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Ophthalmological Help in Cases of Mine-Explosive Injury of the Eye

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Summary: The problem of an increasing percentage of severe trauma among military and civilian personnel has become particularly important. Injury to the organ of vision as a result of a mine-explosive injury is the most severe injury among polytrauma and requires specialised care by a team of doctors. It is very important to adhere to the algorithm of actions for both pre-hospital and highly specialised care to preserve the life and functional fullness of the injured person. The paper presents a brief description of the problem and an analysis of approaches to providing specialised care for eye injuries resulting from mine-blast trauma.

Key words: eye, military, mine-explosive injury, care.

Problem

The current state of the war in Ukraine has caused radical changes in the priorities of our lives and our professional activities. The problem of the increase in the percentage of severe trauma among the military and civilian contingent has acquired special importance. Changes in the conduct of modern hostilities and the emergence of new types of weapons and technologies for the use of explosives have led to significant changes in the nature of injuries and an increase in the number of combined eye injuries and their mine-explosive attachments [1–29].

Explosive injury to the organ of vision is characterized not only by penetration, but also by contusion damage caused by the blast wave [2, 4, 5, 12, 22, 23]. The type and severity of the impact depends on many factors, although the main mechanism determining the degree of injury is the amount of kinetic energy in a short period of time and the distance of the victims from the epicentre of the explosion [2, 3–5, 9–12, 16]. Even though the percentage of head injuries according to different authors fluctuates within significant limits, they have very serious consequences, since at the same time there is damage to the brain, organ of vision, ear, and face [6–8, 10, 11, 15, 18, 20, 26, 28, 29]. In these cases, the eye is highly vulnerable because it is filled with fluid of different densities [1, 13, 15]. The extent and nature of the damage depend on the distance to the explosive agent and the epicentre of the detonation [1]. In addition, there is an assumption that the auditory canals and the optic canal of the orbit become potential paths for the propagation of waves into the central nervous system [16]. On the other hand, the results of clinical observations and experimental studies have shown that the special geometry of the orbit in some cases can prevent the propagation of the blast wave and reduce the force of compression of the eye and the risk of its destruction.

The list of main traumatic factors of mine-blast injury also includes primary and secondary fragments, high-speed and high-temperature gas flows and molten metal particles, flame, and toxic products of explosion and combustion [7, 8].

Given the listed traumatic factors, 4 categories of blast injuries are distinguished.

Category I, or primary blast injury, which occurs as a result of the movement of a blast wave through the body, which is created only by high-level explosives [2, 5].

Category II, or secondary blast injuries, constitute the majority of blast injuries and occur as injuries to the eye and its accessory apparatus by fragments of the explosive device and secondary debris. Explosive eye injuries can be deceptive at first glance, as a small wound may conceal massive lacerations of the deep membranes of the eye or orbital bones with the presence of deep foreign bodies and skull bone fragments [5].

Category III, injuries of a contusion or penetrating nature and sometimes so-called structural collapse, i.e. compression of the body as a whole or its parts, occur as a result of the movement of people and objects by the blast wave [1, 2, 5, 7].

Category IV bast injuries consist of the effects of significant exposure to fire, smoke, radiation, biological agents, fumes, dust, toxins, environmental exposure, and psychological stress [20, 21, 28, 29].

There are observations that in the case of head trauma and concussion of the brain of a mine-explosive nature, unexpected changes may occur in the anterior surface of the eye and the development of long-term consequences of contusion, requiring further ophthalmological control with examination of IOP, cornea, anterior chamber angle, retina, and optic nerve [1, 2, 8–10]. Thus, mine-blast trauma is a special type of polytrauma, which is accompanied by general and local compensatory reactions of varying intensity at the level of different organs and systems [22].

Ophthalmological care in conditions of systemic polytrauma

Eye trauma in conditions of active hostilities most often becomes part of a wider systemic polytrauma. The peculiarities of mine-explosive damage emphasise the need to form an interdisciplinary team of specialists, and ophthalmologists become important members of the multidisciplinary trauma team. A prerequisite for an ophthalmologist to begin work is the stabilisation of the injured patient's condition [22].

Ophthalmologists integrated into the trauma team or in a multidisciplinary hospital should provide effective and timely assessment of vision-threatening conditions and determine the phasing of necessary care.

Eye injuries and vision-threatening conditions should be assessed and treated at the scene of injury or at any stage of evacuation according to existing clinical guidelines for prehospital care (USA CPG ID 03, CPG ID 66) [4, 5, 22, 23]. To determine the extent of the injury and the further course of action, a medical history and initial examination are required.

Providing first aid for eye injury includes identifying the injuring agent and threat to vision, providing immediate eye treatment, and local and systemic infection prevention [4, 5, 22, 23].

The levofloxacin and moxifloxacin-based prophylaxis and treatment regimen covers a broad spectrum of pathogens due to its excellent Gram-negative and Gram-positive coverage with excellent penetration levels [22].

In a multidisciplinary medical institution of level III or IV, primary surgical care should be provided in the first 24 hours after the injury following the most complete possible examination with a clear algorithm of actions by a team of specialists: resuscitation specialist, ophthalmologist, and traumatologist (maxillofacial surgeon).

The initial examination by an ophthalmologist is performed in the emergency room or intensive care unit to determine the condition and degree of damage, determine the necessary set of examinations, and implement priority measures to prevent infection and eye injury during an additional examination.

Primary exposure to an explosive can result in displacement of the optical structures of the eyeball, hyphaemia, conjunctival haemorrhages, serous retinitis, and orbital fracture, which have a non-penetrating, contusive nature [4, 22].

However, eye injuries most often occur as secondary explosive injuries with rupture of the membranes of the eyeball, lacrimal system appendages, eyelids, eyebrows, facial tissues, and bones [4, 5, 21, 22].

Primary surgical treatment includes antimicrobial treatment, revision of the eyelids, conjunctiva, sclera, cornea, removal of superficial and deeper foreign bodies, suture fixation of conjunctival and sclera wounds, and removal of blood from the anterior chamber under general anaesthesia.

Open revision of the outer shell of the eye in the surgery room remains the most effective way to determine penetrating trauma and the presence of foreign bodies, sometimes immediately after providing life support to the injured person in the intensive care unit. Scleral tears are usually repaired using the ZIPPERA or combined technique with adhesives and donor materials [17, 19, 21].

In the presence of destruction and defects of the bones of the orbit and face, their reconstruction, depending on the patient's condition, is performed simultaneously in step I or a few days or weeks after ophthalmic surgery as step II (Fig. 1) [4].

The next steps of an eye restoration depend on its condition. The best way is to use a concrete algorithm of surgical procedures by assessing of the patient's condition, the condition of the eye, and technical capabilities (Figs. 1–4). It should be taken into account that polytrauma of mine-explosive origin requires an optimal joint algorithm of actions by ophthalmologists and maxillofacial surgeons.

Step I includes the revision and washing out of hyphaemia with sealing of the eye wounds and reduction of the facial bones (Fig. 1). The second step includes cataract removal, closed vitrectomy, and gas tamponade (Fig. 2). In this case, the 3-D step in severe cases, for example, included implantation of the irido-phaco prosthesis and Ahmed valve (Figs. 3, 4).

The algorithm of microsurgical treatment of severe eye injuries in some subsequent steps of different procedures with

A.
B.
C.
D.

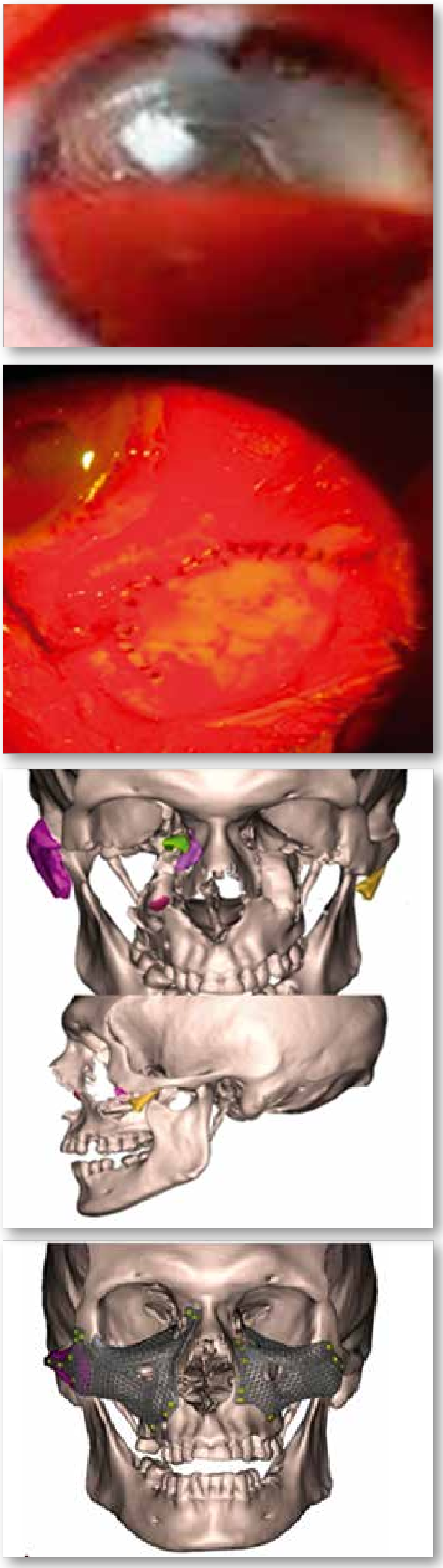

Fig. 1. Step I. Revision and washing out of hyphaemia – A; sealing of the eye shells – B, reconstruction of the facial bones defects: before surgery – C, after operation – D.

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implantation of intraocular implants allows restoration of the anatomical and topographic features of the eye, stabilising the IOP level, and obtaining high functional results.

A.
B.
C.
D.

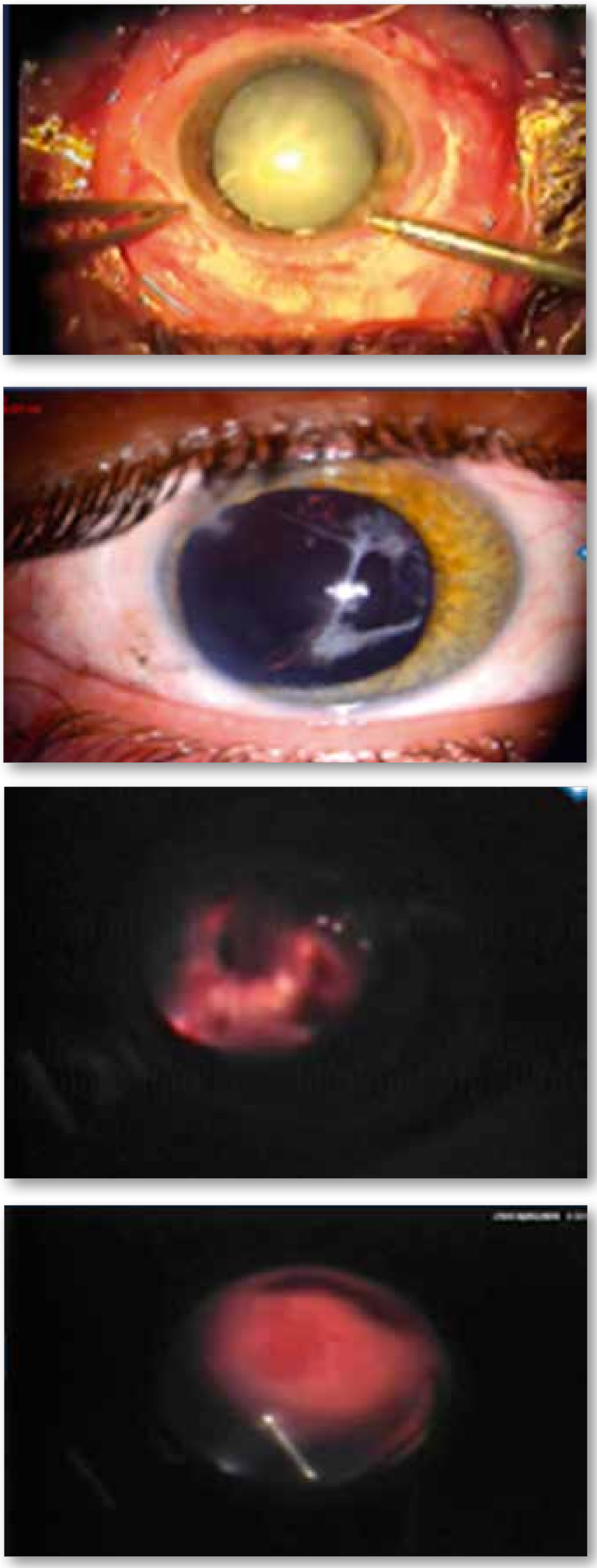

Fig. 2. Step II. Cataract removal (A, B), closed vitrectomy with gas tamponade (C, D).

A.
B.
C.

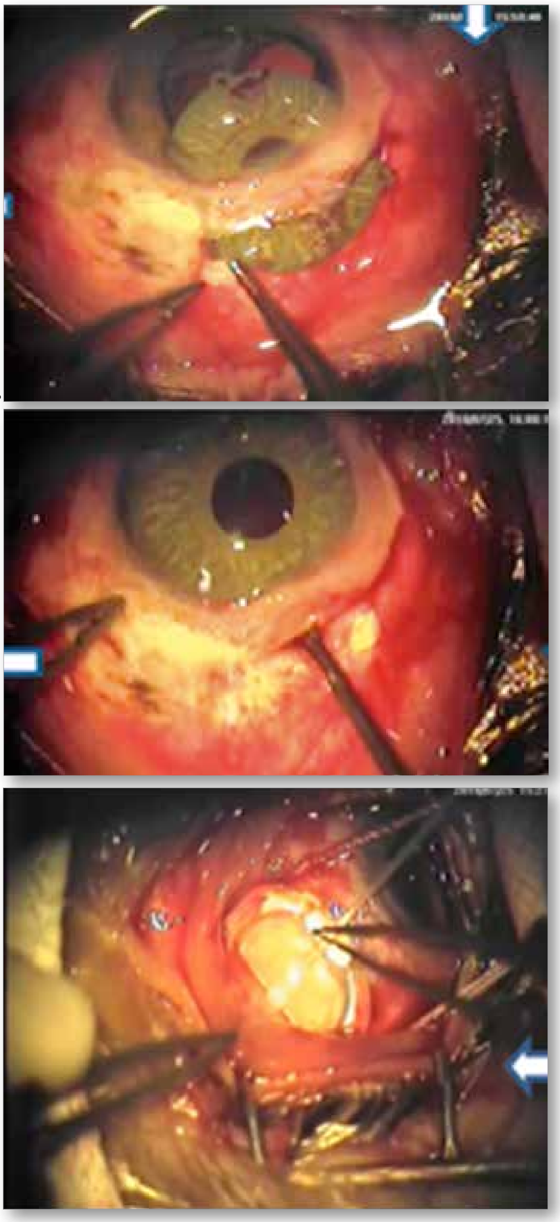

Fig. 3. Step III. Implantation of the irido-phaco prosthesis (A, B) and Ahmed valve (C).

Fig. 4. One year after combine surgery with irido-phaco prosthesis and Ahmedvalve.

Postoperative care

Postoperative care for patients with blast-related ocular trauma is provided in tertiary care settings. Patients with closed ocular injuries require continued regular follow-up and examination by an ophthalmologist to accurately assess visual acuity and the effects of the trauma and surgery [4, 9, 22, 24]. Patients with facial burn problems with exposure keratopathy, chronic epiphora, strabismus, or other non-urgent problems of the eye and its adnexa may be referred by ophthalmologists for elective surgical management [20].

Functional outcomes

Visual function in patients with ocular trauma from blast injuries varies, and the prognosis depends on the type of injury sustained. Most poor outcomes are associated with severe penetrating injuries to the eye and orbit. According to retrospective studies of patients who suffered blast trauma, the most common long-term sequelae were optic nerve avulsion (3%), anophthalmos, subatrophy, severe traumatic neuropathy, corneal scarring and ulceration, tractional retinal detachment, and secondary uncompensated glaucoma [27].

Eye protection

Prevention of eye injury is most effective when polycarbonate bulletproof goggles, ballistic laser protective goggles (BLPS), special cylindrical protective eyewear (SPECS), sun/wind/dust goggles (SWDG), and helmets of various models are used as recommended in areas of potential conflict, which is mandatory for the preservation of the organ of vision in functional and anatomical terms [27]. Technical specifications and regulations for the use of protective equipment must be approved by the military departments of each state. It is known that the worst visual prognosis is usually observed and documented in individuals who did not wear eye protection [22, 23].

Conclusion

The global analysis of the problems of wartime and the 3-year personal experience of the consequences of Russia's military aggression in Ukraine indicate that the prevalence of blindness due to mine-explosive injuries remains quite high. The current level of ophthalmological care in Ukraine of a surgical and rehabilitation direction is at a high level and can be fully applied in the medical practice of multidisciplinary medical institutions. The severe combined consequences of an explosion on the part of the organ of vision against the background of severe damage to the limbs, and other organs and systems are not only a severe psychosocial trauma for patients and their families, but also become a large comprehensive psychosomatic, social, and economic burden.

On the other hand, strict requirements and control over compliance with preventive protection measures and the quality of use of protective equipment should be established. Providing a protection system should be more economical in terms of human life and in terms of medical and economic resources [22]. Measures to create rehabilitation programs for psychological recovery, social support, and social adaptation of people with visual disabilities from wartime are of great importance.

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