Severe Eye Injuries in the War in Iraq, 2003–2005

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Purpose: To document the incidence and treatment of patients with severe ocular and ocular adnexal injuries during Operation Iraqi Freedom.

Design: Retrospective hospital-based observational analysis of injuries.

Participants: All coalition forces, enemy prisoners of war, and civilians with severe ocular and ocular adnexal injuries.

Methods: The authors retrospectively examined severe ocular and ocular adnexal injuries that were treated by United States Army ophthalmologists during the war in Iraq from March 2003 through December 2005.

Main Outcome Measures: Incidence, causes, and treatment of severe ocular and ocular adnexal injuries.

Results: During the time data were gathered, 797 severe eye injuries were treated. The most common cause of the eye injuries was explosions with fragmentation injury. Among those injured, there were 438 open globe injuries, of which 49 were bilateral. A total of 116 eyes were removed (enucleation, evisceration, or exenteration), of which 6 patients required bilateral enucleation. Injuries to other body systems were common.

Conclusions: Severe eye injuries represent a significant form of trauma encountered in Operation Iraqi Freedom. These injuries were most commonly caused by explosion trauma. *Ophthalmology 2008;115:377–382*

Unlike most eye injuries in the civilian sector, trauma in a wartime environment is markedly more severe and frequently is associated with massive concomitant injuries elsewhere in the body. An injury in the civilian sector usually occurs at home, at work, or in the local drinking establishment. The injury may involve a blunt or sharp trauma and possibly a single intraocular foreign body. The patient is brought to the local hospital by family or an ambulance. Evaluation, including computed tomography scanning, occurs fairly expeditiously, and if needed, the patient is taken to the operating room for injury repair. In a wartime environment, the soldier is usually injured with a high-velocity ballistic weapon or fragments from an explosive device. The soldier is usually in a dirty, dusty environment under hostile fire. Initial treatment and stabilization is performed by a medic. The eye injury may or may not be recognized or prioritized because of the severity of other bodily injuries and the need to concentrate on saving the soldier's life. The injured soldier may be transported via ground ambulance or helicopter to reach an ophthalmologist. At the combat support hospital level, the patient usually is treated by a team of surgical specialists. The patient normally is brought to the operating room quickly for life-saving surgical intervention. Thereafter, usually during the same anesthetic treatment, ophthalmologic, maxillofacial, orthopedic, and other injuries are addressed. The soldier may have a markedly disrupted globe, sometimes with foreign bodies and on occasion with involvement of both eyes. Current treatment by a military ophthalmologist usually involves the use of state-of-the-art equipment to include an operating room microscope, a phacovitrectomy machine, and all the instruments necessary to mange a severe ocular trauma patient. The ophthalmologist

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Table 1. Demographics: March 2003 through December 2005

Number of deaths*	1706
Number of personnel injured*	16 356
Number of eye injuries	797
Age (mean), yrs	27 (median, 25)
Gender	
Male	97%
Female	3%
Status	
United States service member	55%
Not United States service member	45%
Documented cases of eye protection worn	74
Eye involved	
Right	42%
Left	36%
Both	22%

*Data obtained from Defense Manpower Data Center.[1]

frequently is called in to assist in nonocular trauma cases. The authors herein report the number and types of eye injuries that have occurred in the war in Iraq from March 2003 through December 2005.

Patients and Methods

The authors retrospectively gathered information on all severe eye injuries treated by United States Army ophthalmologists that occurred in the war in Iraq from March 2003 through December 2005. The patients usually underwent an initial evaluation by a medic or corpsman at or near the location of injury. Then, patients usually were evacuated to an ophthalmologist in Iraq or Kuwait, where they had definitive evaluation and treatment. The patients included coalition forces, enemy prisoners of war, and Iraqi civilians. These data were collected from the physicians serving in combat support hospitals (CSHs) providing ophthalmic care during the invasion of Iraq and during the insurgency operations. The authors did not include any ocular injuries that may have been treated elsewhere during this period.

The authors defined a severe injury as any trauma that resulted in a disruption of the cornea, scleral, or ocular adnexa or any trauma severe enough to cause severe loss of vision (e.g., vitreous hemorrhage or optic neuropathy). They did not include patients with more minor injuries that could be managed in the clinic, such as small corneal foreign bodies or abrasions, small hyphemas, or minor adnexal trauma that did not require repair in the operating room. However, these minor injuries were relatively common and frequently were incapacitating to the soldier. Intraocular and adnexal foreign bodies were confirmed by direct visualization or by radiologic imaging. Data collected for analysis, when available, included patient age, gender, eye injured, type of eye protection, source of the injury, size of the corneal or scleral laceration or both, tissues involved in the injury, presence of an open globe, presence and location of a foreign body, and need for enucleation or evisceration. Other nonocular injuries also were documented.

This study has several limitations that should be addressed. First, the study was retrospective. The data were acquired by medical record review or from information obtained by individual ophthalmologists. Second, the authors had no standardized means of data collection. Therefore, there was a spectrum of data precision that varied from ophthalmologist to ophthalmologist. Third, some data were collected during periods of mass casualties. During these sometimes overwhelming events, time limitations prevented precise data collection. Fourth, the follow-up data of severely injured patients was limited or nonexistent. Many of these patients were moved quickly from CSHs in Iraq to Landstuhl Region Medical Center in Germany for follow-up care. Thus, data on postoperative wound leaks, retinal detachments, endophthalmitis, or final visual acuity were not available to the authors. Fifth, the authors had no accurate data on total injuries or deaths that occurred in the individual hospitals where the data were collected. The total injury data were obtained from an Internet search of total injuries in a given period that occurred in all of Iraq. Thus, the numbers give the reader a general idea of the relative number of eye injuries versus the total injuries inflicted. Therefore, exact percentages are not presented because such information may be misleading.

Results

From March 2003 to December 2005, 16 356 United States military personnel were wounded in action.[1] During this time, 797 patients were evaluated and treated for a severe ocular or ocular adnexal injury (Table 1). The average age was 27 years (median, 25 years; range, 4–61 years). Males made up 97% of ocular casualties. Of those casualties treated, 55% were United States military personnel. Only 74 individuals were documented to have been wearing ocular protection at the time of injury. The right eye was involved in 42% of injuries, the left eye was involved in 36% of injuries, and 22% of injuries were bilateral.

The most common source of an ocular or ocular adnexal injury was an explosion with a fragmentary injury. Other sources of injury included ballistic missile injuries, motor vehicle accidents, blunt trauma, burns, and metal-on-metal injuries (Table 2). Because of the preponderance of fragmentary injuries, there were numerous intraocular, orbital, conjunctival and corneal, and lid foreign bodies (Table 3; Fig 1). The foreign bodies were made up not only of the metallic shrapnel from an explosive round, but also of dirt, cement, and other objects surrounding the explosion.

Open globe injuries were documented in 438 patients, including 49 patients who had bilateral open globe injuries (Table 3; Fig 2). The globe lacerations ranged in size from 1 to 43 mm (mean, 11.2 mm; median, 8 mm). Globe injuries were severe enough to require removal in 116 patients, including enucleation in 52 patients (6 were bilateral), evisceration in 34 patients, traumatic enucleation (no viable ocular tissue in the orbit) in 29 patients, and exenteration in 1 patient (Fig 3).

Other than the eye itself, the surrounding tissues often were involved in the injury (Table 3). The most common injury to the lids included lacerations, foreign bodies, and burns (Fig 4). There were numerous orbital fractures and orbital foreign bodies. The optic nerve was affected with optic neuropathy and optic nerve avulsion.

Table 2. Source of Injury (469 Patients with Documented Source of Injury)

Source	n (%)
Explosion	344 (73%)
Ballistic injury	51 (11%)
Motor vehicle accident	25 (5%)
Blunt injury	17 (4%)
Burn	8 (2%)
Metal on metal	7 (1.5%)
Fall	5 (1%)
Assault	5 (1%)
Other	7 (1.5%)

Table 3. Types of Eye Injuries

Type	n
Foreign bodies	
IOFB	116
Orbit	95
Corneal/conjunctival	86
Eyelid	31
Open globe injuries	
Total no.	438 (49 bilateral)
Mean laceration size (mm)	11.2 (median, 8; range, 1–43)
Eyelid injuries	
Lid laceration	197
Lid foreign body	31
Tissue loss	12
Avulsion	11
Canalicular	9
Burn	5
Optic nerve injury	
Avulsion	14
Optic neuropathy	13
Orbital injury	
Fracture	100
Foreign body	95

IOFB = intraocular foreign body.

The eye usually is not affected alone, but rather, other body parts often are injured at the same time (Fig 5). The other body parts most frequently injured in association with an eye injury include the face, extremities, head and neck, thorax, abdomen, and ear.

Discussion

Of the 16 356 injured and 1706 Americans killed from the onset of the Iraq War in March 2003 through December 2005, many suffered severe eye trauma.[2–36] These data delineate nearly 800 severe eye injuries sustained by United States soldiers, allied forces, enemy combatants, and civilian personnel during this same period.

It should be kept in mind that this report covers ocular injuries from both the land invasion of Iraq and the Iraq insurgency. Although there were similarities, the medical treatment and evacuation systems were somewhat different for each phase. The land invasion of Iraq was a war of movement, with clear-cut objectives and reliable knowledge of enemy troop positions. The time and location of planned major offensives usually were well known, and this information was passed on to medical personnel so that preparations could be made for efficient care of expected casualties. The wounded normally were evacuated by helicopter from behind a clearly defined front line to forward surgical teams or CSHs. Because our army was advancing quickly, sometimes over hundreds of miles, the medical evacuation route was by nature quite lengthy. The head and neck teams, which included ophthalmic surgeons, usually were part of a mobile CSH that had the ability to relocate as needed to support better the surgical needs of the advancing units.

The medical care system during the insurgency phase of the war was quite different. For the most part, the enemy chose when and where to attack and there were no front lines. Thus, the medical care provided usually was unplanned and was largely a reaction to casualties produced during enemy attacks. In contrast to the long evacuation routes of mobile CSHs during the ground war, CSHs during the insurgency were located in fixed facilities near where many of the casualties were begin generated. During a portion of the invasion and during the insurgency the head and neck team was located in Baghdad. This proved to be an excellent location because the Baghdad area has been a major source of wounded during the insurgency. Thus, the time from injury to treatment generally has been shorter during the insurgency as compared with that of the land invasion. As in previous conflicts, explosions during the Iraq War commonly caused fragmentary injuries. In the current study, explosive injuries caused 73% of all eye trauma. During the insurgency, artillery rounds or other explosions frequently have been placed in advance and have been detonated at close range near Allied troops. This has resulted in devastating injuries to the ocular and periocular tissues, often with avulsion of the lid and disruption or complete destruction of corneal or scleral tissue. The authors have found the repair of these severe wounds to be extremely difficult if not impossible. Explosions produce numerous fragments that impact the globe and adnexa. These fragments are comprised of not only metal, but also secondary projectiles such as dirt, rocks, cement, glass, plastic, fiberglass, and wood. The gross contamination of these wounds requires meticulous debridement and potentially increases the risk of local or systemic infections. Superficial lid, conjunctival, and corneal foreign bodies are removed at the time of initial repair. Intraocular foreign bodies usually are left in place and often are removed days to weeks later, after the patient has been evacuated to a military facility in the continental United States.[37]

Because of the severity of the injuries a large number of our patients require removal of the eye or have no viable ocular tissue to repair. The eye is removed primarily only if it is functionally destroyed with no possibility of visual or cosmetic rehabilitation. The fact that many severely injured eyes are not removed primarily is a testament to the excellent treatment the patient received by the front-line medic, the rapid evacuation of the patient from the point of injury to the definitive care of an ophthalmologist, and the outstanding repairs performed by the military ophthalmologists. The rate of enucleation was as high as 50% in World War I,[7] 35% to 40% in World War II,[10,12,14] and 27% in the Korean War.[18] Our capacity to repair an injured eye surgically has improved, but the destructive forces also have increased. Although the enucleation rates improved from World War II to Korea, they have remained relatively stable over the last several wars. In more recent wars, the rate of eye removal was as follows: 20% during Vietnam,[20,22–24] less than 15% in the 1973 and 1982 war in the Middle East,[26–29] 18% during Operation Desert Storm,[31] less than 10% in the Iran-Iraq War,[32] and 13% during the war in Croatia, Bosnia, and Herzegovina.[34] The present rate of primary removal of the eye of approximately 13% is in line with these most recent conflicts. However, given the ex-

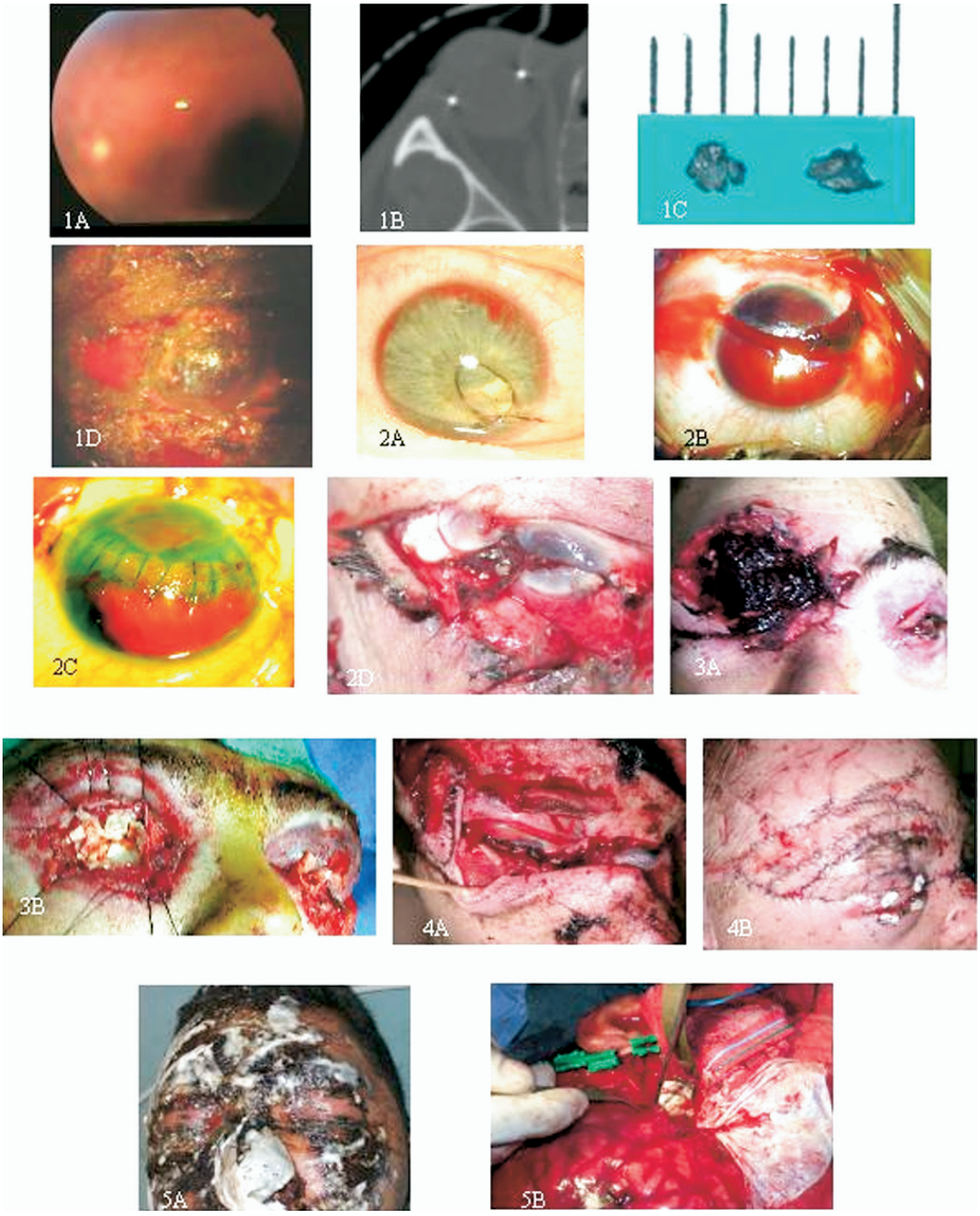

Figure 1. **A**, Metallic foreign body seen on clinical examination. Also present is a mild vitreous hemorrhage. **B**, Computed tomographic scan of multiple foreign bodies in the vitreous of an injured soldier. **C**, The two foreign bodies that were removed from the eye in B. **D**, Numerous lid and corneal foreign bodies associated with an explosion injury. Many of the foreign bodies are dirt and mortar (from concrete).
Figure 2. **A**, Limbal wound with hyphema and peaking of the pupil. **B**, **C**, Photographs obtained, respectively, before and after surgery of a large corneal scleral laceration. **D**, Markedly disrupted globe after an explosion injury.
Figure 3. Photographs showing representative massive, disruptive injuries with tissue loss resulting in the need for an enucleation or evisceration.
Figure 4. Photographs obtained (**A**) before surgery and (**B**) after surgery showing an extensive facial and lid laceration resulting from an explosive injury.
Figure 5. **A**, Photograph showing facial burns with associated eye injuries. **B**, Photograph showing a cranial foreign body that was also associated with an orbital foreign body.

treme severity of many of the ocular injuries that have been repaired, the authors anticipate that many repaired eyes eventually required a secondary enucleation.

The authors report a large number of cases in which the patient's eye was completely destroyed by the injury and no viable tissue was found in which to repair the globe. As Mader et al[36] discussed previously, these severe eye injuries are in contrast to those seen in civilian practice, where the wound usually is caused by a relatively slow-speed projectile, a blunt injury, or a single foreign body fragment. In these civilian injuries, the eye usually is disrupted with a single rupture site and the globe remains largely intact. In a ballistic or explosion injury, such as the authors describe, the projectile strikes the eye at a high velocity. The explosion pressure and multiple foreign bodies may shred the ocular and adnexal tissue into multiple pieces, leaving unidentifiable remnants of the eye, making repair impossible. Additionally, because of the severity of the injury to the eye and surrounding tissues, the ocular tissues may be mixed with tissue from the face, sinuses, and central nervous system, making repair even more difficult.

The severity of the injuries to the body varies greatly depending on the patient's location in relationship to the explosion (in a confined space versus in the open), the size of the explosive device, and proximity to the explosion. A smaller explosion or greater distance from the blast usually results in fewer or less severe total body injuries. With smaller explosions or greater distance, the foreign body projectiles may barely penetrate the skin, clothing, or protective devices. However, these same small or slow-moving projectiles may cause a devastating injury to the eye, potentially resulting in the loss of function or possibly the loss of the eye. Although the eye makes up only a small percentage of the body surface area, it is still extremely susceptible because of the need to visualize an enemy or target, and thus exposing the face and eyes, and the difficulty of persuading soldiers to use protective eyewear.[38,39] Although protective glasses will not stop bullets, large fragments, and high-speed projectiles and would not have prevented all of the injuries described, many injuries might have been prevented or the severity of injury lessened by the wearing of protective eyewear.[28,38–43] Less than 10% of our patients admitted to wearing protective eye wear at the time of injury.

A common injury in wartime is the patient who experiences multisystem trauma. With the advent of body armor and the Kevlar (Dupont, Wilmington, DE) helmet, injuries to the head, chest, and upper abdomen have decreased to some extent. This, in turn, means that the face, eyes, and extremities may be more susceptible to injury. Because of multisystem trauma, ophthalmologists often find themselves working side by side with other specialists, including otolaryngologists, oral maxillofacial surgeons, neurosurgeons, general surgeons, orthopedic surgeons, and cardiothoracic surgeons.

During the period examined, eye trauma in the war in Iraq was associated most commonly with explosions and fragmentary munitions. These tended to cause very severe eye injuries, resulting in a large number of ruptured globes. The destructive nature of wartime injuries results in tissue loss and the resultant loss of an eye in numerous patients. Unlike injuries in the civilian sector, wartime trauma often causes bilateral injuries with multiple foreign bodies. Although eye protection might have limited some of the trauma, it could not have prevented all injuries.

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