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Radiology during a war – experience in Ukraine

Die Radiologie im Krieg – Erfahrung aus der Ukraine

Authors
Nataliia Nehria[1], Yevhenii Nehria[2], Tymofii Bukharin[2]

Affiliations
1 Radiology, Imaging centers “MRT plus”, Kyiv, Ukraine
2 Endoscopy and Minimally Invasive Surgery, Universal clinic “Oberig”, Kyiv, Ukraine

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Correspondence
Dr. Nataliia Nehria
Radiology, Imaging centers “MRT plus”, Vulytsya
Kompozytora Meytusa 5, 02000 Kyiv, Ukraine
n.m.negria@gmail.com

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ABSTRACT

Background Military radiology, an integral part of military medicine, plays a pivotal role in medical triage, diagnosis, and treatment. Its significance lies in providing timely and accurate assessments in challenging situations.

Method The utilization of contemporary sonographic techniques enables rapid identification of life-threatening conditions, ensuring prompt medical aid and facilitating regional anesthesia. Computed tomography emerges as a critical tool for assessing injury extent, planning surgeries, monitoring postoperative phases, and conducting retrospective evaluations, especially when anatomical dissection is complex.

Conclusion Battlefield radiology not only enhances the understanding of injury mechanisms and battlefield traumas but also contributes significantly to the overall improvement of diagnostic and treatment approaches. Ukrainian doctors actively engaged in diverse stages of patient care accumulate a wealth of knowledge, substantially elevating the survival rates of wounded individuals. This experience serves as the foundation for ongoing enhancements and the advancement of military radiology, even during periods of peace.

Key Points

- Military radiology is essential in medical triage, diagnosis, and treatment within military contexts.
- Modern sonographic methods enable swift identification of life-threatening conditions.
- Computed tomography is indispensable for assessing injuries, planning surgeries, and conducting retrospective evaluations.
- Ukrainian doctors actively contribute to the knowledge base, improving diagnostic and treatment practices.
- The acquired experience serves as a foundation for ongoing advancements in military radiology, extending its impact beyond wartime scenarios.

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ZUSAMMENFASSUNG

Hintergrund Die Militärradiologie spielt eine entscheidende Rolle in der Militärmedizin, indem sie wesentliche Beiträge zur medizinischen Triage, Diagnose und Behandlung leistet. Moderne sonografische Methoden ermöglichen die schnelle Diagnose lebensbedrohlicher Zustände und erleichtern somit eine prompte medizinische Versorgung sowie periphere Regionalanästhesie. Die Computertomografie wird als unverzichtbares Instrument zur Bestimmung des Verletzungsumfangs, der Planung chirurgischer Eingriffe, der Überwachung im postoperativen Verlauf und retrospektiven Bewertung in Abwesenheit der Möglichkeit zur Durchführung einer Obduktion betrachtet.

Methode Die Militärradiologie sammelt umfassendes Wissen über die Mechanismen von Verletzungen und die Besonderheiten hochenergetischer Traumata. Ukrainische Ärzte, die direkt an der medizinischen Versorgung in verschiedenen Phasen beteiligt sind, tragen maßgeblich zu diesem Wissensfundament bei. Dieser Beitrag dient dazu, Diagnose und Behandlung zu verbessern und die Überlebensrate der Verwundeten entscheidend zu erhöhen.

Schlussfolgerung Die Militärradiologie spielt eine zentrale Rolle in der effektiven Versorgung von Verletzten und trägt zur kontinuierlichen Weiterentwicklung der Militärmedizin bei. Die gewonnene Erfahrung bildet die Grundlage für wei-

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tere Optimierungen und die Entwicklung dieses bedeutenden medizinischen Bereichs, selbst in Zeiten des Friedens.

Kernaussagen
- Militärradiologie ist unerlässlich für medizinische Triage, Diagnose und Behandlung in der Militärmedizin.
- Sonografische Methoden ermöglichen eine schnelle Diagnose lebensbedrohlicher Zustände und erleichtern die periphere Regionalanästhesie.
- Computertomografie ist ein entscheidendes Instrument zur Bewertung von Verletzungsumfängen und chirurgischer Planung.
- Ukrainische Ärzte tragen maßgeblich zur Akkumulation von Wissen über Verletzungsmechanismen und hochenergetische Traumata bei.
- Die gewonnene Erfahrung bildet die Grundlage für die fortlaufende Verbesserung der Militärradiologie, auch in Zeiten des Friedens.

Introduction

December 28, 1895 can be considered the official birth of radiology since the book “Über eine neue Art von Strahlen” (About a New Kind of Rays) by Wilhelm Conrad Röntgen was published on this day. In the 19th century, both the science and military sectors experienced rapid growth and development. European armies introduced firearms to their weaponry. Military surgeons recognized the importance of using a “new type of rays” to diagnose firearm injuries and published an article in March 1896 about the use of the X-ray method for detecting bullet wounds. The years 1897–1898 during the territorial and colonial conflict between the Russian and British Empires are considered to mark the beginning of military radiology [1]. 123 years have passed since then. Radiology has since become an integral part of military medicine and plays an important role not only in diagnosis but also in the healing process.

The structure and severity of combat injuries vary and depend on the type of weapon and military technology. Modern armies have weapons with high kinetic energy and numerous effects resulting in an increase in the percentage of combined injuries, e. g., explosions result in a combination of mechanical and thermal injuries [2, 3, 4].

The Russian invasion of Ukraine has resulted in a high percentage of multiple and combined injuries. This fact greatly complicates the process for treating and evacuating the wounded, increases the need for complex surgical aid within a relatively short period of time, and increases the percentage of mistakes in both treatment and organizational processes [2, 3, 5, 6, 7, 8, 9]. The amount of time it takes for medical aid to be provided affects treatment results. Collaboration between radiology and clinical medicine allows a better understanding of pathological processes and shortens the time for the provision of medical aid.

Military radiology is a specific branch of radiology requiring knowledge of the mechanism of injuries and patterns of high-energy trauma and has been actively being developed since Russia’s initial invasion of Ukraine in 2014.

Phases of medical care in times of war

Wartime medical care is provided in Ukraine in accordance with the basic principles of Ukrainian health law using a 4-stage system:

First stage of medical care (0.5–15 km behind the frontline, within the first 10–60 minutes): This stage includes preclinical and acute initial treatment. It also includes self-help and support by medics and general practitioners in mobile units. Care is provided in medical vehicles. Ultrasound and digital radiographs are used at this point.

Second stage of medical care (25–60 km behind the frontline, within 60 minutes): Specialized medical care is provided at this point. Care is provided at stabilization points and/or mobile hospitals. Time plays a crucial role in preserving the limbs and lives of the wounded.

Third and fourth stages of medical care (200 km or more behind the frontline, 12–24 hours): These stages include tertiary, highly specialized medical care at stationary military hospitals and specialized facilities. Care is provided within 12–24 hours. Rehabilitation and palliative care systems implement treatment measures with the goal of restoring function impacted or lost due to injury in order to create optimal conditions for the return to normal life, work, and military service.

Imaging methods

Ultrasound

Ultrasound is the most commonly used imaging method when treating wounded individuals during all stages of care [2] (▶ **Fig. 1**). Ultrasound examination is primarily used during the first two stages of care for identifying life-threatening injuries (▶ **Fig. 2**). The use of fast protocols like FAST (eFAST) and point-of-care ultrasound (POCUS) has proven to be effective for evaluating blunt abdominal and chest trauma and for providing clear answers to specific diagnostic questions. The main advantage of fast protocols is that radiologists are not needed since these protocols can be performed by physicians as well as emergency medical technicians.

In addition to the use of ultrasound for diagnosis, it is also used for guiding peripheral regional anesthesia administration both during evacuation and at mobile hospitals/field support points. The use of the FAST protocol has shortened the duration of the preoperative diagnostic workup, improved the quality and efficiency of medical triage, and reduced the number of diagnostic mistakes [1, 10].

X-ray

Mobile X-ray devices (▶ **Fig. 3**) are used at field support points and mobile hospitals treating the moderately to severely wounded

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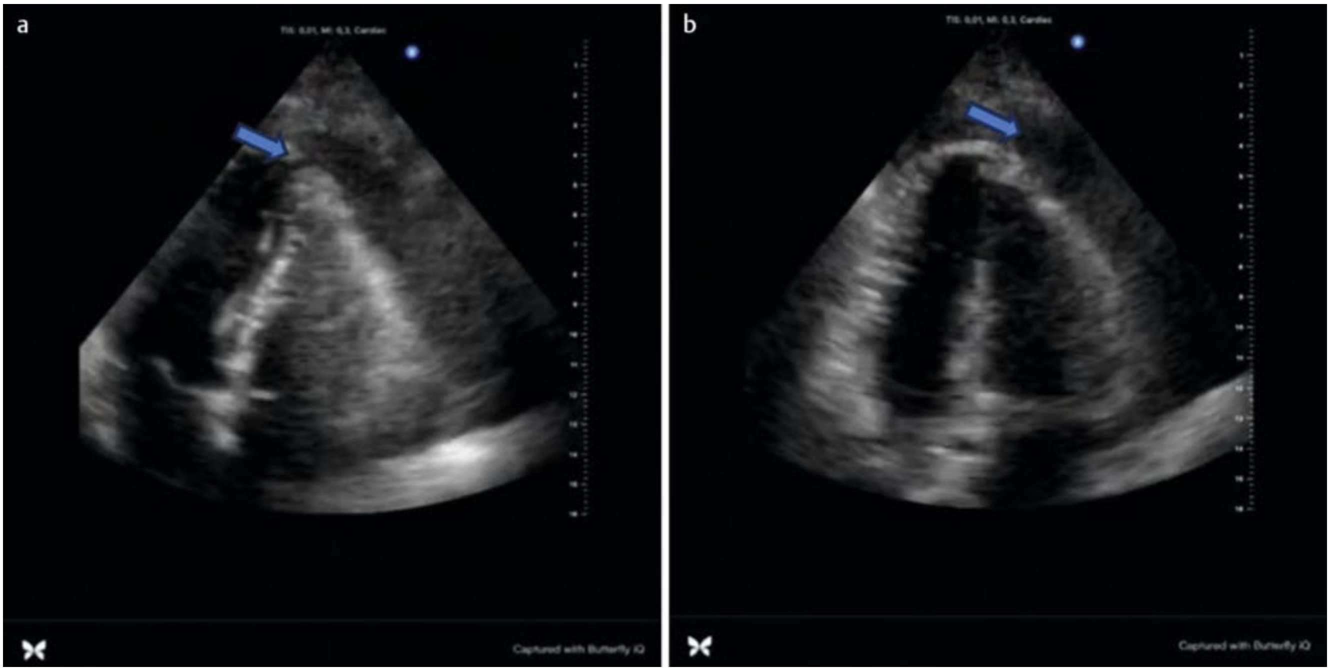
with the goal of stabilizing acute life-threatening injuries. These patients are subsequently assessed to determine further care and are transferred to centers with the necessary equipment. The acquired X-ray images are evaluated directly on the monitor of the X-ray device by the medical team at the mobile hospital/field support point.

Chest X-rays are acquired to rule out pneumothorax and hemothorax (▶ **Fig. 4**) which require immediate care with drainage placement [10]. They are also used to detect bullet fragments in the chest and to evaluate the distance from major vessels and the heart (▶ **Fig. 4**).

Images of the pelvis and extremities are used to evaluate fractures (▶ **Fig. 5**), to detect foreign objects and their location (▶ **Fig. 6**), and to triage amputation injuries (▶ **Fig. 7**) [11, 12].

▶ **Fig. 1** Portable ultrasound device.

▶ **Fig. 3** **a** Mobile X-ray device at a field support point 15 km from the front line.



▶ **Fig. 2** **a** Cardiac ultrasound: Bullet wound to the apex of the heart (arrow). **b** Cardiac ultrasound: Hemopericardium (arrow).

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Computed tomography (CT)

In a hybrid war, i. e., a war causing combined injuries, noninvasive imaging methods play an important role. When diagnosing gunshot wounds, computed tomography in particular makes it possible to evaluate the type and scope of injuries and the topography of postoperative conditions [13, 14, 15, 16, 17]. CT is the second most commonly used imaging method beginning in the second stage of medical care.

It has many advantages due to its speed, noninvasiveness, high sensitivity for differentiating between air, fluid, and blood, as well as high topographical accuracy for the identification of injuries and foreign objects and for the evaluation of the injury severity and the wound path. With CT over 50 % of additional injuries can be detected compared to other imaging methods and physical examination alone [18].

When performing imaging of the wounded, that main goal is the timely detection of life-threatening injuries requiring immediate surgical treatment, the prediction of the migration of foreign objects (▶ **Fig. 8**), and the diagnosis of injury complications.

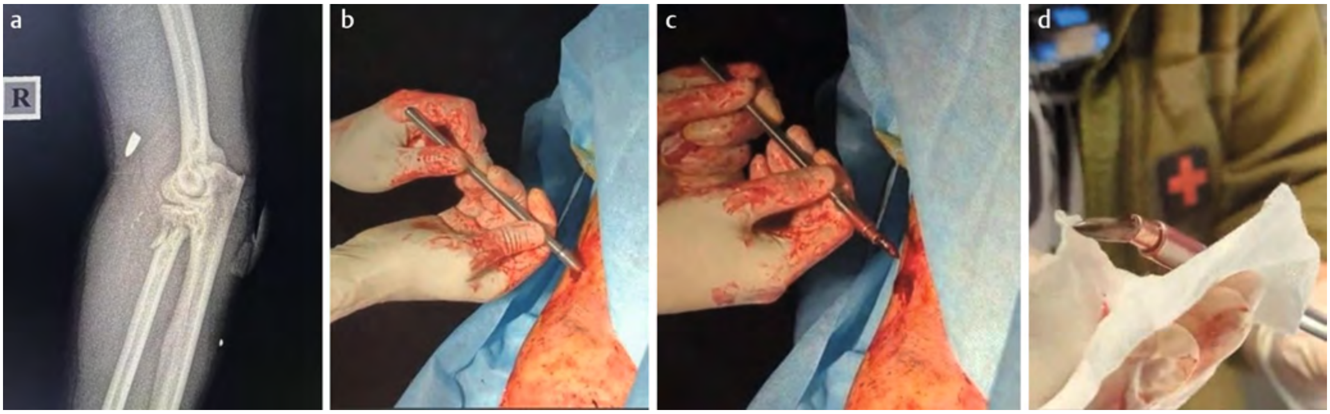
Wounded patients are first scanned from the head to the pelvis sometimes including the extremities since the prediction of the path of a bullet or a fragment is an extremely complex task in the case of combined injuries [2, 12]. Wound paths penetrate various parts of the body and can consequently be in a thoracoabdominal, abdominopelvic, or cardiothoracic location and affect every organ [17].

Bullets and shrapnel can sometimes travel like an embolism along vessels. Angiography is performed particularly in patients with wounds caused by shrapnel injuries without an exit wound [10, 15, 19].

Postmortem CT examinations are considered the gold standard for the retrospective evaluation of the diagnosis and treatment of gunshot wounds if it is not possible to perform an autopsy [18].

▶ **Fig. 4** Chest X-ray a. p. plane: Metal fragment in the mediastinum, left-sided hemopneumothorax.

▶ **Fig. 5** **a** X-ray of the left shoulder, y-view: Multifragmentary fracture of the left humerus. **b** Pelvic X-ray a. p.: Fracture of the superior and inferior pubic ramus on the left, multiple metal fragments in the genital region.



▶ **Fig. 6** **a** Lateral image of the right elbow joint: Comminuted fracture of the radius, bullet in the soft tissue of the cubital fossa. **b** Removal of the bullet. **c** Removal of the bullet. **d** Removal of the bullet.

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Magnetic resonance imaging (MRI)

Magnetic resonance imaging is used as a visualization method to assess the long-term consequences of combat injuries in the third and fourth phases of medical care and during rehabilitation. The use of MRI is often limited due to metal fragments in the body of the injured person. After removal of the fragments, MRI can be safely performed (▶ **Fig. 9**) and makes it possible to evaluate both soft-tissue changes and bone lesions.

Head

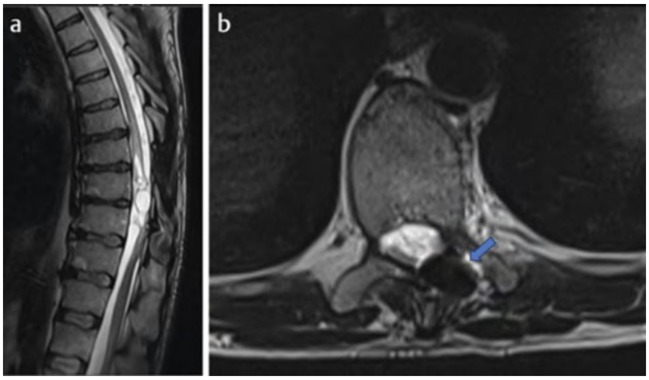
In modern armed conflicts, deaths with a neurosurgical profile are 50 % soft-tissue damage to the head, 28 % penetrating head trauma, and 17 % non-penetrating injuries. The percentage of explosion and blast injuries is increasing and comprises 70 % of combat wounds. Combined injuries occur in approximately 30 % of cases and multiple injuries in 7 % of those affected [20, 21].

Skull and brain injuries are classified as closed or open depending on the type of tissue damage. In the case of closed injuries to the brain and skull, only the skin is damaged while the soft tissue of the head as well as the epicranial aponeurosis remain intact. An injury to the brain and skull is considered open when the integrity of both the skin and aponeurosis is damaged. This category also includes fractures at the base of the skull [22, 23].

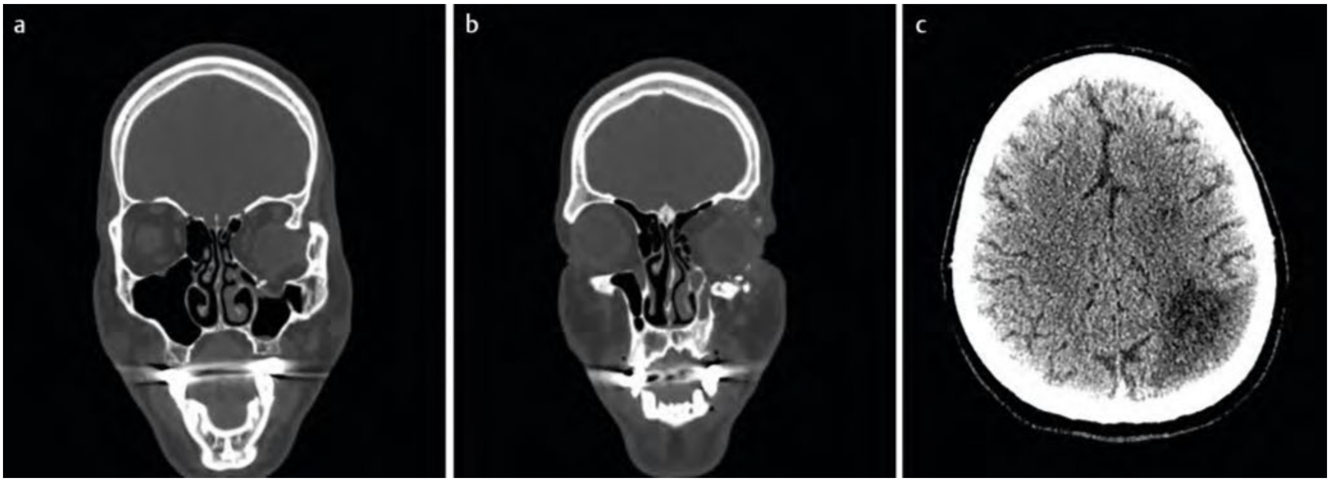
Open head and brain injuries are categorized as penetrating and non-penetrating. Open non-penetrating injuries are characterized by the integrity of the dura mater which protects the subarachnoid space and the brain tissue from possible infection.

In the case of open penetrating skull injuries, the dura mater is usually damaged, often resulting in infection. Therefore, it is important for the further planning of surgical interventions and the prognosis of possible complications for radiology to clearly identify the type of injury to the skull and brain.

▶ **Fig. 7** Lateral X-ray of both feet: Traumatic amputation with short midfoot stump.



▶ **Fig. 9** **a** MRI examination of the thoracic spine of a patient with lower paraparesis: Condition after surgery to treat a bullet wound in the thoracic region of the spine, post-traumatic myelomalacia of the spinal cord. **b** MRI examination of the thoracic spine of a patient with lower paraparesis: Metal artifact (arrow) caused by a small foreign object.



▶ **Fig. 8** **a** Coronal CT scan of the skull: Fractures of the left orbital floor, dislocation of the lateral orbital wall and the left globe of the eye, and prolapse of the fat tissue into the maxillary sinus. **b** Coronal CT scan of the skull: Numerous small bone fragments in the soft tissue of the left orbital cavity. **c** Transverse CT scan of the skull: Focal encephalomalacia of the left hemisphere resulting from a hemorrhagic contusion.

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Skull fractures are categorized as linear, competing, fragmented, puncture, and splintered fractures. The location of the skull fracture and its connection to the base of the skull and the top of the skull are taken into consideration. A basilar skull fracture is considered an open penetrating skull injury since it is normally associated with a tear of the dura mater.

When radiologists are evaluating head injuries, it is important to determine the exact location of bone fragments (▶ **Fig. 10a, e**), the presence of foreign objects, and their relationship to the main blood vessels, as this information plays an important role in the further planning of the scope of surgical interventions and often determines the patient's prognosis.

Gunshot wounds to the head include the elements of injury described above but also have their own special features. They are classified as injuries caused by a projectile, shrapnel, or a bullet. Depending on the type of injury canal, a differentiation is made between simple, penetrating, perforating, and graze injuries. Brain injury locations include the forehead, temples, top of the head, and back of the head as well as parabasal injuries.

In the case of head injuries, it is important to detect brain contusions, diffuse axonal damage, intracerebral and intracranial hematomas, and brain compression.

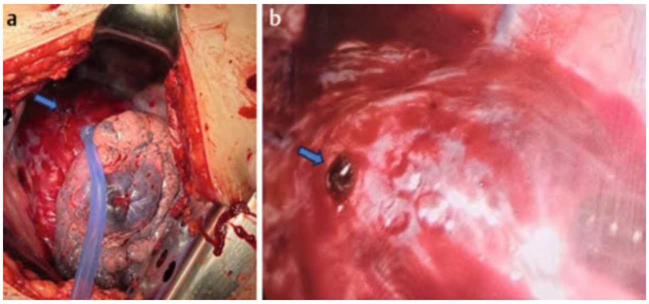
Brain contusions are characterized by macroscopic damage to the brain tissue and are clearly seen on CT (▶ **Fig. 10d**) and MRI. Swelling as well as hemorrhages of the brain tissue, which are usually associated with fractures in the top of the skull or the base of the skull, and significant subarachnoid bleeding are seen on CT.

Diffuse axonal damage to the brain is a separate form of craniocerebral trauma that is considered severe. This is seen on CT and MRI in the form of parenchymal swelling, compression of the ventricles and subarachnoid spaces, and small focal hemorrhages in the white matter (▶ **Fig. 10b, c**), the corpus callosum, the subcortical brain structures, and the structures of the brainstem.

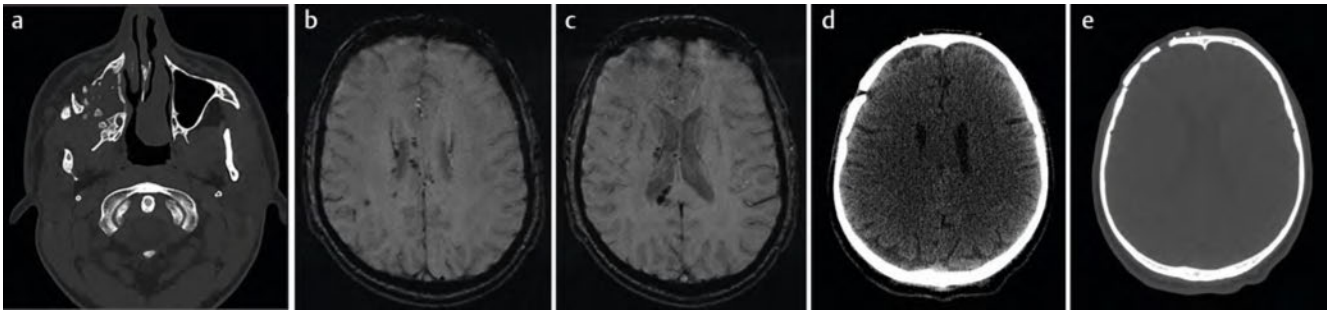
Brain compression presents as qualitative impaired consciousness, vegetative disorders, amnesia, epileptic seizures, and the occurrence and progression of focal neurological deficits. Brain compression is caused by the development of an intracranial hemorrhage resulting in the compression of brain structures, the displacement of bone fragments into the cranial cavity, the development of acute hydrocephalus, pneumocephalus, or the quick progression of secondary cerebral edema. CT is the most important imaging method for diagnosing intracranial hematomas.

Thorax

Trauma involving the organs in the chest cavity comprises approximately 7–12 % of combat surgeries [16]. The severity of these injuries is the result of the combination of lung injuries, vascular damage (▶ **Fig. 11**), and trauma to the pericardium, heart, and esophagus [24]. Chest trauma can be divided into two types: penetrating and blunt. There are also "regional injuries" that can be both blunt and penetrating. Penetrating wounds are caused by the direct effect of a wounding agent (bullet, shrapnel, body armor, etc.) that compromises the integrity of tissues. A special characteristic of blunt trauma is that organ damage occurs without visible signs on the surface [14]. The large majority of combat chest injuries are shrapnel wounds (up to 72 %) [24]. The characteristics, shape, and size of an injury canal depend on the kinetic energy and the physical properties of the wounding agent. In the case of perforating gunshot wounds, significant external bleeding is typically seen. The injury canal is identified on CT by a hole in the parenchyma (▶ **Fig. 12**) surrounded by a zone of lung parenchymal damage and containing blood, air bubbles, fragments of damaged tissue, and foreign objects. A pulmonary contusion, which occurs in both penetrating and blunt trauma, is usually seen on CT as diffuse areas with increased density in the lung tissue that can indicate bleeding, edema, or inflammation.



▶ **Fig. 11** **a** Projectile (arrow) in the mediastinum (intraoperative images). **b** Projectile (arrow) in the mediastinum (intraoperative images).



▶ **Fig. 10** **a** Transverse CT scan of the skull: Image of a multifragmentary fracture of the right maxilla two months after the trauma. **b/c** Transverse MRI scan of the head: Diffuse axonal damage (grade 1 according to Adams) on SWI. **d** Transverse CT scan of the skull: Chronic epidural hematomas on the right frontal side. **e** Transverse CT scan of the skull: Fractures of the right frontal bone and multiple foreign objects in the subcutaneous soft tissue.

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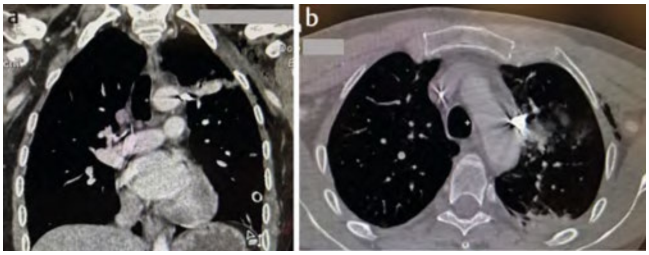
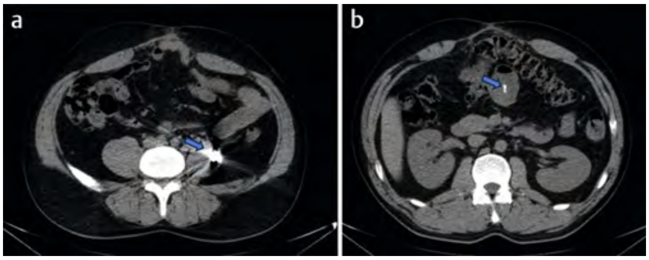
Blast injuries can result in lung rupture with bleeding, bilateral pulmonary contusions, skeletal damage, and damage to the soft tissue of the chest wall [2]. In the case of penetrating chest trauma, vascular damage with massive bleeding in the pleural cavity and the formation of a tension pneumothorax can be the main causes of death. Perforating wounds of the mediastinum are diagnosed in only 1–3 % of cases since this type of trauma results in immediate death in 97–99 % of cases [16].

Abdomen and pelvis

Abdominal and pelvic injuries are the most severe modern combat injuries and due to hybrid warfare they present a challenge with respect to selecting suitable surgical approaches and effective medical imaging methods [13, 25, 26, 27]. Closed abdominal trauma in combination with gunshot wounds comprise approximately 20 % of all medical losses.



► **Fig. 12** **a** Coronal thoracic CT scan: Projectile in the left mediastinum lateral to the aortic arch. Clearly visible projectile path in the left lung. **b** Transverse thoracic CT scan: Projectile in the left mediastinum lateral to the aortic arch.



► **Fig. 13** **a** Transverse CT scan of the abdomen: Penetrating injury to the abdominal cavity with metal fragments (arrow) in the left psoas muscle. **b** Transverse CT scan of the abdomen: Penetrating injury to the abdominal cavity with fragments (arrow) in the large intestine.

Abdominal and pelvic gunshot wounds are the most complex cases in military radiology [10, 11] and military surgery [26].

Abdominal gunshot wounds are penetrating in 33 % of cases and non-penetrating in 67 %. Shrapnel and blast wounds are the most common type of abdominal injury (62 %) while only 1 % of injuries are pelvic injuries [25, 17].

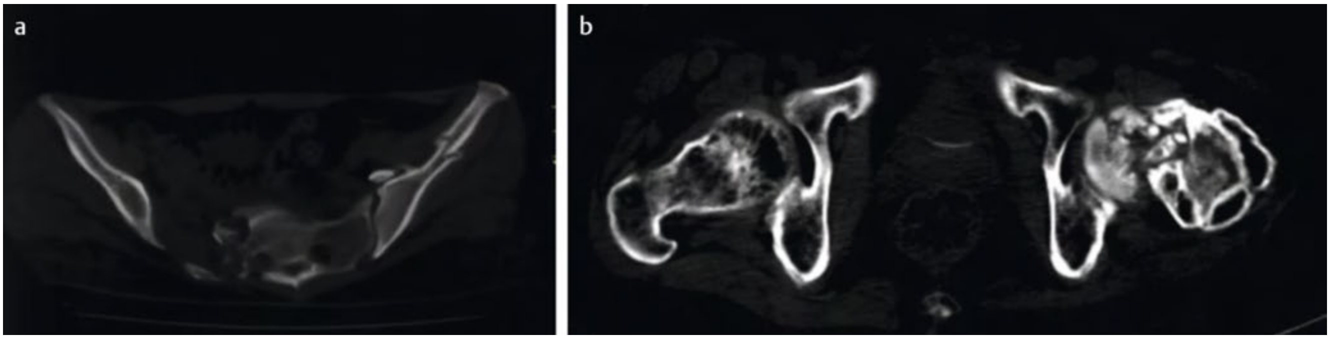
Depending on the type of tissue damage and organ trauma in the abdomen and pelvis, a differentiation is made between non-penetrating and penetrating injuries as well as closed abdominal trauma (► **Fig. 13**). Pelvic fractures are quite common and require a detailed description of the displacement of bone fragments (► **Fig. 14**) and determination of the topography in relation to large vessels and nerve bundles.

Thoracoabdominal injuries are one of the most complex combined injuries caused by simultaneous injury of the ribcage and the abdomen with damage to the diaphragm.

Extremities

Trauma to the extremities is one of the most common causes of surgical death in wars and military conflicts and comprises approximately 54–70 % of all deaths. In most cases, this type of trauma is part of a polytrauma. Extremity fractures are associated with severe soft-tissue damage in one third of cases. Tibial fractures comprise 42.1 % of cases and are usually caused by bullet wounds. Femoral fractures occur in 23.8 % of cases, humerus fractures in 22.3 %, and forearm fractures in 11.8 %. These fractures are typically shaft fractures. Intraarticular fractures are diagnosed in 17.1 % of cases. Of the 76.4 % of bullet wounds caused by modern weapons, 35.1 % are comminuted fractures and 41.3 % are splintered fractures. Primary bone injuries comprise 7.1 % of injuries, with 79.3 % of long bone injuries having defects of 3 cm or more [12].

In the case of trauma to the extremities, it is important for radiologists to characterize injuries to soft tissue, bones, and joints. Depending on the number and location of the injuries, they should be classified as isolated, multiple, and combined injuries. If possible, the description of a bullet wound should include the type of projectile (bullet, shrapnel, explosive projectile, etc.), the type of injury (perforating, penetrating, graze), the type of frac-



► **Fig. 14** **a/b** Transverse CT scan of the pelvis: Multifragmentary dislocated fractures of the pelvis **a** and of the left femur.

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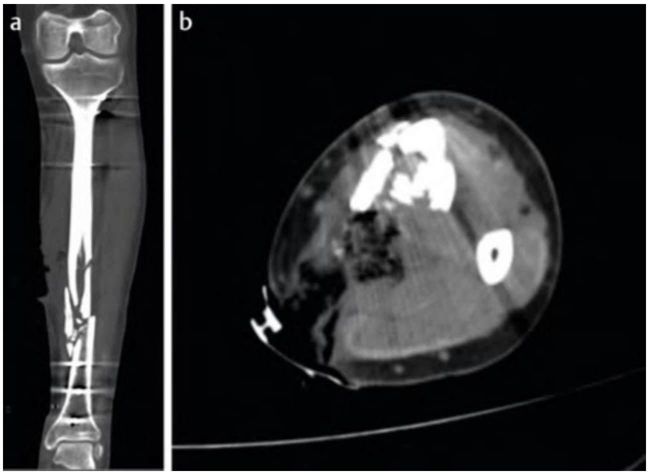
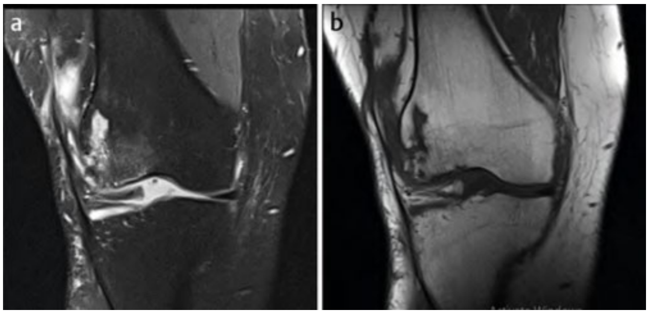


▶ **Fig. 15** Coronal **a** and transverse **b** CT scan of the lower leg: Multi-fragmentary fracture of the tibia with external fixation **a**. Soft-tissue damage to the lower leg **b**.



▶ **Fig. 16 a/b** Coronal MRI scan of the knee joint: Condition after removal of a metal fragment. Bone defect of the distal femur.

ture (complete, incomplete) (▶ **Fig. 15**), the size of bone defects (▶ **Fig. 16**), the nature of the fracture line (transverse, oblique, etc.), the location, accompanying injuries to soft tissue, main vessels and nerves, and joints and their structures, as well as the location of injuries in multiple, combined, and complex trauma. Complications should also be documented.

Conclusion

Military radiology is a special field of radiology requiring an understanding of the characteristics of the pathogenesis of military injuries and the specific radiological signs. Radiologists play an important role in the medical team since they determine the severity of anatomical changes, identify potential risk factors, and predict possible complications.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1] Magiorinis E, Vladimiros L, Diamantis A. History of Military radiology: the early period (1896–1916). Balkan Military Medical Review 2010; 13: 163–169

[2] Grechanyk O I, Abdullaiev RY, Dykan IM et al. Medical and statistical aspects of radiodiagnosis of modern combat trauma in the conditions of hybrid warfare in Eastern Ukraine. International Medical Journal 2021; 2: 79–87. doi:10.37436/2308-5274-2021-2-14

[3] Belenky V. A., Negoduiko V.V., Mykhalusov R.N. Analysis of errors in the performance of primary surgical treatment of gunshot wounds to soft tissues. Surgery of Ukraine 2015; 1: 7–13

[4] Kutovenko OK, Krut SO, Halkovych TM et al. Military chest trauma. The experience of a pulmonologist. Clinical Immunology

[5] Eastridge BJ. Died of wounds on the battlefield: Causation and implications for improving combat casualty care. The Journal of Trauma: Injury, Infection, and Critical Care 2011; 71 (1): 4–8

[6] Khomenko IP et al. Deficiencies and achievements in the treatment of the wounded and injured in the ATO conditions: a collection of scientific works 2016; 122–127

[7] Charles CT. Battle casualties. Incidence, mortality and logistic considerations. Springfield 2013: 283–285

[8] Hodgetts T, Davies S, Midwinter M et al. Operational mortality of UK service personnel in Iraq and Afghanistan: A one year analysis 2006–2007. J. R. Army Med. Corps 2007: 252–254. doi:10.1136/jramc-153-04-07

[9] Janak JC, Mazuchowski EL, Kotwal RS et al. Comparison of military and civilian methods for determining potentially preventable deaths: A systematic review. JAMA Surgery 2017; 153: 367–375. doi:10.1001/jamasurg.2017.6105

[10] Folio LR. Combat Radiology: Diagnostic Imaging of Blast and Ballistic Injuries. ISBN: 978–1-4419–5854–9; Springer; 2010: 232. doi:10.1007/978-14419-5854-9

[11] Khomenko SP, Grechanyk OI, Abdullaev RY et al. X-ray diagnosis of combat surgical trauma: guidelines. Kyiv, Ukrainian: MP Lesya; 2018: 40

[12] Buryanov OA, Strafun SS, Shlapak IP et al. Firearm injuries of the extremities. Methodical recommendations. Kyiv, 2015: 46

[13] Belyi VY, Zarutskiy YL, Zhovtonozhko AI et al. Essays on surgery for abdominal combat trauma. Russian. ISBN: 978–966–8126–89–5. Kiev: Lesya; 2016: 212

[14] National guide for physicians who refer patients for radiological. ISBN 978–966–8796 40–1. Kyiv, Ukrainian: Medicine of Ukraine; 2016: 74

[15] Ministrini S, Baiocchi G, Pittiani F et al. Gunshot wound without entrance hole: where is the trick? – a case report and review of the literaturer. World J Emerg Surg 2015; 10: 52

[16] Dykan I. Radiological diagnosis of thoracic gunshot wounds. Radiation Diagnostics, Radiation Therapy 2020; 2: 70–80. doi:10.37336/2707-0700-2020-2-6

[17] Zarutskyi YL, Klishevych BA, Polezhaiev HO. Combat closed abdominal trauma, diagnosis and treatment at the stages of medical-evacuation support. Military Medicine of Ukraine 3 2019; 19: 46–55

[18] Grechanyk OI, Abdullaiev RY, Lurin IA. Modern aspects of diagnosis of the abdominal gun-shot woundings. Experience of a hybrid war in the East of Ukraine. Clinical Surgery 2021; 88: 42–52. doi:10.26779/2522-1396.2021.56.42

[19] Peramaki ER. Pictorial review of radiographic patterns of injury in modern warfare: imaging the conflict in Afghanistan. Can Assoc Radiol J 2011; 62 (2): 90–106. doi:10.1016/j.carj.2010.03.005

[20] Sirko AH. Gunshot Injuries to the Skull and Brain during Armed Conflict in Eastern Ukraine. Report 2. Surgical Treatment. Ukrainian Neurosurgical Journal 2015; 2: 46–53

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[21] Sirko A. Skull and brain gunshot wound during the armed conflict in eastern Ukraine/ A. Sirko // 25th Annual Conference of Neurotrauma Society of India, 12–14th August, 2016, New Delhi, India. – P. 48

[22] Sirko AH. Skull Defects Repair after Decompressive Craniectomy for Severe Cranial-Cerebral Trauma. Medical Perspectives 2015; 16 (4): 74–78

[23] Suzuki T, Takafumi W, Shigeki F et al. Traumatic left ventricular free-wall laceration by a gunshot: report of a case. Surgery Today 2014; 44 (6): 1152–1155

[24] Astree Swiech, Boddaert G., Daban J-L. et al. Penetrating thoracic injuries: a retrospective analysis from a French military trauma centre. Journal of the Royal Army Medical Corps 2019; 6. doi:10.1136/jramc-2019-001159

[25] Zarutskyi YL, Bilyi VY. Military field surgery. ISBN 978–966–136–624–3. Kyiv, Ukrainian: Fenix; 2018: 552

[26] Emergency War Surgery. 4th ed. Ukrainian edition. Our format, 2015. – 540 p. ISBN: 978–617–7279–09–8. Kyiv, Ukrainian, 2013

[27] Svitlychnyi EV, Grechanyk OL. Ultrasound diagnosis of trauma and its complications. ISBN: 978–966–8126–89–5. Kyiv, Ukrainian: Chalchynska NV; 2016: 214

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