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CASE REPORT **Open Access**

Management of gunshot injury to the abdominal aorta and inferior vena cava: a case report of a combat patient wounded in the Russo-Ukrainian war

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Abstract

Background Russo-Ukrainian war is associated with severe traumas, including injuries to the major vessels. Penetrating aortic injury remains one of the most difficult injuries; the mortality rate is 90–100% in case of gunshot wounds, associated with frequent lethal outcomes due to uncontrolled bleeding. Of the three main abdominal veins, the inferior vena cava (IVC) is the most frequently damaged, which is required quick and appropriate surgical decisions to be made. Little is known about the management of gunshot injuries to such major vessels as the aorta and IVC. It is also worth mentioning about the importance to share our practical experience from the ongoing war for better understanding and future considerations by war surgeons of the vascular trauma management. The aim of the study was to demonstrate the specific features of the diagnosis and management of a gunshot shrapnel blind penetrating wound to the abdomen with injury to the aortic bifurcation level and the infrarenal section of the inferior vena cava.

Case presentation A 44-year-old male soldier of the Armed Forces of Ukraine received a gunshot injury to the abdomen from a mortars' explosive shelling. The patient was evacuated to the Forward Surgical Team (Role 1) and received primary surgical treatment within one hour after the injury according to the "golden hour" principle. Then, evacuated was performed to the Role 3 hospital in Kharkiv. At the Role 3 hospital, the patient underwent second-look surgery as well as damage control surgery. At revision, no active bleeding was observed, and the surgical pads (packed previously by the Forward Surgical Team) were removed. Further revision showed a metal projectile within the aortic wall at the level of aortic bifurcation and wall defects were also detected for inferior vena cava. This metal projectile was removed by using the multifunctional surgical magnetic tool followed by suturing of the aortic wall defect as well as defects of the inferior vena cava.

Conclusions Application of Damage Control Surgery is a useful approach in the management of severe vascular injury as well as useful to stop abdominal contamination by intestinal contents. The application of a surgical magnetic

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tool for the searching and removal of ferromagnetic foreign bodies reduces operative trauma and reduces the time for identification of foreign bodies.

Introduction

Vascular injuries are common in warfare, demonstrating five times more frequent incidence in modern wars because of the application of high-energy weapons, causing severe damage to tissues [1–6]. Also, one out of five (20%) combat wounds are diagnosed with bleeding from unspecified sources, associated with significant blood loss. Vascular injury is considered one of the most severe injuries. It is associated with significant damage of soft tissues, thoracoabdominal gunshot injuries, limb amputations, or lethal outcomes [1, 3, 7]. The high-energy weapon is associated with severe damage to military personnel, including vascular injury, as shown in clinical and experimental studies [4, 5, 7–10]. Vascular trauma is frequent in combat casualties, constituting up to 12% in Operation Iraqi Freedom and Operation Enduring Freedom, which is higher by 1–3% as compared to WWII, the Vietnam War, and the war in Korea. The frequency of gunshot injuries to the major abdominal vessels is 1.7–7.8% during the ATO/OOC (i.e. hybrid period of Russo-Ukrainian war 2014–2022) [11].

Penetrating aortic injury remains one of the most difficult injuries; the mortality rate is 90–100% in the case of gunshot wounds, associated with frequent lethal outcomes due to uncontrolled bleeding [12, 13]. The possible clinical outcomes in patients after the gunshot injury to the aorta are aortocaval fistula or aortic pseudoaneurysm formation, which should be considered in the patients' follow up. There are different options for the management of aortic gunshot injuries such as open surgery or peripheral balloon embolization. In almost all cases, urgent surgical treatment is indicated to prevent immediate death. Patients wounded by small-caliber, low-velocity bullets with hemorrhage in the aortic wall almost always survive.

Of the three main abdominal veins, the inferior vena cava (IVC) is the most frequently damaged, which is required quick and appropriate surgical decisions to be made. The overall incidence of IVC injuries ranges from 0.5 to 5% of penetrating injuries and 0.6–1% of blunt injuries. Approximately 30–50% of patients will die before reaching the hospital due to exsanguination or associated injuries. Of those who survived at admission, 20–57% patients die during operations due to severe blood loss or during postoperative period due to shock [14]. In previous publications, we have reported features of a vascular gunshot injury, however, little is known about the management of gunshot injuries to such major vessels as the aorta and IVC. It is also worth mentioning about the importance to share our practical experience from the ongoing war for better understanding and future considerations by war surgeons of the vascular trauma management [3, 4, 15]. The aim of the study was to demonstrate the specific features of the diagnosis and management of a gunshot shrapnel blind penetrating wound to the abdomen with injury to the aortic bifurcation level and the infrarenal section of the inferior vena cava.

Case presentation

A 44-year-old male soldier of the Armed Forces of Ukraine received a gunshot injury to the abdomen from a mortars' explosive shelling. The patient got first medical aid at the place of injury within 10 min (according to the principle "platinum minute") and within one hour (principle "golden hour") was transported to the Forward Surgical Team, which is in line with the Military Medical Doctrine of Ukraine [16]. At the Forward Surgical Team, the patient's condition was extreme, he had undergone laparotomy and revision of abdominal and retroperitoneal cavities, followed by right hemicolectomy, suturing of defects of the small intestine, obstructive resection of jejunum, retroperitoneal hematoma evacuation (300 ml), lavage and drainage of the abdominal cavity. Intra-abdominal packing with laparotomy pads was performed for the right abdominal flank to temporarily control hemorrhage. The patient was also undergone for primary surgical debridement for wounds of the upper and lower limbs as well as fasciotomy of the right femoral area. The time of operation was 90 min at the stage of management by the Forward Surgical Team. Considering the severity, the patient was transported to the higher level of medical care, which is the Military Medical Clinical Center of Northern Region (i.e. Role 3 hospital) of Command of Medical Forces of Armed Forces of Ukraine located in Kharkiv city within 4 h. At admission, the patient's severity status was judged as moderate. At Role 3 hospital, the patient was evaluated by ultrasonography using FAST-protocol for the abdomen and chest (Sonosite Micromaxx, 2017) showing an absence of free fluid in both the abdomen and chest. The blood test included routine clinical chemistry, biochemical analyses, coagulation analyses, and blood typing. A whole-body multispiral computed tomography (CT) scan was used with a 0.5 mm slice image (Toshiba Activion 16 machine, Japan). The arterial phase of the CT scan showed a foreign body of metal density (i.e. metal projectile), located in the aortic wall at the level of aortic bifurcation, but without signs of blood extravasation (Fig. 1).

24 h after the admission to the Role 3 hospital, the patient underwent second-look surgery. At revision,

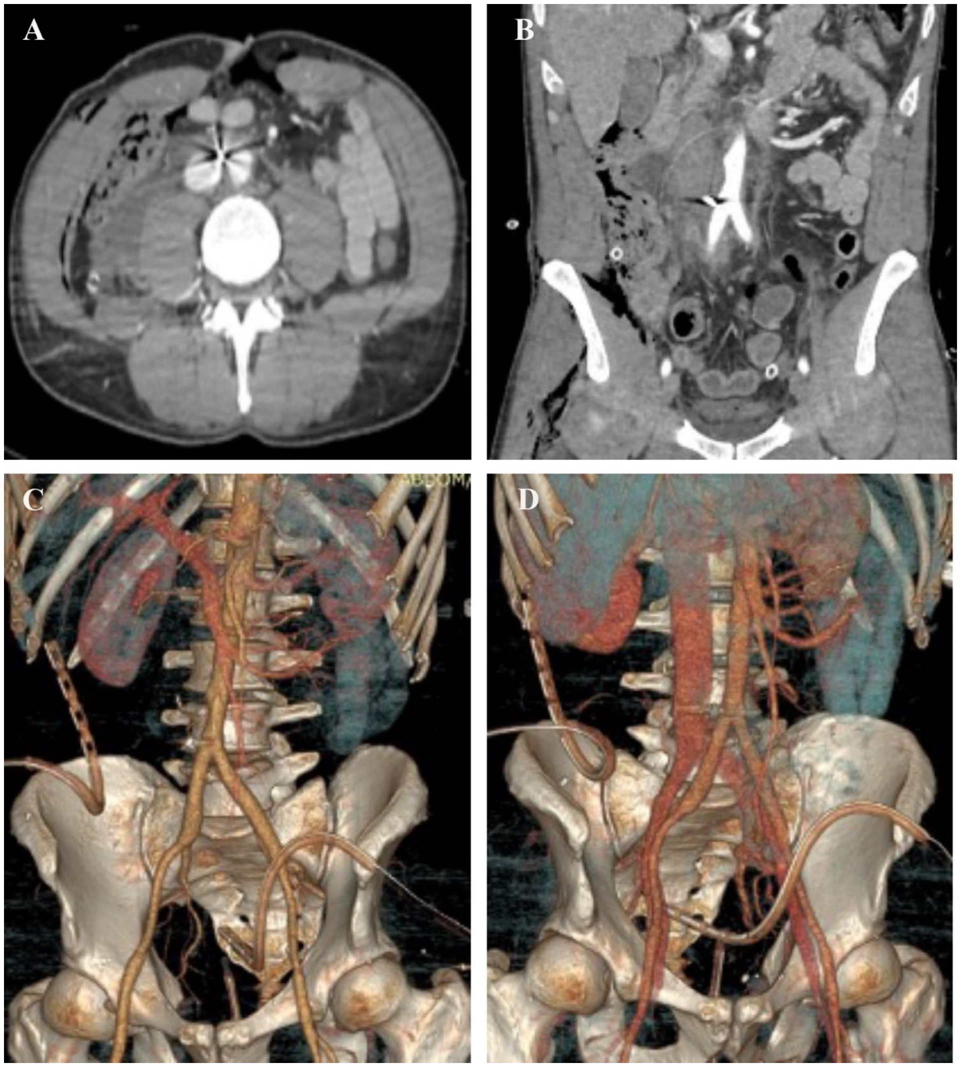

Fig. 1 CT scan image at admission to the Role 3 hospital illustrating metal fragment in the retroperitoneal space in area of aortic bifurcation, free air in the abdomen, abdominal packing with laparotomy pads in right abdomen, two drainage tubes, closes laparostomy: in axial projection **(A)**, coronal projection **(B)**, 3D modeling of arterial phase of a CT scan **(C)**, 3D modeling of venous phase of a CT scan

no active bleeding was observed, and the surgical pads were removed. Further revision showed a metal projectile within the aorta wall at the level of aortic bifurcation and wall defects were also detected for inferior vena cava. This metal projectile was removed by using the multifunctional surgical magnetic tool followed by suturing of the aortic wall defect as well as defects of the IVC. The operation ended with an ileostomy and drains to the abdomen were placed.

48 h after the injury, the patients underwent third-look surgery in order to revise the abdominal cavity, the right parts of the extraperitoneal space, to remove surgical pads. At third look revision, liver, spleen, stomach, and duodenum were identified in normal state. Resected parts of the jejunum and transverse colon were without pathological changes. The revision of the area of aortic bifurcation showed hematoma without sign of tension. The possible presence of the metal shell was suspected and revision of that hematoma was performed by using a multifunctional surgical magnetic tool using previously described protocols. In brief, the metal fragment is usually identified by X-ray or CT-scan. During the operation, if available, we use C-arc and insert magnetic tool to the area of the metal fragment location. The choice for the specific magnetic tool shape depends on the metal fragment contours and locations. Frequently, the metal fragment is fixed and rotated by the endoscopic forceps for reliable catching by the magnetic tool and its subsequent removal from the body [17, 18]. At the revision of the hematoma, the metal fragment was identified and removed. After the removal of small metal shell, the active aortic bleeding started and we stopped it by proximal and distal application of surgical clamps. We

hypothesize that hematoma caused compression to the defect in the aorta, which prevented the bleeding in first place.

Further revision showed perforations of both the aorta and IVC in the area proximal to the aortic bifurcation. These defects were sutured. The blood loss was 300 ml. The time of operation was 90 min and stages of operation are illustrated in Fig. 2.

In 2 days after the restoring of aorta wall integrity, the fourth look revision was performed for the abdomen, right retroperitoneal space, removal of gauze packings, application of ileotransverse anastomosis. Sanitation and redraining of the abdominal cavity. At revision of the aorta and IVC defect areas we observed no pathological changes (Fig. 3).

In the postoperative period, intestinal motility was restored on the 4th day after the operation. The draining tubes from the abdominal cavity were removed on the 5th day and sutures on the 14th day. During the treatment at Role 3 hospital, the patient was administered antibiotic therapy, infusion therapy, anticoagulants, and painkillers. The patient was discharged from the inpatient department on the 21st day after the surgery and continued rehabilitation at Role 5 hospital.

Discussion

Abdominal gunshot wounds with simultaneous damage to both the aorta and IVC are very uncommon in wars, whereas separate injuries to those vessels are more common with frequent lethal outcomes [11, 19–21]. This case report is consistent with our previous publications and another example of possibilities to apply highly-specialized surgical care nearby to the battlefield line (Role 3 hospital) in Kharkiv city, which is close to the border with Russia. In this case report we also emphasized the importance of damage control surgery and application of surgical magnets to treat our patient with severe gunshot injury as we also showed in our previous reports [3, 17, 22]. It is also another example of what kind of trauma Ukraine's war surgeons deal with and how we can achieve excellent outcomes in the management of severe gunshot injuries at the high risk of artillery strikes on medical facilities by the russian army. It is also important to inform global surgical community about the achievement in combat trauma, which might help to other military doctors and may as well be included in possible investigations by artificial intelligence [23].

MEDEVAC is the suggested standard for medical evacuation worldwide [24]. However, there is a high risk for medical evacuation in the Roles 1–2 hospital in Ukraine due to the high activity of Russian air forces, attempting to shut down any vehicles, including sanitary transport with attacks on both combat and civil medical facilities [3, 4, 9, 15, 22, 25–30].

Pocivavsek et al. demonstrated a case of a thoracoabdominal gunshot wound with trans-diaphragmatic trajectory features of the projectile. The authors also applied the FAST protocol and simultaneous laparotomy and thoracotomy were also performed. Similar to our situation, manual bleeding control was applied followed by clamp application and suturing of aortic defect [31].

Baldwin et al. presented the case of intubated patient who was admitted to the tertiary center 6 h after the injury. The authors also applied drainage to the chest followed by the application of endovascular repair surgery [12]. Branco et al. showed an investigation of early trauma deaths among 25,428 cases, which was associated with a high rate at the trauma care civil hospitals. However, a decreased mortality rate was associated with the application of endo-vascular procedures, which might be considered in gunshot injury to the aorta in civil conditions [21]. The authors discussed the advantages and disadvantages of using open surgery vs. endovascular repair of gunshot aortic injuries [21]. To our best knowledge, endovascular repair has not been yet introduced in combat conditions. However, other advanced technologies such as minimally invasive surgery or hemodialysis might likely be also considered at a hospital of Role 3 or even Role 2 in the Russo-Ukrainian war, considering that this warfare is associated with unexpected challenges such as complicated evaluation of the patients to the appropriate level of medical care. However possible costs for such an equipment should be considered in Ukraine which is a country with limited medical resources as well as bad planning for medical provision [4, 15, 22, 23, 26, 32]. Another possible alternative for the management of gunshot injury to the aorta is resuscitative endovascular balloon occlusion of the aorta (REBOA), which was presented by Northern et al. in the study of combat injury [33]. The authors showed the high utility of REBOA, which is improved damage control resuscitation (DCR) [33]. In contrast to our study, but in line with Northern et al., Campbell et al. presented a study of vascular injuries with the application of resuscitative thoracotomy, resuscitative endovascular REBOA, and whole blood emergency donor panels [34].

In line with other authors, DCR plays an important role in saving patients in the Russo-Ukrainian war [34]. The application of REBOA seems appropriate for our patients, and it might be introduced at Role 3 hospitals in Ukraine. Similar to others and based on our experience, we have applied damage control surgery and damage control resuscitation to also manage severe vascular trauma. Damage control surgery allows to achieve better results of the management at Role 2 hospital as well as to prepare the patient for the management at the higher level of medical care (Role 3 and 4 hospitals) [16, 20, 30, 35–38]. As we have shown previously, the application of

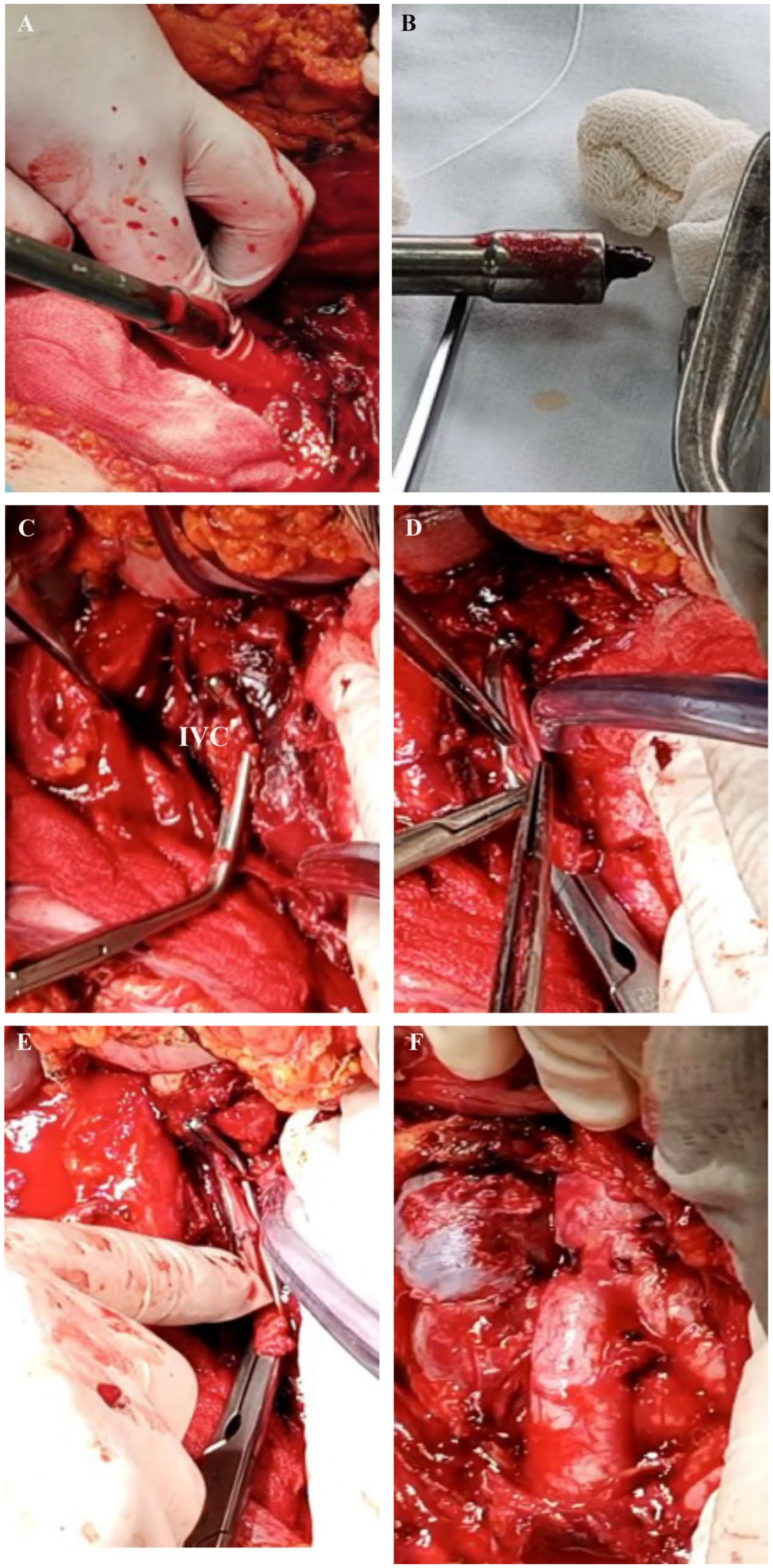

Fig. 2 Illustration of the surgical stages: **A** – removal of the metal fragment from aortic wall with application of surgical magnetic tool followed by pressure of the aortic defect by digit; **B** – photgraph of the removed metal projectile; **C** – application of the Satinsky clamp to inferior vena cava (IVC); **D** – photgraph illustrating preformation in the IVC; **E** – photgraph illustrating suturing of the IVC; **F** – view of the operation filed of the sutured aorta and IVC without signs of bleeding

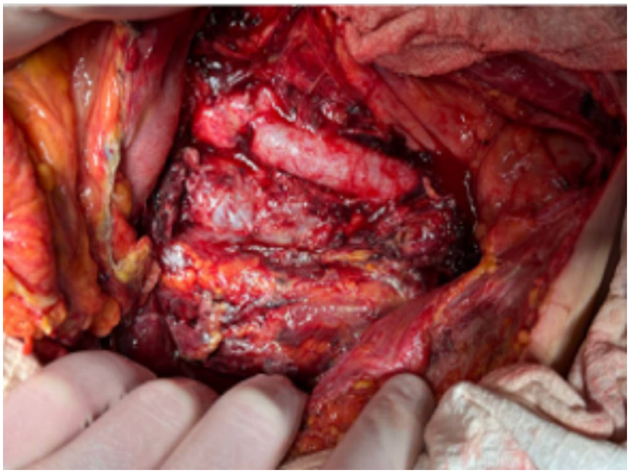

Fig. 3 Intraoperative view of the aorta and inferior vena without signs of bleeding in the area of gunshot defects indicating consistency of the sutures at the 4th postoperative day

the surgical magnetic tool (designed and manufactured in Ukraine) is associated with the distinct removal of metal fragments in patients with gunshot injuries [17, 18, 22, 26]. Similar to others and based on our experience, we have applied surgical magnets to treat the patient due to their high effectiveness in removing ferromagnetic shells [18, 22]. In line with Jaha et al., we also conducted a revisions (second, third, fourth looks) surgery and observed hematoma in the area of aorta injury [39]. However, in contrast to that study, we used a surgical magnetic tool to remove the projectile. Our results show the utility of surgical magnetic tool application to significantly minimize surgical trauma and shorten the time of surgical intervention.

Conclusions

Application of Damage Control Surgery is a useful approach in the management of severe vascular injury as well as useful to stop abdominal contamination by intestinal contents. The application of a surgical magnetic tool for the searching and removal of ferromagnetic foreign bodies allows for minimized operative trauma and reduces the time of identification of the foreign body.

Author contributions

IL – designed the study, drafted manuscript, literature search, and analyses. EK - study conception and design, collected the data; VM – study conception and design, collected the data; VN – designed the study, acquisition of data, drafted manuscript, literature search, and analyses; SS – study conception and design, collected the data, preparation of figures; YB – drafted the manuscript; MG – literature search and analyses; AD – analysis, and interpretation of data, critical revision and supervision; final approval, submission of the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethical Committee at the Kharkiv National Medical University (Kharkiv, Ukraine). The study was performed by the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Written informed consent was obtained from the participant.

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests

The authors declare no competing interests.

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References

1. Rogovskyi VM, Gybalo RV, Lurin IA, Sivash YY, Oklei DV, Taraban IA. A case of Surgical Treatment of a gunshot wound to the Left Scapular Region with damage to the distal axillary and proximal brachial arteries. World J Surg. 2022.
2. Nitecki SS, Karram T, Ofer A, Engel A, Hoffman A. Vascular injuries in an urban combat setting: experience from the 2006 Lebanon war. Vascular. 2010;18(1):1–8.
3. Gybalo RV, Lurin IA, Safonov V, Dudla DI, Oklei DV, Dinets A. Retained bullet in the neck after gunshot wounds to the chest and arm in combat patient injured in the war in Ukraine: a case report. Int J Surg Case Rep. 2022;99:107658.
4. Rogovskyi VM, Koval B, Lurin IA, Gumeniuk K, Gorobeiko M, Dinets A. Temporary arterial shunts in combat patient with vascular injuries to extremities wounded in russian-ukrainian war: a case report. Int J Surg Case Rep. 2023;102.
5. Tsymbaliuk V, Lurin I, Gumeniuk K, Herasymenko O, Furkalo S, Oklei D, et al. Modeling of wound ballistics in biological tissues using engineering simulatoin software. Medicni Perspektivi. 2023;28(1):37–48.
6. Ratnayake A, Worlton TJ. Military history of vascular Injury Taxonomy with a View toward Future Consensus. Mil Med. 2022;187(5–6):116–8.
7. Tsema IV, Bespalenko AA, Dinets AV, Koval BM, Mishalov VG. Study of damaging factors of contemporary war, leading to the limb loss. Novosti Khirurgii. 2018;26(3):321–31.
8. Gumeniuk K, Lurin I, Tsema I, Susak Y, Mykhaylenko O, Nehoduiko V, et al. Woundary ballistics of biological tissue's plastic deformation on the model of ballistic plastiline using hollow point and shape-stable bullets. J Educ Health Sport. 2021;11(11):37–57.
9. Tertyshnyi SV, Lurin I, Khomenko IP, Gumeniuk KV, Shapovalov VY, Nehoduiko VV, et al. A new approach for reconstruction of the gunshot defect of the flexor surface of the ungual (distal) phalanx by the proper transverse branch of the digital artery: a case report of combat patient injured in the russo-ukrainian war. Scand J Trauma Resusc Emerg Med. 2023;31(1):64.
10. Gumeniuk K, Lurin IA, Tsema I, Malynovska L, Gorobeiko M, Dinets A. Gunshot injury to the colon by expanding bullets in combat patients wounded in

hybrid period of the russian-ukrainian war during 2014–2020. BMC Surg. 2023;23(1).
11. Rogovsky V, Nagalyk M, Shepetov M. Angiosurgical assistance during the Joint Force operation in eastern Ukraine in the period from 2014 to 2020. Curr Aspects Military Med. 2020;27(2):145–52.
12. Baldwin ZK, Phillips LJ, Bullard MK, Schneider DB. Endovascular stent graft repair of a thoracic aortic gunshot injury. Ann Vasc Surg. 2008;22(5):692–6.
13. Nyberger K, Caragounis EC, Djerf P, Wahlgren CM. Management and outcomes of firearm-related vascular injuries. Scand J Trauma Resusc Emerg Med. 2023;31(1):35.
14. Usman R. Management of Traumatic Abdominal Inferior Vena Cava Injuries and predictors of its mortality. J Surg Pakistan. 2019;24(3):110–5.
15. Tertyshnyi SV, Lurin I, Khomenko IP, Gumeniuk KV, Shapovalov VY, Nehoduiko VV et al. A new approach for reconstruction of the gunshot defect of the flexor surface of the ungual (distal) phalanx by the proper transverse branch of the digital artery: a case report of combat patient injured in the russo-ukrainian war. Scand J Trauma Resusc Emerg Med. 2023;31(1).
16. Kazmirchuk A, Yarmoliuk Y, Lurin I, Gybalo R, Burianov O, Derkach S et al. Ukraine's Experience with Management of Combat Casualties Using NATO's Four-Tier Changing as Needed Healthcare System. World J Surg. 2022.
17. Negoduyko V, Mikhaylusov R, Velikodnyi A, Kovtun K. Research of foreign bodies soft tissue gunshot origin. Georgian Med News. 2019;297:13–7.
18. Michaylusov RN, Negoduyko VV, [RESULTS OF SURGICAL MAGNETIC INSTRUMENTS APPLICATION FOR SURVEY OF WOUNDS AND REMOVAL OF FERROMAGNETIC FOREIGN BODIES]. Klin Khir. 2016(7):58–60.
19. Chang R, Drake SA, Holcomb JB, Phillips G, Wade CE, Charlton-Ouw KM. Characteristics of Trauma Mortality in patients with Aortic Injury in Harris County, Texas. J Clin Med. 2020;9(9).
20. García A, Millán M, Burbano D, Ordoñez CA, Parra MW, González Hadad A, et al. Damage control in abdominal vascular trauma. Colomb Med (Cali). 2021;52(2):e4064808.
21. Branco BC, Musonza T, Long MA, Chung J, Todd SR, Wall MJ, et al. Survival trends after inferior vena cava and aortic injuries in the United States. J Vasc Surg. 2018;68(6):1880–8.
22. Lurin I, Khoroshun E, Negoduiko V, Makarov V, Shypilov S, Boroday V, et al. Retrieval of ferromagnetic fragments from the lung using video-assisted thoracoscopic surgery and magnetic tool: a case report of combat patient injured in the war in Ukraine. Int J Emerg Med. 2023;16(1):51.
23. Lurin I, Gorobeiko M, Lovin A, Gorobeyko B, Lovina N, Dinets A. Application of artificial intelligence in civil and military medicine. Georgian Med News. 2024(348):94–8.
24. O'Donnell MT, Huang ML, Gerling KA, Rasmussen TE, White JM, Koelling EE. Use of MEDEVAC resources in Austere settings: Paget-Schroetter in the deployed environment. Mil Med. 2023;188(11–12):3683–6.
25. Lurin I, Burianov O, Yarmolyuk Y, Klapchuk Y, Derkach S, Gorobeiko M, et al. Management of severe defects of humerus in combat patients injured in russo-ukrainian war. Injury. 2024;55(2):111280.
26. Gumeniuk K, Lurin IA, Tsema I, Malynovska L, Gorobeiko M, Dinets A. Gunshot injury to the colon by expanding bullets in combat patients wounded in hybrid period of the russian-ukrainian war during 2014–2020. BMC Surg. 2023;23(1):23.
27. Golovko S, Gybalo R, Lurin I, Taraban I, Kobirnichenko A, Ganiuk V, et al. Penetrating gunshot wounds to the penis: a case report of combat patient injured in the war in Ukraine. Int J Emerg Med. 2023;16(1):5.
28. Golovko S, Gybalo R, Lurin I, Taraban I, Kobirnichenko A, Ganiuk V et al. Penetrating gunshot wounds to the penis: a case report of combat patient injured in the war in Ukraine. Int J Emerg Med. 2023;16(1).
29. Lurin I, Khoroshun E, Negoduiko V, Makarov V, Shypilov S, Boroday V et al. Retrieval of ferromagnetic fragments from the lung using video-assisted thoracoscopic surgery and magnetic tool: a case report of combat patient injured in the war in Ukraine. Int J Emerg Med. 2023;16(1).
30. Rogovskyi VM, Koval B, Lurin IA, Gumeniuk K, Gorobeiko M, Dinets A. Temporary arterial shunts in combat patient with vascular injuries to extremities wounded in russian-ukrainian war: a case report. Int J Surg Case Rep. 2022;102:107839.
31. Pocivavsek L, Bishop E, Khabaz K, Ota T, Skelly C, Hampton D. Simultaneous injury to the inferior vena cava and the intrathoracic aorta. J Trauma Acute Care Surg. 2020;89(6):e170–2.
32. Dinets A, Nykytiuk O, Gorobeiko M, Barabanchyk O, Khrol N. Milestones and pitfalls in strategic planning of healthcare in capital city in transition. Georgian Med News. 2021(315):189–95.
33. Northern DM, Manley JD, Lyon R, Farber D, Mitchell BJ, Filak KJ, et al. Recent advances in austere combat surgery: use of aortic balloon occlusion as well as blood challenges by special operations medical forces in recent combat operations. J Trauma Acute Care Surg. 2018;85(1S Suppl 2):S98–103.
34. Campbell K, Naumann DN, Remick K, Wright C. Damage control resuscitation and surgery for indigenous combat casualties: a prospective observational study. BMJ Mil Health. 2021;167(1):18–22.
35. Anatoliyovych IL, Yuriyovych OU, Valentynovych OH. Surgical treatment features of liver gunshot wound with a dumdum bullet (expanding bullet). Int J Emerg Med. 2022;15(1):57.
36. Khomenko I, Tsema I, Humeniuk K, Makarov H, Rahushyn D, Yarynych Y, et al. Application of damage control tactics and transpapillary biliary decompression for organ-preserving Surgical Management of Liver Injury in Combat Patient. Mil Med. 2022;187(5–6):E781–6.
37. Polcz JE, White JM, Ronaldi AE, Dubose JJ, Grey S, Bell D, et al. Temporary intravascular shunt use improves early limb salvage after extremity vascular injury. J Vasc Surg. 2021;73(4):1304–13.
38. Chen S, Yang J, Zhang L, Yang L, Qin H, Liu D, et al. Progress on combat damage control resuscitation/surgery and its application in the Chinese People's Liberation Army. J Trauma Acute Care Surg. 2019;87(4):954–60.
39. Jaha L, Ademi B, Ismaili-Jaha V, Andreevska T. Bullet embolization to the external iliac artery after gunshot injury to the abdominal aorta: a case report. J Med Case Rep. 2011;5:354.

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