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Rationale for Classifications of Craniocerebral Combat Wounds Inflicted by Modern Weapons

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ABSTRACT

BACKGROUND: During the Great Patriotic War, craniocerebral combat wounds were classified. Currently, gunshot wounds demonstrate a greater variety, severity, and extent of tissue injury in craniocerebral regions on the periphery of the wound canal compared to wounds from past wars. Furthermore, advanced diagnostic techniques that can identify previously undescribed cerebral wound canals, which were generally considered fatal, are now available. Thus, new classification systems for craniocerebral gunshot wounds are required.

AIM: The work aimed to broaden the fundamental classification of craniocerebral gunshot wounds by including the current clinical and anatomical findings, facilitating a more comprehensive clinical diagnosis.

METHODS: The assessment findings and treatment outcomes of two groups of wounded patients were analyzed. Group 1 included 127 patients with craniocerebral gunshot wounds who had been treated in a military hospital during the Soviet–Afghan War. Group 2 comprised 67 wounded participants of modern armed conflicts who were treated at the Neurosurgery Clinic of the Kirov Military Medical Academy.

RESULTS: A contemporary clinical and anatomical classification of craniocerebral gunshot wounds was developed. This classification includes posterior cranial fossa (the cerebellum and brainstem) wounds. The proposed classification offers a framework for more accurate triaging based on injury severity. This facilitates decision-making for surgical prioritization, including in scenarios involving mass admissions. Primary attention should be given to patients with wound canal passing through the cortex and white matter of the brain. Generally, the more convex trajectory of the wound canal is associated with less severe brain injury. Surgical procedures are performed after stabilization of vital signs in patients with wound canals passing through the first-level (e.g., subcortical structures, ventricles, and brainstem) and second-level (e.g., cortex and cerebellar hemispheres) brain structures. The prognosis of these wounded patients largely depends on the severity and extent of damage to vital brain structures.

CONCLUSION: The developed clinical and anatomical classification is beneficial for elucidating the nature of craniocerebral gunshot wounds, facilitating a targeted triage of admitted wounded patients, ensuring surgical prioritization, and predicting the prognosis and outcome of craniocerebral wounds.

Keywords: clinical and anatomical classification; craniocerebral gunshot wounds; craniocerebral mine blast injuries; penetrating head injuries; wound canal; combined wounds; triage.

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Обоснование подходов к построению классификации боевых ранений черепа и головного мозга, нанесенных современным оружием

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АННОТАЦИЯ

Обоснование. Классификация огнестрельных ранений черепа и головного мозга была разработана в период Великой Отечественной войны. Огнестрельные ранения настоящего времени отличаются от ранений прошлых войн еще большим их разнообразием, тяжестью, обширностью зоны поражения тканей черепа и головного мозга по периферии от раневого канала. Кроме того, разработаны новые методики диагностики, позволяющие выявить ранее не описанные ходы раневых каналов головного мозга, считавшимися, как правило, фатальными. Поэтому назрела необходимость в создании современной классификации огнестрельных ранений черепа и головного мозга.

Цель — усовершенствовать базисную классификацию огнестрельных ранений черепа и головного мозга и внести в нее современные клинико-анатомические особенности для построения развернутого клинического диагноза.

Методы. Проанализированы данные обследования и лечения двух групп раненых. Первую группу составили 127 раненых с огнестрельными черепно-мозговыми ранениями, лечившихся в условиях армейского специализированного госпиталя (Афганская война). Во вторую группу вошли 67 раненых (участники современного вооруженного конфликта), получивших лечение в клинике нейрохирургии Военно-медицинской академии им. С.М. Кирова.

Результаты. Разработана современная клинико-анатомическая классификация огнестрельных ранений черепа и головного мозга, в состав которой включены ранения задней черепной ямки (мозжечка и ствола головного мозга). На основании предложенной классификации появляется возможность проведения более точной по тяжести ранения медицинской сортировки раненых и определения очередности оказания им хирургической помощи, в том числе при массовом поступлении. Установлено, что в первую очередь в хирургической обработке нуждаются раненые, у которых раневой канал проходит через кору и белое вещество головного мозга. При этом чем более конвекситально проходит раневой канал, тем меньше повреждение головного мозга. После стабилизации жизненно важных функций операции выполняют тем раненым, у которых раневой канал проходит через 1-ю (подкорковые образования, желудочки и ствол головного мозга) и 2-ю (кора головного мозга и полушария мозжечка) зоны мозга. Прогноз у этой категории раненых будет зависеть от тяжести и объема повреждения жизненно важных структур головного мозга.

Заключение. Разработанная клинико-анатомическая классификация позволяет уточнить характер огнестрельных черепно-мозговых ранений, целенаправленно проводить медицинскую сортировку поступающих раненых, определять очередность оказания им хирургической помощи, а также определять прогноз и исход черепно-мозговых ранений.

Ключевые слова: клинико-анатомическая классификация; огнестрельные ранения черепа и головного мозга; минно-взрывные черепно-мозговые ранения; проникающие ранения черепа; раневой канал; сочетанные ранения; медицинская сортировка.

Как цитировать

Орлов В.П., Мирзаметов С.Д. Обоснование подходов к построению классификации боевых ранений черепа и головного мозга, нанесенных современным оружием // Вестник Российской военно-медицинской академии. 2025. Т. 27, № 3. С. 321–330. DOI: 10.17816/brmma678185 EDN: KLLBGI

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BACKGROUND

The classification of craniocerebral gunshot wounds was established based on the experience gained during the Great Patriotic War. Over the past 10–15 years, new types of firearms have been developed, resulting in a substantial increase in their destructive potential. Moreover, projectiles have become more diverse regarding ballistic characteristics, flight velocity, and the materials from which they are manufactured [1, 2]. Consequently, contemporary gunshot wounds differ from those of previous wars by greater variability, severity, and extent of tissue damage surrounding the wound canal [3, 4]. The course of the wound process in gunshot injuries is determined by multiple factors, with the most critical being the nature and volume of devitalized tissue, which largely determine the outcome [5]. In addition, several studies have demonstrated the toxicity and carcinogenicity of modern metallic fragments [6–8].

In addition to the kinetic energy of the projectile, the characteristics of the wound canal play a critical role in the course of the injury in penetrating craniocerebral wounds. Critical factors include the depth and extent of destruction of brain parenchyma and the proximity of the wound canal to vital structures (e.g., subcortical nuclei and brainstem) [9].

Injuries to the subcortical structures involve particular severity of brain damage. The subcortical nuclei are multifunctional and participate in the coordination of complex motor acts, in processes such as autoregulation within the body (metabolism, immune and endocrine systems, biorhythmic processes, etc.) and in subconscious and unconscious processes of mental activity [10–12]. Simultaneous injuries to the subcortical structures and cerebral cortex represent the most severe lesions, often leading to unfavorable outcomes.

During the Great Patriotic War, bullet wounds in the posterior cranial fossa were generally fatal, and wounded soldiers died on the battlefield. Consequently, such injuries were not included in the penetrating craniocerebral wound classification [13]. However, in modern local high-technology combat operations, mine–explosive wounds (MEW) prevail. MEW are of multi-regional combined and polyetiologic combined character, with metallic fragments (shrapnel) being one of the injurious factors. Among the wounded with fragment-induced gunshot injuries of the posterior cranial fossa, there are patients who reach the stage of specialized medical care with damage involving the cerebellum and brainstem. Despite the severity of these injuries, there are numerous cases wherein patients survive after undergoing primary surgical debridement.

The introduction of modern radiological equipment and spiral computed tomography into specialized medical care has enabled to more accurately diagnose cranial injuries, visualize the trajectory of the wound canal with bone fragments and metallic foreign bodies, and verify traumatic alterations in the brain, including all types of hematomas and skull fractures.

For a comprehensive understanding regarding diagnostics, establishing an accurate diagnosis, triage, and determining the sequence of surgical care, a modern classification of craniocerebral gunshot wounds is required.

This study aimed to improve the basic classification of craniocerebral gunshot wounds based on clinical and anatomical characteristics to develop an extended clinical diagnosis that would reflect the severity, nature of the injury, and treatment outcomes and serve as a guide for triage of the wounded at the stage of specialized medical care and for determining the sequence of surgical interventions.

METHODS

This retrospective cohort study included 194 patients with craniocerebral wounds sustained during the war in Afghanistan and during high-technology combat operations in a modern armed conflict, forming two groups. Data on examination and treatment for all the patients who were managed at the stage of specialized medical care were analyzed to determine the severity and nature of craniocerebral wounds. Furthermore, to confirm the need for improving the basic classification of craniocerebral gunshot wounds, it was crucial to demonstrate the fundamental differences between the groups, attributable to the nature of combat operations in a 20th-century war versus those of a modern high-technology 21st-century war.

Group 1 consisted of 127 patients in the acute period of craniocerebral gunshot wounds treated in an army specialized hospital (during the Afghan war). Among the patients in this group, 120 were 18–20 years old, six were 21–30 years old, and one was 37 years old. Table 1 presents the diagnostic algorithm for group 1 patients.

Group 2 included 67 patients (participants in a modern armed conflict). The sample was sequentially formed as patients were admitted to the Department of Neurosurgery of the S.M. Kirov Military Medical Academy from the stage of specialized medical care (level 4) after receiving required medical and surgical treatment. In this group, 30 patients were 41–65 years old, 16 were 31–40 years old, and 11 were 21–29 years old. Almost all patients, with the exception of one, sustained combined and multiple mine–explosive injuries. They were admitted to the neurosurgery department on days 4–8 after injury, most after primary surgical debridement. Table 2 presents the diagnostic algorithm for group 2 patients.

Patients with craniospinal injuries did not reach the stage of specialized medical care.

The study was approved by the local Ethics Committee of the S.M. Kirov Military Medical Academy (Minutes No. 305, dated July 22, 2025).

Statistical analysis of data was performed using Microsoft Excel 2010 (Microsoft Corporation, USA).

RESULTS AND DISCUSSION

Notably, by the nature of the injuring projectile, fragment wounds occurred in 62.8% of group 1 cases, whereas bullet wounds occurred in 37.2%. The mildest injuries were soft tissue wounds, diagnosed in 43 patients (33.9%) with gunshot wounds: 31 fragment injuries and 12 bullet wounds. Although skull soft tissue injuries are classified as minor, 13 of these cases were accompanied by clinical manifestations of

Table 1. Algorithm for the examination of group 1 patients

Method and procedures of examination	Purpose of examination
General condition assessment	Evaluate vital functions and overall status (satisfactory, moderate, severe, critical, and terminal)
Neurological examination	Determine level of consciousness using the Glasgow Coma Scale; assess pupil size and light reaction and eye movement. Evaluate general cerebral and focal symptoms (paresis, paralysis, etc.) and pelvic organ function and identify meningeal signs
Surgical examination	Detect presence/absence of ongoing external bleeding and cerebrospinal fluid leakage. Identify isolated or combined (single or multiple) cranial and brain wounds and the nature of the predominant combined wound (head, chest, abdomen, or extremities)
Craniography, echoencephalography, electrocardiography, lumbar puncture, laboratory tests (complete blood count, cerebrospinal fluid and urine analysis, and Rh factor determination)	Clarify the nature of the injury and assess displacement of midline brain structures in cases of cerebral contusion and intracranial hematomas
Consultation with related specialists (otorhinolaryngologist, ophthalmologist, surgeon, traumatologist, etc.)	Engage additional specialists as needed during surgical examination and in the postoperative period

Table 2. Algorithm for the examination of group 2 patients

Method and procedures of examination	Purpose of examination
General condition assessment	Evaluate vital functions and overall status (satisfactory, moderate, severe, critical, or terminal)
Neurological examination	Determine level of consciousness using the Glasgow Coma Scale; assess pupil size and light reaction and eye movements. Evaluate general cerebral and focal symptoms (paresis, paralysis, etc.) and pelvic organ function and identify meningeal signs
Surgical examination	Identify isolated or combined (single or multiple) cranial and brain wounds and nature of the predominant combined injury (head, neck, chest, abdomen, pelvis, spine, or extremities)
Spiral computed tomography, CT angiography, electrocardiography, lumbar puncture, laboratory tests (complete blood count, cerebrospinal fluid and urine analysis, and Rh factor determination)	Clarify the nature and localization of the wound tract (contusion foci, hematomas, bone fragments, metallic foreign bodies, and displacement of midline brain structures)
Selective cerebral angiography	Diagnose traumatic cerebral arterial aneurysms following penetrating gunshot wounds of the skull and brain
Consultation with related specialists (otorhinolaryngologist, ophthalmologist, maxillofacial surgeon, surgeon, traumatologist, and internist)	Engage additional specialists as needed during surgical examination

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traumatic brain injury. Concussion of the brain was observed in nine patients, and cerebral contusion with subarachnoid hemorrhage in four. On admission, most patients with soft tissue injuries of the cranial vault were conscious (Glasgow Coma Scale [GCS] score: 15), whereas three patients presented with sopor (GCS score: 8).

In group 1, nonpenetrating cranial wounds were diagnosed in 19 patients (14.9%), of which 11 were fragment wounds and 8 were bullet wounds. On admission, most of these patients were conscious and in satisfactory condition; however, 7 exhibited varying degrees of impaired consciousness, ranging from moderate stupor to sopor (GCS score: 13 to 8). All patients presented with generalized neurological symptoms on admission. As generalized disturbances gradually regressed, focal neurological symptoms became apparent.

Among 65 patients (51.2%) with penetrating craniocerebral wounds, isolated injuries were observed in 42, including 3 with multiple wounds. Regarding the nature of the injuring projectile, fragment wounds were found in 27 patients (41.5%) and bullet wounds in 38 (58.4%). Based on wound canal characteristics, blind penetrating injuries were identified in 21 patients: 8 had simple blind penetrating craniocerebral wounds, 4 had radial wounds, 5 had segmental wounds, and 4 had diametrical wounds. In cases of blind radial and diametrical craniocerebral wounds with ventricular wall involvement, external cerebrospinal fluid leakage was observed.

Tangential penetrating wounds were identified in 10 cases, through-and-through wounds in 18, and ricochet wounds in 6. The general condition of patients with blind simple penetrating craniocerebral wounds and tangential penetrating wounds was satisfactory or moderately severe. In patients with radial and diametrical blind wounds of the skull and brain, the general condition was severe, with loss of consciousness ranging from deep obtundation to terminal coma (GCS score: 11 to 3). Among all cases of penetrating injuries, the 18 patients with through-and-through penetrating cranial wounds were the most severely affected.

Notably, 44.5% of group 1 patients with penetrating craniocerebral wounds were admitted to the stage of specialized medical care over 6 h after injury; 33.6% within the first 24 h; 18.1% on days 2–3; and 3.8% on day 4. During this period, diffuse cerebral neurological symptoms predominated over focal signs. Among 65 patients with penetrating craniocerebral wounds admitted to the field hospital, 55 exhibited varying degrees of impaired consciousness.

The most severe degree of impaired consciousness, that is, coma, ranging from moderate to terminal, was observed in 31 patients; sopor in 11; and moderate obtundation in 13. Ten patients were conscious on admission. Thirteen patients were admitted in shock due to massive blood loss and associated injuries to other organs; six of these patients showed brainstem symptoms.

The most severe injuries among through-and-through and blind penetrating cranial wounds were segmental, radial, and diametrical bullet wounds, which resulted in fatal outcomes within 2–5 days of injury in most cases, as they were accompanied by extensive brain parenchymal damage often incompatible with life.

As a result of MEW, four patients in group 2 sustained combined fragment wounds to the soft tissues, and three sustained multiple fragment wounds. In addition, in all patients admitted to the neurosurgical clinic, spiral computed tomography of the brain revealed type I or II contusion foci and a laminar subdural hematoma in one case. All patients admitted to the neurosurgical clinic were in clear consciousness (GCS score: 15) and in satisfactory condition.

In six patients with nonpenetrating wounds resulting from MEW, the injuries were combined and multiple. In all group 2 patients, spiral brain computed tomography demonstrated type IV contusion foci; in four patients, these contusion foci were accompanied by intracerebral hematomas associated with brain vessel injury. On admission, four patients were in a state of moderate obtundation (GCS score: 13), and two were fully conscious; their condition was assessed as satisfactory.

The most severe cases were 57 patients with penetrating craniocerebral wounds, of whom 39 were admitted in a conscious state (clear consciousness or moderate obtundation; GCS score:13–15 points). Furthermore, 18 patients were admitted in comatose state (coma grades I–II; GCS score: 6–5), including 4 who were on mechanical ventilation.

Among the admitted patients with penetrating craniocerebral wounds, 29.8% required extended repeat surgical debridement for retained bone fragments, deeply embedded metallic projectiles, anterior parabasal injuries involving the frontal sinuses and orbits, and posterior cranial fossa and brainstem injuries. In 10.4% of cases, repeat operations were performed for patients who developed early infectious complications.

Table 3 shows data on the characteristics of craniocerebral wounds in group 2 patients.

Comparison of diagnostic and treatment findings between the two groups demonstrated differences in the frequency and nature of craniocerebral wounds. In group 1, the difference between fragment and bullet wounds was 25.6%. In group 2, all injuries, with the exception of a single tangential bullet wound, were fragment-related, multi-regional combined, and polyetiologic combined and combined (with burns) in two cases. Furthermore, no through-and-through craniocerebral wounds were observed in group 2. No significant differences were found in injury severity and wound canal characteristics between the groups (Table 4).

Based on the data presented in Table 4, brain structures (according to magnetic resonance imaging) were conditionally divided into two anatomical zones (Fig. 1).

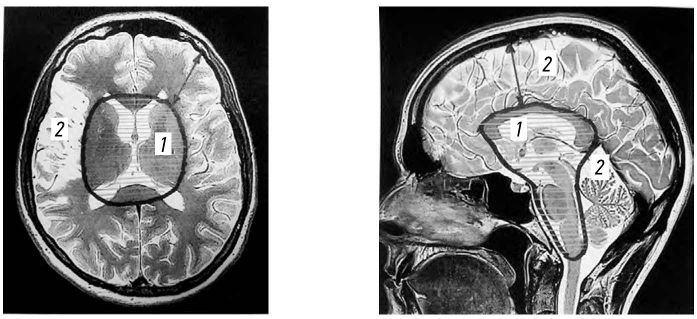
Based on the severity of craniocerebral gunshot wounds, all zone 2 injuries could also be conditionally subdivided into wound canals passing closer to the convexital surface of the brain, regarded as less severe, and wound canals passing closer to zone 1, considered more severe. The latter

Table 3. Characteristics of craniocerebral wounds in group 2 patients, absolute numbers

Type of wound	Mine–explosive	Bullet	Fragment
Soft tissue	4	–	4
Nonpenetrating (up to the dura mater)	6	–	6
Penetrating:	56	1	56
–tangential	9	1	9
–ricochet	2	–	2
Blind wounds:	30	–	30
–simple	13	–	13
–segmental	5	–	5
–radial	6	–	6
–diametrical	6	–	6
Through-and-through wounds:	0	0	0
–segmental	0	0	0
–diametrical	0	0	0
Diagonal	2	–	2
Parabasal:	15	–	15
–anterior (fronto-orbital)	7	–	7
–middle (temporomastoid)	2	–	2
–posterior (posterior cranial fossa and craniocerebral–spinal)	6	–	6

Table 4. Severity of condition in wounded patients of both groups according to the type of craniocerebral wound type

Type of wound	General condition	Level of consciousness	Vital functions
Soft tissue Nonpenetrating Penetrating: –tangential –simple blind –segmental (within one cerebral lobe) –ricochet –anterior parabasal	Satisfactory Moderate severity	Clear consciousness, moderate or deep obtundation, stupor (Glasgow Coma Scale score: 15–8)	Preserved
Penetrating gunshot wounds: –diagonal –segmental bihemispheric (blind, through-and-through) –radial uni- and bihemispheric –diametrical (through-and-through, blind) Parabasal: –temporomastoid –posterior cranial fossa (cerebellum and brainstem)	Severe, extremely severe, or terminal	Stupor, coma I–II, terminal coma (Glasgow Coma Scale score: 8–3)	Impaired (mechanical ventilation, tracheostomy, and hemodynamic instability)



a *b*

Fig. 1. Schematic division of the brain into zones: *a*, sagittal section; *b*, axial section. *1*, subcortical structures, ventricles, and brainstem; *2*, cerebral cortex and cerebellar hemispheres.

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included gunshot soft tissue injuries accompanied by type I and II contusion foci and intracerebral hemorrhages and nonpenetrating wounds with type III and IV contusion foci, intracranial hematomas, and external ventricular cerebrospinal fluid leakage. Among penetrating craniocerebral wounds, these comprised tangential penetrating wounds, simple blind wounds, segmental wounds confined to a single lobe, ricochet wounds, and anterior parabasal wounds associated with frontal sinus and orbital wall damage. These patients survived after primary surgical debridement and were transferred for further rehabilitation with varying focal neurological deficits.

All gunshot wounds (bullet and fragment) wherein the wound canal crossed both anatomical zones were the most severe. These included penetrating gunshot wounds classified as diagonal, segmental bihemispheric (blind or through-and-through), radial uni- and bihemispheric, diametrical, parabasal involving the temporomastoid region, and posterior cranial fossa wounds. In this subgroup, fatal outcomes were frequently observed after primary surgical debridement, and most survivors were in vegetative state.

Spiral computed tomography of the brain at the stage of specialized medical care allows for the diagnosis to be established not by the entry wound on the skull, but according to the affected lobes and brain structures. Extended diagnostic formulations include 1) mine–explosive wound (combined, multiple); 2) gunshot fragment penetrating simple blind wound of the left frontal lobe of the brain with type IV contusion focus; 3) perforating fracture of the left frontal bone; 4) multi-regional combined injury (e.g., involving the neck, spine, chest, abdomen, pelvis, and extremities); 5) polyetiologic combined injury (e.g., burns, frostbite, radiation exposure); 6) surgical interventions performed (with date); and 7) comorbid diseases.

Fig. 2 shows the vascular involvement zones of the brain in penetrating craniocerebral gunshot wounds.

Figs. 3–7 present wound canals in penetrating cranial fragment wounds, along with examples of diagnostic formulations.

Data obtained from the examination and treatment of patients in group 2 demonstrated that conducting modern high-technology combat operations predominantly results in multiple, multi-regional combined and polyetiologic combined mine–explosive injuries involving the head, chest, abdomen, and extremities. The clinical and anatomical classification proposed below enables more accurate medical triage according to the severity of injuries and allows for determining the priority of surgical care, including under conditions of mass casualty admissions. For this purpose, the diagnostic algorithm applied in group 2 was used (Table 2).

It was established that the most promising patients based on survival and recovery—those primarily requiring surgical

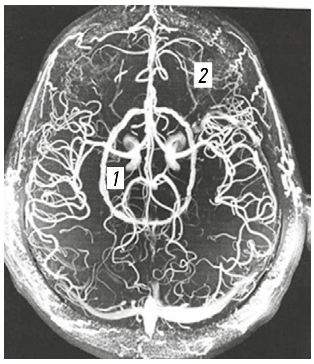

Fig. 2. Magnetic resonance angiography of the brain with vascular distribution zones: *1*, vessels of the subcortical structures, ventricles, and brainstem; *2*, vessels of the cerebral cortex.

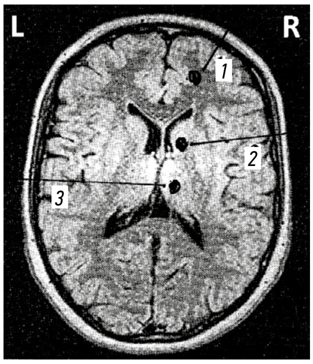

Fig. 3. Gunshot penetrating blind simple and radial wounds of the skull and brain. Diagnoses examples: *1*, mine–explosive wound (MEW). Gunshot fragment blind penetrating simple wound of the right frontal lobe of the brain; *2*, MEW. Gunshot fragment blind penetrating radial wound of the right frontal lobe of the brain; *3*, MEW. Gunshot fragment blind penetrating radial bihemispheric wound of the left parietal lobe of the brain

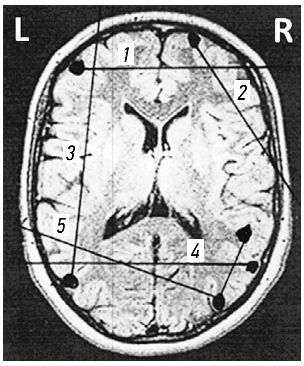

Fig. 4. Gunshot penetrating segmental wounds of the skull and brain. Diagnoses examples: *1*, mine–explosive wound (MEW). Gunshot fragment blind (through-and-through) penetrating bihemispheric segmental wound of the frontal lobes of the brain; *2*, MEW. Gunshot fragment blind (through-and-through) penetrating segmental wound of the right frontal lobe of the brain; *3*, MEW. Gunshot fragment blind (through-and-through) penetrating segmental wound of the left frontal and parietal lobes of the brain; *4*, MEW. Gunshot fragment blind (through-and-through) penetrating bihemispheric segmental wound of the parietal lobes of the brain; *5*, MEW. Gunshot fragment blind (through-and-through) penetrating segmental bihemispheric ricochet wound of the left parietal and right occipital lobes of the brain.

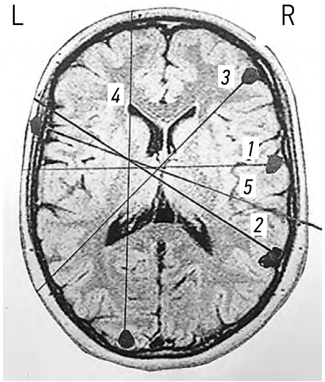

Fig. 5. Gunshot penetrating diametrical wounds of the skull and brain. Diagnoses examples: *1*, mine–explosive wound (MEW). Gunshot fragment blind (through-and-through) penetrating diametrical wound of the frontal lobes of the brain; *2*, MEW. Gunshot fragment blind (through-and-through) penetrating diametrical wound of the left frontal and right parietal lobes of the brain; *3*, MEW. Gunshot fragment blind (through-and-through) penetrating diametrical wound of the left parietal and right frontal lobes of the brain; *4*, MEW. Gunshot fragment blind (through-and-through) penetrating diametrical paramedian wound of the right frontal, parietal, and occipital lobes of the brain; *5*, MEW. Gunshot fragment through-and-through penetrating incomplete diametrical wound of the right parietal and left frontal lobes of the brain.

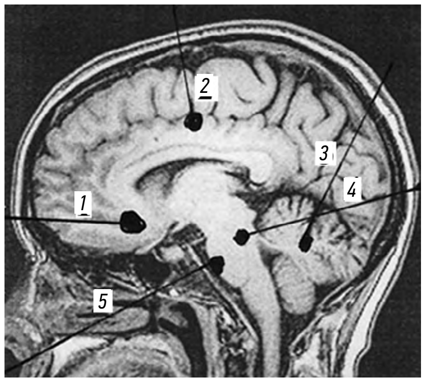

Fig. 6. Gunshot penetrating diagonal and parabasal wounds of the skull and brain. Diagnoses examples: *1*, mine–explosive wound (MEW). Gunshot fragment blind (through-and-through) penetrating anterior parabasal wound of the frontal lobe of the brain; *2*, MEW. Gunshot fragment blind (through-and-through) penetrating diagonal wound of the frontal lobe of the brain; *3*, MEW. Gunshot fragment blind (through-and-through) penetrating diagonal wound of the occipital lobe and cerebellar hemisphere; *4*, MEW. Gunshot fragment blind (through-and-through) penetrating wound of the occipital lobe, cerebellar hemisphere, and brainstem; *5*, MEW. Gunshot fragment blind (through-and-through) penetrating parabasal wound of the brainstem

debridement—are those whose wound canal is located in zone 2, i.e., passing through the cerebral cortex and white matter. The more convexital the course of the wound canal, the less extensive the brain damage and, consequently, the more favorable the expected outcome following primary surgical debridement.

After vital function stabilization, surgery is performed in those patients whose wound canal traverses both zones. The prognosis in this category depends on the severity and extent of vital brain structure damage, which ultimately determines treatment outcomes and survival. In cases of infectious complications, the prognosis for survival becomes less favorable.

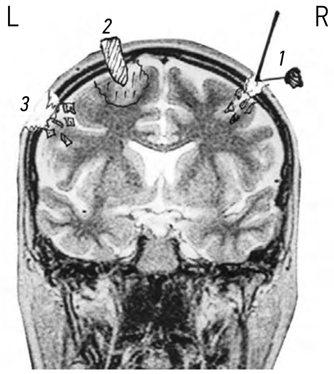

Fig. 7. Gunshot penetrating tangential, incomplete, and ricochet wounds of the skull and brain. Diagnoses examples: *1*, mine–explosive wound (MEW). Gunshot fragment (bullet) penetrating ricochet wound of the right frontal lobe of the brain; *2*, Gunshot bullet penetrating incomplete wound of the left frontal lobe of the brain; *3*, MEW. Gunshot fragment (bullet) penetrating tangential wound of the left frontal lobe of the brain.

Thus, based on the fundamental intergroup differences associated with the conduct of hostilities in 20th-century warfare and in 21st-century high-technology combat, a modern clinical–anatomical classification of combat craniocerebral injuries caused by contemporary weapons was developed.

Clinical–Anatomical Classification of Combat Craniocerebral Wounds Caused by Contemporary Weapons

Mine–explosive wounds: combinations: head, neck, spine, chest, abdomen, pelvis, and extremities/

Laterality of injury: single, multiple, or polyetiologic combined (burns, frostbite, and radiation exposure).

Anatomical brain structures: cerebral cortex and white matter:

- zone 2 (injuries closer to the cortex are less severe; injuries closer to zone 1 are more severe);
- zone 1: subcortical nuclei, brainstem.

Type of projectile: bullet, fragment, and other types.

Nature of injury: soft tissue, nonpenetrating, or penetrating.

Penetrating injuries (by wound canal type):

- *blind wounds:* simple; segmental (within one or two lobes, bihemispheric, bihemispheric with internal ricochet)—zone 2; ricochet—zone 2; diagonal—zones 2–1; radial (uni-/bihemispheric)—zones 2–1; and diametrical (bihemispheric)—zones 2–1–2;
- *through-and-through wounds:* tangential—zone 2; segmental (within one or two lobes, bihemispheric)—zone 2; or diametrical (bihemispheric)—zones 2–1–2.

Localization by brain lobe: frontal, parietal, temporal, or occipital.

Parabasal wounds: fronto-orbital, temporomastoid—zone 2; craniocerebral–spinal (cerebellar hemispheres)—zone 2; or brainstem (blind, through-and-through)—zone 1.

Types of skull fracture: incomplete (outer table), linear, depressed, comminuted, perforating, or fragmented.

Intracranial injuries:

– zone 2: concussion, cerebral contusion, subarachnoid hemorrhage, contusion foci (types I–IV), cerebral compression, epidural/subdural hematomas, depressed fractures, injury to the vein of Galen and confluence of dural venous sinuses, post-traumatic cerebral aneurysm formation, bone fragments, and metallic foreign bodies in the wound canal;
– zone 1: contusion foci (types I–IV), parenchymal hematomas with intraventricular hemorrhage and possible tamponade, subcortical nuclei and brainstem injury, and external ventricular cerebrospinal fluid leakage.

CONCLUSION

The proposed clinical–anatomical classification allows for a more precise characterization of craniocerebral injuries. At the stage of specialized medical care (level 4), it enables more accurate medical triage of incoming patients by determining the leading injury and priority of surgical intervention, establishing the prognosis for further evacuation, and predicting the outcome of craniocerebral wounds.

ADDITIONAL INFORMATION

Authors' contribution: V.P. Orlov: general concept development, data analysis, article writing; S.D. Mirzametov: research design, data analysis. The authors have approved the version for publication and have also agreed to be responsible for all aspects of the work, ensuring that issues relating to the accuracy and integrity of any part of it are properly considered and addressed.

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ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. В.П. Орлов — разработка общей концепции, анализ данных, написание статьи; С.Д. Мирзаметов — дизайн исследования, анализ данных. Авторы одобрили версию для публикации, а также согласились нести ответственность за все аспекты работы, гарантируя надлежащее рассмотрение и решение вопросов, связанных с точностью и добросовестностью любой ее части.

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Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Раскрытие интересов. Авторы заявляют об отсутствии отношений, деятельности и интересов за последние три года, связанных с третьими лицами (коммерческими и некоммерческими), интересы которых могут быть затронуты содержанием статьи.

Оригинальность. При создании настоящей работы авторы не использовали ранее опубликованные сведения (текст, иллюстрации, данные).

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