Migration of a Shrapnel Embolus into the Inferior Vena Cava after a Mine-Blast Liver Injury, Managed with Magnet-Assisted Extraction: A Case Report

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Received: 30 June 2025

Accepted: 5 November 2025

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DOI 10.5001/omj.2029.22

Abstract

Missile embolism by a bullet or shrapnel fragment is an extremely rare but potentially lethal complication of penetrating trauma, especially when the fragment migrates to a major vein such as the inferior vena cava (IVC). Such intravascular fragments can cause life-threatening sequelae, including cardiac valve damage, pulmonary artery embolism, or even sudden death. We present the case of a 49-year-old serviceman who sustained a severe thoracoabdominal blast injury from a mine explosion in combat. He arrived in hemorrhagic shock and underwent damage-control surgery with an urgent laparotomy and liver packing to control hemorrhage. After initial stabilization, postoperative imaging revealed a ~10 mm metallic fragment in the IVC. Within 24 hours, repeat scans confirmed that the fragment had migrated into the IVC lumen. An attempt to retrieve it at a field hospital was unsuccessful, and the patient was then transferred to a tertiary center for definitive care. On the eighth day after injury, a multidisciplinary team performed an open surgical procedure via a transdiaphragmatic approach to expose the suprahepatic IVC. Under intraoperative fluoroscopic guidance, a small venotomy was made, and a high-strength (~0.5 Tesla) neodymium magnet encased in a sterile cover was used to attract and extract the fragment from near the cavo-atrial junction. The venotomy was then sutured closed. The postoperative course was uneventful, with no procedure-related complications. The patient was discharged on postoperative day 14 and continued therapeutic anticoagulation for three months. At a 3-month follow-up, he remained asymptomatic, and imaging confirmed normal venous patency with no residual fragments. This case highlights the importance of early diagnosis, thorough imaging, multidisciplinary planning, and innovative techniques such as magnet-assisted extraction in successfully managing rare combat-related vascular emboli.

Keywords: Missile embolism; Inferior vena cava; Blast injuries; Magnetic extraction; Liver trauma.

Introduction

Abdominal combat injuries account for ~7-9% of wounds, with liver trauma carrying high mortality primarily due to hemorrhage. An even rarer complication is missile (bullet/shrapnel) embolism of the inferior vena cava (IVC).[1-5] Migration of a bullet or fragment within the vasculature can have fatal consequences - cases of heart valve dysfunction, pulmonary artery embolism, and sudden death have been reported.[6] As only isolated reports of migrating shrapnel emboli to the IVC exist in the literature, this case is of practical interest for surgeons regarding

the diagnosis and treatment of this complication. Because of the rarity of missile embolism, there are no standardized management guidelines, decisions are necessarily individualized.[7]

Case Report

A 49-year-old Ukrainian serviceman sustained severe chest and abdominal injuries due to a mine-blast during combat. At a forward surgical unit, an urgent laparotomy was performed to control hemorrhage (damage-control surgery with liver packing, removal of a fragment of the 10th rib, and massive blood transfusion). On arrival, the patient's hemodynamic status had stabilized (blood pressure ~120/75 mmHg, heart rate ~92 bpm). Initial laboratory tests revealed a hemoglobin of 105 g/L (indicating moderate anemia), leukocytosis with WBC 17.7×10^9/L, hypoproteinemia with total protein 41.9 g/L, and elevated liver enzymes (ALT 222 U/L, AST 160 U/L). Computed tomography (CT) scan on Day 2 showed a ~10×8 mm metallic fragment in hepatic segment VIII; on repeat imaging within 24 h the fragment had migrated into the IVC lumen (Figure 1). A surgical attempt to remove the fragment at a field hospital was unsuccessful. Although the unsuccessful cavotomy at the field hospital had no immediate complications, it likely contributed to cephalad displacement of the fragment. This experience prompted a planned open approach at a tertiary center with cardiothoracic backup.

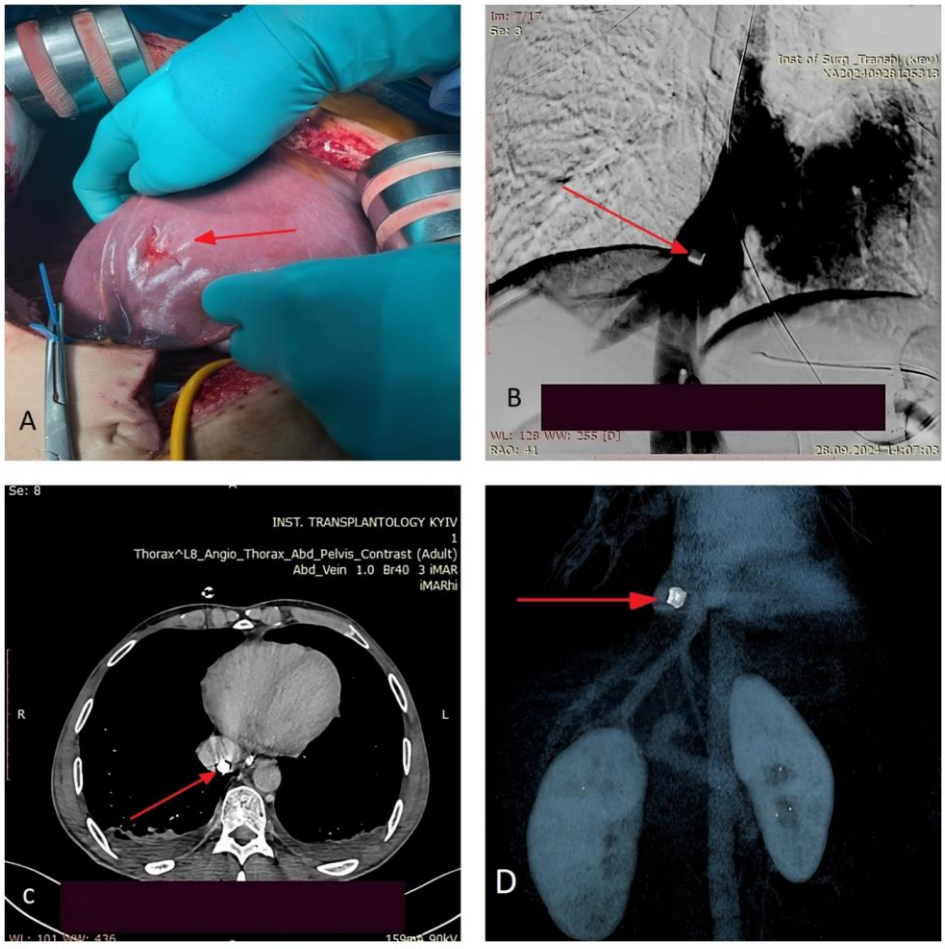

Figure 1: (A) Entry wound in the right liver lobe (arrow). (B) IVC venography showing the fragment in the supradiaphragmatic IVC (arrow). (C) Axial contrast-enhanced CT confirming the fragment along the posterior suprahepatic IVC wall (arrow). (D) 3D-CT reconstruction showing fragment position relative to major vessels (arrow).

An endovascular approach was deemed high-risk due to the fragment's cavo-atrial location and recent abdominal operations; therefore, we planned an open transdiaphragmatic approach with full vascular control. On the eighth day post-injury, a repeat open surgical procedure was performed to extract the fragment. The existing midline laparotomy incision was reopened and extended to the right, and a transdiaphragmatic approach was used to expose the suprahepatic segment of the IVC. Under intraoperative fluoroscopic guidance (Figure 2A), vascular control included clamping the IVC below the hepatic veins and just below the diaphragm, with a Pringle maneuver to minimize hepatic inflow. Following a small anterolateral venotomy of the suprahepatic IVC, a sterilized high-strength neodymium magnet (approximately 0.5 Tesla) enclosed in a sterile cover was introduced through the venotomy to retrieve the metallic fragment. The procedure was performed under strict aseptic conditions, ensuring effective magnetic capture of the fragment. The cavotomy was subsequently closed with a continuous 5-0 prolene suture. The postoperative period was uneventful. He remained on therapeutic anticoagulation for three months after discharge. At a 3-month follow-up visit, the patient was asymptomatic, and repeat ultrasound confirmed normal venous patency with no recurrent emboli or residual fragments. The extracted fragment is shown in Figure 2B.

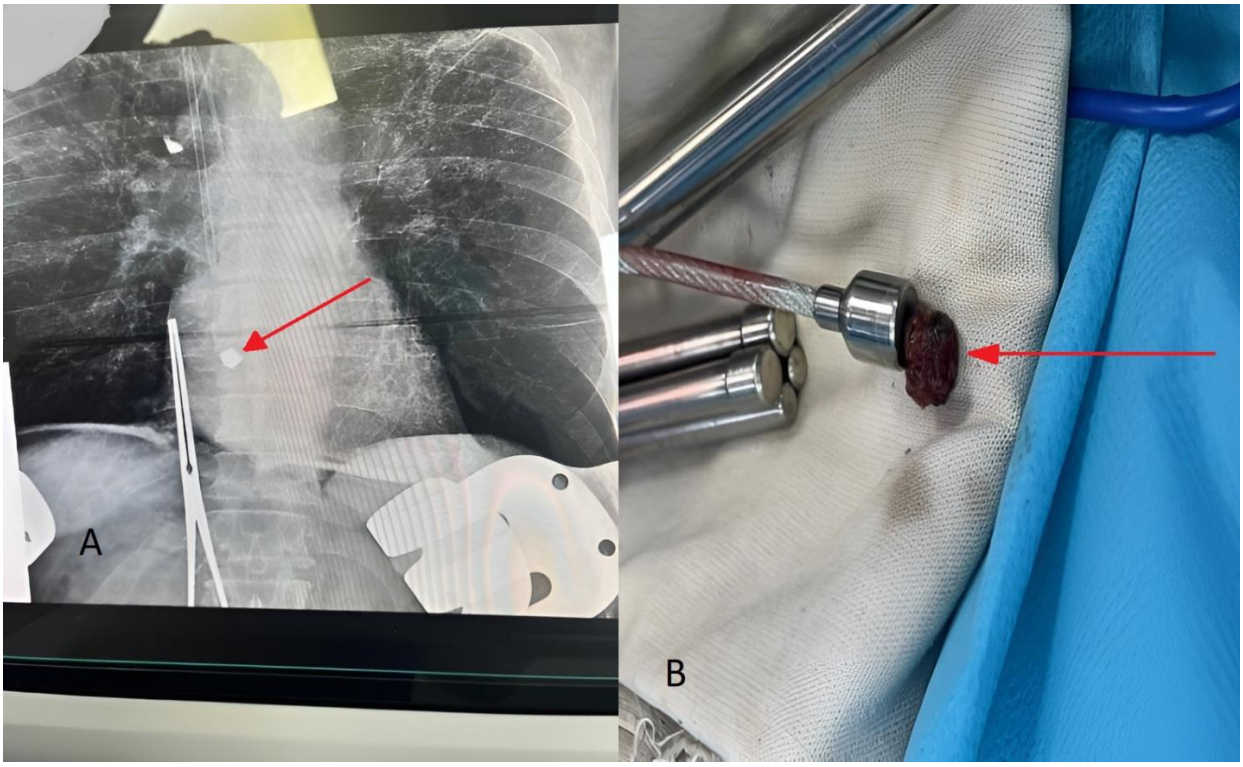

Figure 2: (A) Intraoperative fluoroscopy showing the fragment at the IVC–right atrium junction (arrow), a location carrying high risk of cardiac embolization. (B) Extracted ferromagnetic shrapnel (~10 mm) immediately after magnet-assisted removal, confirming successful retrieval without the need for cardiopulmonary bypass.

Discussion

This case illustrates a rare but serious complication of combat trauma. Notably, at the site where the fragment entered the IVC, surgery revealed a healed (~10 mm) defect in the caval wall, likely sealed by the fragment itself. Such a mechanism of spontaneous plugging of a venous injury by the fragment has been described in other reports of shrapnel embolism.[8] Early damage-control surgery and staged treatment were critically important for this patient's survival.

Shrapnel (missile) embolism is an extremely rare phenomenon - only a few hundred cases have been documented in over a century - yet its consequences can be severe. Potential complications include cardiac valve damage, infection, pulmonary embolism, and stroke.[7] A high index of suspicion is required for diagnosis; key

indicators are the absence of an exit wound and the "migration" of the projectile on sequential imaging. Owing to the rarity of such cases, clear management guidelines are lacking, and treatment strategy is determined on a case-by-case basis.[12] Arterial bullet or shrapnel emboli usually require urgent removal to prevent ischemia. The management of venous emboli is more debated; however, many authors recommend removal in nearly all cases given the risk of life-threatening complications, especially if the fragment is mobile (migrating).[9] From a practical standpoint, decisions should consider the fragment's size and location as well as the patient's condition. Fragments located near the heart or in the pulmonary circulation (particularly those larger than 5 mm) should be removed if possible. In some cases, minimally invasive endovascular retrieval methods have been successful-using intravascular snares or baskets.[10] In our case, an endovascular approach was deemed too risky due to the fragment's location at the IVC-right atrium junction and the recent abdominal surgeries; therefore, an open surgical approach was chosen, with a cardiothoracic surgical team on standby.

A unique aspect of this case was the use of a magnet to retrieve the embolus. Many war-related metal fragments are ferromagnetic. In our case, the retrieved ~10 mm shrapnel fragment was strongly attracted to a magnet, consistent with an iron-containing (ferrous) composition. Exploiting this property can simplify extraction. This technique has been described in at least one similar case.[11] By using a powerful magnet to extract the fragment from the IVC, a much more invasive procedure was avoided (such as atriotomy or the use of cardiopulmonary bypass).

Given the variability of these situations, there are no standardized protocols for managing shrapnel embolism, and each case should be handled individually.[12] However, recent case reports of bullet and shrapnel emboli in various parts of the vascular system (including the hepatic veins and cardiac chambers) underscore the need for high vigilance and timely diagnosis and, when possible, prompt removal of the intravascular foreign body to prevent severe complications.[13-15]

Endovascular retrieval is less invasive and has been successful in selected large-vessel cases but may lose control near the cavo-atrial junction. Open surgery is more invasive yet provides definitive vascular control, which is crucial when fragments are large, mobile, or adjacent to the heart. Magnet-assisted extraction leverages ferromagnetism to simplify retrieval and may avoid atriotomy or cardiopulmonary bypass (CPB) when a fragment lies high in the IVC or near the right atrium. Selection criteria include size (>5 mm), mobility, proximity to the heart/pulmonary artery, material, and patient stability. In our case, the fragment's cavo-atrial location, size, and documented migration favored an open, magnet-assisted strategy with cardiothoracic backup. The timely open magnet-assisted retrieval prevented critical complications such as the fragment migrating into the heart or pulmonary artery (which could have caused valvular damage, massive pulmonary embolism, or even sudden death). This approach obviated the need for riskier measures like atriotomy and cardiopulmonary bypass and resulted in no procedure-related complications (no thrombosis, no infection), effectively mitigating the major risks inherent to a migrating intravascular foreign body. This approach likely avoided sudden embolization to the heart or pulmonary artery and obviated a more invasive atriotomy/CPB, while maintaining direct vascular control.

Additionally, recent case reports in the Oman Medical Journal have highlighted related trauma scenarios. For example, Umar et al. reported a case of a bullet fragment lodged in the bulbar urethra causing urinary retention,[16] and Muhanna et al. described the surgical management of an isolated iliac vein injury in blunt trauma.[17] These reports underscore the diverse challenges in managing ballistic and vascular injuries.

Notably, a recent case report in Oman Medical Journal documented an intravascular foreign-object migration - a 3 mm embolization coil that inadvertently traveled to the patient's right atrium.[18] This illustrates that even iatrogenic materials can embolize to the heart, reinforcing the importance of prompt removal of intravascular fragments to prevent severe outcomes.

Conclusion

Shrapnel embolism into the venous circulation is a rare complication of penetrating trauma, but its consequences can be extremely serious. Clinicians should maintain a high level of suspicion for missile embolism in injured patients-especially when the location of a fragment cannot be explained by the presumed trajectory of the wound. If emboli are detected (arterial or high-risk venous), most should be removed whenever feasible to prevent severe

complications. This case highlights that timely hemorrhage control, careful imaging surveillance, and innovative surgical approaches can achieve a successful outcome even in the setting of a rare and life-threatening combat injury.

Acknowledgments

The authors thank the medical and surgical teams involved in the care of this patient. A portion of the manuscript was translated from Ukrainian to English using artificial intelligence-assisted tools; all translations were reviewed, edited, and approved by the authors for accuracy and clarity.

Dislcosure

All patient data were fully anonymized. Written informed consent for treatment and for scientific use of clinical data was obtained. Institutional ethics confirmation is available upon request (see the separate Consent document submitted with this manuscript). The authors declare no conflicts of interest.

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