choice of surgical approach should depend on the patient's physiological status, the mechanism of injury, the extent of associated thoracic damage, and the overall survivability potential.

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Два випадки застосування відкритого та відеоторакоскопічного доступів до верхньої порожнистої вени при бойовій травмі в Україні

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Мета роботи – проаналізувати клінічні особливості та результати хірургічного лікування бойових ушкоджень верхньої порожнистої вени, а також визначити оптимальну тактику оперативного втручання, враховуючи механізм травми, тяжкість стану пацієнта та супутні пошкодження органів грудної клітки.

Матеріали і методи. Наведено два клінічні випадки бойової травми з ушкодженням верхньої порожнистої вени; пацієнти перебували на лікуванні в Запорізькому військовому госпіталі (Україна). Обидва пацієнти отримали вогнепальні осколкові проникні поранення грудної клітки під час бойових дій. Проаналізовано клінічні дані, результати інструментальних досліджень, інтраопераційні знахідки, особливості оперативного втручання та післяопераційний перебіг. Залежно від клінічного стану пацієнта, характеру поранення та локалізації ушкодження судини застосовано два різні хірургічні підходи – виконано відкриту операцію та відеоторакоскопічне втручання. Особливу увагу приділено механізму травми, супутнім ушкодженням органів грудної клітки, гемодинамічній стабільності пацієнтів і можливості застосування малоінвазивних технологій при бойовій травмі.

Результати. У першому клінічному випадку виконано відкрите оперативне втручання з ушиванням ушкодження верхньої порожнистої вени через тяжкість травми та наявність супутніх ушкоджень. У другому випадку успішно застосовано відеоторакоскопічний доступ для видалення стороннього тіла та відновлення стінки судини. Обидва пацієнти вижили, післяопераційний період мав сприятливий перебіг, минув без ускладнень. Наведені спостереження показали, що при сучасних бойових пораненнях, спричинених низькошвидкісними

уламками, інколи можливе тимчасове «герметизування» дефекту судини самим уламком, що дає змогу виконати відстрочене оперативне втручання після евакуації до спеціалізованого лікувального закладу.

Висновки. Ушкодження верхньої порожнистої вени при бойовій травмі – рідкісні, але потенційно життєво небезпечні стани, що потребують своєчасної діагностики й індивідуалізованого хірургічного підходу. Відкриті операції, як і відеоторакоскопічні втручання, можуть бути ефективними методами лікування. Вибір оперативної тактики має залежати від загального стану пацієнта, механізму травми, обсягу супутніх ушкоджень та прогнозу виживання.

Сучасні медичні технології. 2026. Т. 18, № 2(69). С. 149-154

Penetrating injuries to the superior vena cava (SVC) are rare and often fatal. Existing literature primarily describes stab wounds and gunshot injuries to the SVC, with few reports on combat-related trauma involving this vessel. The injury mechanisms observed in the Ukrainian conflict significantly differ from those reported in previous wars. Unlike prior armed conflicts, where gunshot wounds predominated, most combat-related vascular injuries in Ukraine result from blast fragments, including those from drone-detonated explosives. Notably, small, low-velocity fragments may, in some cases, embed within the vascular wall, effectively sealing the defect and preventing immediate exsanguination. This phenomenon allows for prolonged casualty evacuation and facilitates delayed but planned surgical interventions. However, in the current operational environment, prolonged evacuation times – due to tactical constraints and deliberate targeting of medical assets – often exceed the conventional "golden hour", impacting patient outcomes.

The majority of reported vena cava injuries involve the inferior vena cava [1,2]. Literature predominantly focuses on case reports, diagnostic evaluations, and management strategies that address both arterial and venous trauma, as well as contemporary approaches to reconstructive aortic surgery in complex pathologies [1,3,4]. Vascular injuries are classified into blunt, penetrating, and iatrogenic etiologies [1,2]. The largest published series of combat-related vena cava injuries, consisting of 82 cases, was reported during the Vietnam War; however, all involved the inferior vena cava [3]. Successful surgical repair of SVC injuries remains infrequent, with only a limited number of cases documented [3,5,6]. Although temporary hemostasis may be achieved through soft clot formation in certain injuries, a high index of suspicion for major vascular trauma is required [1,2,7].

The management of SVC injuries remains complex and context dependent. Permissive hypotension resuscitation strategies may be beneficial in preventing excessive hemorrhage in critically injured patients [8]. In select cases, vascular ligation has been employed as a life-saving measure [9], while in others, endovascular stenting has demonstrated efficacy in achieving hemostasis [10]. However, existing literature largely omits technical considerations for the surgical repair of SVC injuries in the setting of combat trauma, particularly those resulting from blast fragmentation. Additionally, no reported cases describe the use of video-assisted thoracoscopic (VATS) surgery for combat-related mediastinal vascular trauma.

At our Role 3 institution, we managed two cases of SVC fragment injuries, in which the retained metallic fragment functioned as a temporary vascular seal. Given that SVC injuries are both rare and highly lethal [11], these cases contribute valuable insight into the evolving understanding of combat vascular trauma and its management as part of future investigations.

Aim

To analyze the clinical features and surgical outcomes of combat-related superior vena cava injuries and to determine the optimal operative strategy considering the mechanism of injury, severity of the patient's condition, and associated thoracic damage.

Materials and methods

This study reports our experience in managing two cases of SVC injury. The study was conducted in accordance with bioethical standards and was approved by the Bioethics Committee of Zaporizhzhia State Medical and Pharmaceutical University (Protocol No. 4, dated March 12, 2026). Written informed consent was obtained from all eligible patients.

Results

Clinical case 1. Our first patient was a 45-year-old male who was injured during mortar shelling, 20 hours prior to admission. Initial medical care provided by the forward surgical team 18 hours after the injury included: occlusive dressing of the wound without drainage of the pleural cavity. During evacuation by ground assets, the patient was in stable condition without signs of blood loss or respiratory compromise.

His past medical history was notable for a 27 pack-year history of smoking, otherwise unremarkable.

On hospital admission, the patient had the following findings on physical exam: normal vital signs; coarse breath sounds, diminished on the right. On the right side of his chest, he was noted to have an entry wound in the deltopectoral groove near the shoulder joint with a 1 x 2 cm skin defect and abrasions of the wound margins, without active bleeding and no evidence for air movement.

Chest computed tomography (CT) without intravenous contrast per local protocol showed a small right-sided apical pneumothorax, 11-mm right hemothorax, intramuscular emphysema of the right chest wall, an area of focal consolidation with pneumatocele and surrounding "ground glass" opacity in the 5th segment of the right lung; 15 mm metallic foreign body at the level of the right auricle adjacent to the vena cava; and 5-mm hemopericardium *(Fig. 1)*.

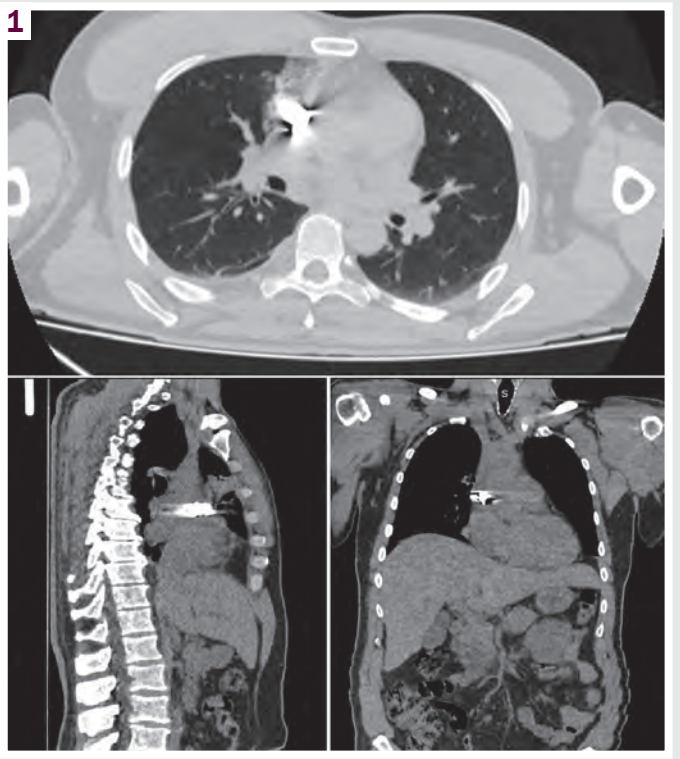

Fig. 1. Case 1, CT scan of the chest showing a metallic foreign body in the anterior mediastinum projecting over the SVC and associated with a small right-sided hemothorax and hemopericardium; double contour of the foreign body is caused by motion artefact and confirms contact with a moving structure.

With a metallic fragment localized in the anterior mediastinum near the great vessels, a high index of suspicion for vascular injury was maintained. In our surgical planning, we needed to account for control of the great vessels in the mediastinum, removal of metallic foreign body, and potential repair of presumed SVC injury.

During the surgical intervention, the patient was positioned supine with 30 degrees elevation of the right side. Following anterior thoracotomy in the 5th intercostal space, 300 mL of blood and clots were removed from the pleural cavity. On the pericardium at the confluence with the SVC, we noted a 1-cm tissue defect with the edge of a metallic foreign body protruding in the center. Any manipulations near the foreign body resulted in leakage of dark blood. Packing with surgical sponges was performed to facilitate evaluation for other injuries; the lung was freed from the inferior pulmonary ligament and tidal volume was reduced on the ventilator. A pericardiotomy was then performed anterior to the phrenic nerve. As a result, 80 mL of serosanguinous fluid was removed from the pericardial sac. A metallic fragment was localized in the wall of the intrapericardial SVC. Prior to fragment removal, the lateral wall of the SVC was elevated and clamped longitudinally without interrupting blood flow. The fragment was safely removed, and the SVC wall defect was repaired. The postoperative course was uneventful. The chest tube was removed on postoperative day 4. On postoperative day 7, the patient was evacuated to the next Role of care.

Clinical case 2. Our second patient was a 52-year-old male who was injured 9 hours prior to hospital arrival as a result of a drone strike. Five hours after the injury, he was evacuated to Role 2. Injuries included: severe penetrating head injury, penetrating right chest injury and right upper extremity trauma with vascular injury and humeral fracture. The forward surgical team at Role 2, which does not have CT or neurosurgical capability, placed a right-sided chest tube, ligated the right brachial vein, and placed an external fixator for the complex right upper extremity injury. Damage control resuscitation with 2 units of red blood cells and 2 units of plasma was performed. The patient was mechanically ventilated and further evacuated by ground to Role 3.

His past medical history was notable for 36 pack-year history of smoking, otherwise unremarkable. The patient arrived at Role 3 on mechanical ventilation with normal vital signs. Exam findings included penetrating ballistic head trauma to the right parietal region with leakage of cerebrospinal fluid through an open skull fracture; Glasgow coma score 11T; multiple fragment wounds of the posterior and lateral torso; chest tube in the right pleural cavity drained about 100 mL of blood without air leak; and right upper arm external fixator with penetrating injury of the right shoulder with soft tissue defects and ballistic fracture of the right humerus.

Initial work-up included CT of head, chest, abdomen and pelvis without contrast (per local protocol), X-rays of the right upper extremity and laboratory analysis. CT showed the following findings: penetrating fragment injury of the right parietal region of the skull and brain with pneumocephalus, ballistic penetrating injury of the right chest with a fragment at the lung base, right pneumothorax, right pulmonary contusion, pneumomediastinum,

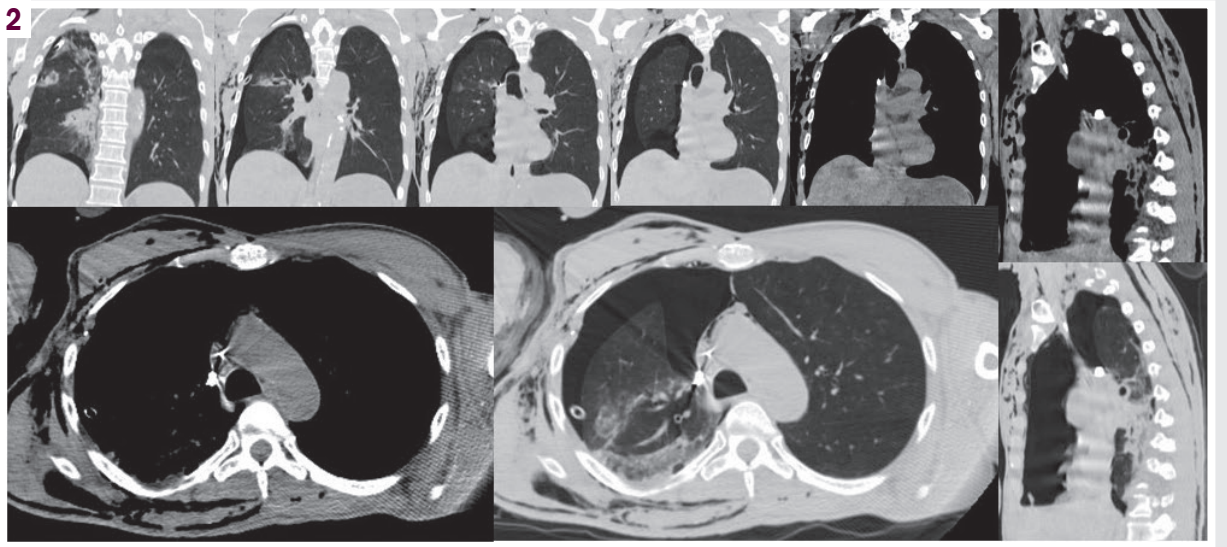

Fig. 2. Case 2, a series of CT slices of the chest showing a fragment in the SVC, also penetrating injury of the lung parenchyma, and right-sided hemopneumothorax; vascular catheter is noted in the lumen of the vessel.

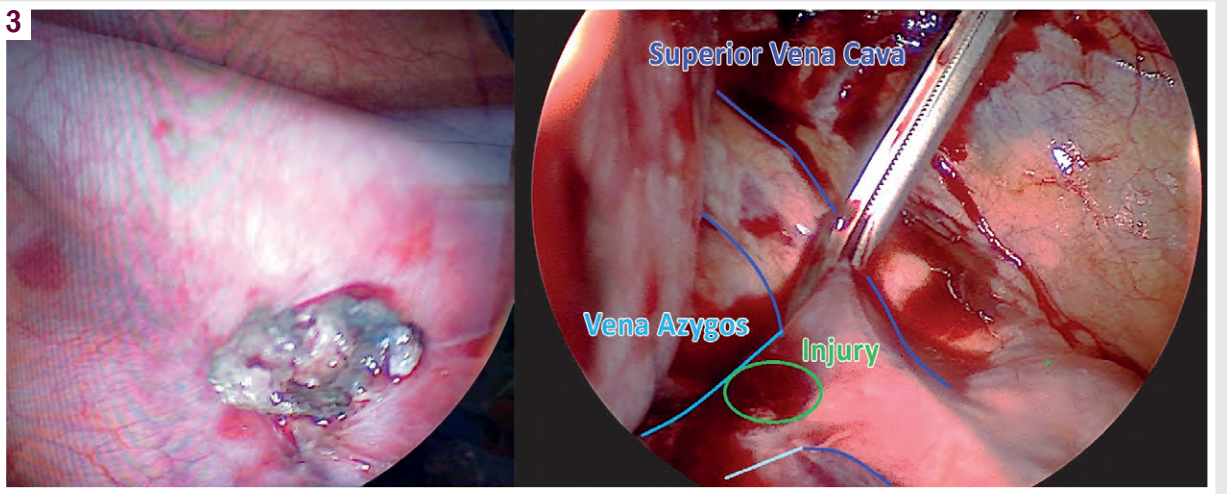

Fig. 3. Case 2, intraoperative picture of the SVC injury site, a fragment is lodged in the vessel wall; bleeding control is achieved before suturing the injury site.

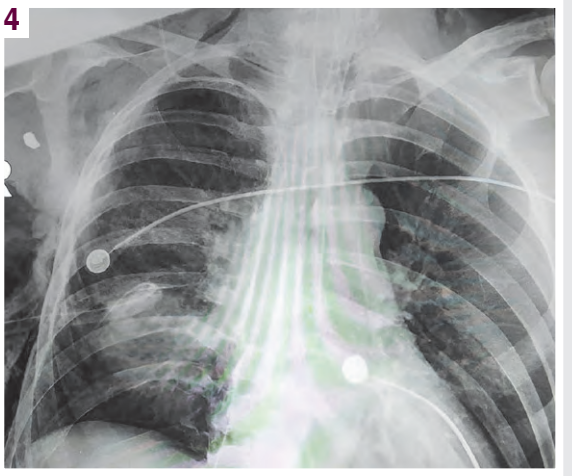

Fig. 4. Case 2, postoperative 1-view X-ray of the chest in anteroposterior projection.

and multiple fragments within the soft tissues of the back and abdominal wall. The surgical team performed an independent evaluation of the CT images and raised suspicion for a fragment injury of the SVC *(Fig. 2)*. X-ray of the right shoulder: comminuted displaced fracture of the middle third of the humerus; multiple metallic foreign bodies in the soft tissues of the neck, shoulder, and the right chest.

Pre-operative diagnosis: Blast injury. Penetrating fragment injury of the head with an entry wound in the right parietal region, metallic and bone fragments within the brain parenchyma, depressed open parietal bone fracture, cerebrospinal fluid leakage, pneumocephalus; fragments within the soft tissues of the supraorbital and parieto-occipital regions of the scalp; penetrating fragment injury of the right chest, right lung laceration, fragment injury of the SVC, right hemopneumothorax; multiple fragments within the soft tissues of the trunk; fragment injury of the right shoulder, ballistic comminuted and displaced fracture of middle third of the right humerus; right brachial vein injury and right brachial artery contusion, with multiple retained foreign bodies within the soft tissues of the right upper extremity.

Emergency neurosurgical intervention was a priority in this patient, and he was taken to the operating room for craniectomy. Wound debridement and parietal bone resection were performed; metallic and bone fragments were removed. The dural defect was closed with periosteum. Concurrently with the neurosurgical team, a second team debrided the right shoulder and repaired the neurovascular bundle of the right upper extremity. A second chest drain was placed. The patient required ongoing damage control resuscitation during the surgery due to recurrent episodes of hemodynamic instability with hypotension. During postoperative observation, his lung mostly expanded but atelectasis of the right lower lobe persisted. He did not have any further blood loss from the right pleural space, but an air leak persisted. It was known that a metallic foreign body was retained in the anterior-superior mediastinum, adjacent to the great vessels, which could potentially erode through the vessels and lead to life-threatening hemorrhage. Therefore 12 hours after the hospital admission, the decision was made to perform a right-sided VATS which revealed that the lung laceration was hemostatic and there was no air leak; a fragment was found to be lodged in the wall of the SVC above the confluence with the azygos vein. The lateral wall of the SVC was clamped longitudinally in order to isolate both the vascular defect and the foreign body *(Fig. 3)*. The fragment was removed with a magnet, and the vessel wall was closed with a lateral vascular suture. Total blood loss of 50 mL was recorded.

A repeat chest X-ray showed re-expanded lungs, post-traumatic contusion of the right upper lobe, chest wall emphysema, chest tube present in the right pleural cavity, and retained metallic fragments in the right chest *(Fig. 4)*.

On the 2nd day, the patient was transferred to the next Role of care in critical but hemodynamically stable condition, pharmacologically sedated and mechanically ventilated.

Discussion

Combat injuries in the Ukraine conflict are caused primarily by fragments due to weaponization of drones, artillery, or various ballistic missiles. A lower energy fragment, rather than lacerating a major vessel and causing fatal hemorrhage, may “breach and lodge” into the vessel wall. This phenomenon facilitates casualty survival in the setting of prolonged evacuation and delayed access to surgical care. Under such circumstances, the clinical picture alone may be misleading, and further diagnostic delays may occur. Ballistic injuries caused by fragments have very diverse intracorporeal trajectories. CT is the diagnostic modality of choice for blast injury. It allows diagnosis of injuries with localization of fragments and their trajectories. However, metallic foreign bodies also cause significant artifacts during CT scanning, which may degrade the quality of imaging and may obscure significant findings in the surrounding tissues. Furthermore, it may be difficult to determine the exact location of the fragments near moving structures such as the heart, central vessels or the diaphragm, due to the motion artifact.

Our standard protocol, used in 95 % of studies, does not include intravenous contrast during CT imaging for trauma due to limited availability of contrast agents.

Surgical planning is influenced by several factors such as mechanism of injury, duration of evacuation and the overall patient’s condition. Foreign body migration from another site should be considered [9]. Anesthesia should be administered with double-lumen endotracheal tube which allows for single-lung ventilation. This facilitates surgical access to the mediastinum and visualization during VATS. To prevent blood loss during foreign body removal and surgical repair of the SVC wall, we place vascular clamps in the longitudinal orientation on the lateral wall, along the long axis of the vessels.

Our two cases show that taking an individualized approach to surgical decision-making in case of penetrating injuries to the great vessels of the chest with foreign bodies lodged in the vessel wall, leads to best outcomes. VATS may be safely used in well-selected casualties. For best results it is also mandatory to consider the level of staff preparedness, current workload, and completeness of patient workup along with the patient’s overall condition and injury complex. Appropriate imaging modalities must be available.

Conclusions

1. In Ukraine, combat injury patterns differ significantly from what was observed in other recent conflicts. Penetrating fragment injuries predominate among the combat casualties. Furthermore, tactical conditions and deliberate targeting of medical assets lead to prolonged evacuation delays.

2. Penetrating injuries of the superior vena cava with low velocity projectiles may lead to a “breach and lodge effect”. Fragments get lodged in the vessel wall and temporarily function as a “vascular patch”. In such settings, when vascular intervention is neither necessary nor feasible immediately following the injury, surgeons may have time to optimize operative planning.

3. In carefully selected patients, video-assisted thoracoscopy is a viable option for surgical repair of the penetrating injuries to the great vessels of the chest.

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