Chapter 7

PSYCHOLOGICAL AND OPERATIONAL IMPACTS OF MILITARY LASERS

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INTRODUCTION

The human combatant is and always has been the most important system on the battlefield. Weapons, equipment, supplies, tactics, and doctrine are all essential, but they are all brought to bear on the enemy by the capability and will of individual human beings who act alone or in concert with others. Lasers have been present on the battlefield for many years, largely as components of rangefinders and target-designating systems. Laser-based systems dramatically improve accuracy and thus have helped to reduce civilian casualties and collateral damage. However, because lasers are now widely distributed with air, land, and sea forces, they have also become a nearly ubiquitous source of potential harm.

Until now, battlefield lasers have been confined largely to adjunctive roles in rangefinders and designators. Widespread intentional use of lasers as *antipersonnel weapons* has not occurred, and the purposeful use of lasers in this role has been proscribed by international agreement.[1] In the future, directed-energy weapons systems, including lasers, will be even more widely used to support fire-control and training systems. Lasers may yet be developed for use as *antimateriel weapons* or, despite the current ban on their intentional use against human beings, as antipersonnel weapons.

Comparatively few cases of injury (perhaps a few hundred) have resulted from exposure to lasers in military and nonmilitary settings. The most well-known cases involve the sometimes intentional, sometimes inadvertent exposure of pilots to laser-directed aircraft cockpits; but ground troop exposures have also occurred, and some significant injuries have been sustained. Unavoidably, service members will encounter lasers on the modern battlefield, and some service members will be injured by them. To manage this threat effectively, it is crucial that we understand its potential psychological impact and how warfighters may respond.

It might well be argued that, to date, as much or more psychological than physical harm has been done by real and potential accidental exposure to lasers in the military and in commercial aviation. Tragic accident cases, mainly involving short-distance exposure to Q-switched laser pulses of high power and short duration, have resulted in severe retinal damage and permanent visual disability. Fortunately, such cases have been rare. More common are exposures that cause immediate visual disruption (glare, afterimage, or flash blindness), but that leave no permanent trace in the exposed person's eye and no permanent damage to vision. However, in some cases, laser exposures have resulted in significant disability despite the lack of any known organic mechanism. Where no biological basis can be found, such consequences must be psychological. This is not to say that reported symptoms are not real or that the person who experiences such symptoms is in any sense weak, stupid, crazy, or a malingerer. Rather, it is simply the case that challenging and dangerous conditions inherent to military life or in commercial flying can interact with human psychology, sensory experience, and perception. This is made all the more likely by sensationalized and incorrect information or reports about lasers and their potential dangers.

In some respects, lasers can be usefully compared to chemical weapons.[2] Chemical weapons and lasers are both "unconventional." Both can be invisible and undetectable until it is too late to defend against them, and both can cause significant injury. The prospect of an invisible and unfamiliar threat is frightening. Lasers superficially resemble the "death rays" of popular science fiction, and most people have relatively little experience with lasers projected over long distances. Lasers are extensively used in everyday technology, but often are not recognized by the average person. Chemical weapons are used militarily in much the same way they are employed in daily life, but our modern familiarity with insecticides and their effects is relatively recent.

The introduction of gas warfare had a significant psychological impact on soldiers in World War I, in part because the idea was new that one might be injured by something neither seen, heard, nor smelled. The Army's response to this problem included the "gas chamber" exercise whose purpose was (and still is) to convince recruits that gas was a real threat and to build their confidence with the effective use of protective masks. In this exercise, trainees are brought into a chamber containing tear gas while wearing a gas mask. Then, they are required to remove the mask shortly before exiting the chamber. Thus, they receive a brief but compelling exposure to the noxious gas. The intended effect of this exercise is mainly psychological. The gas chamber exercise continues as a rite of passage for all members of the American military.

It has been proposed that service members may benefit from a laser training exercise conceptually similar to the gas chamber exercise.[3,4] Like chemical weapons, lasers may be invisible yet potentially harmful. Their operational mechanisms are not readily apparent to untrained individuals, and laser protection requires specialized protective equipment. In 1995, the International Committee of the Red Cross (ICRC; Geneva, Switzerland) published a pamphlet supporting a

campaign to ban "blinding weapons."[5] To dramatize the threat, the pamphlet included sensational photos of chemical weapon victims from World War I.

Unfortunately, such emotional appeals ignore several important differences between battlefield lasers and chemical weapons. Lasers contribute precision to the battlefield, and precision ultimately helps to reduce unnecessary suffering. Chemical weapons offer no such benefit. Chemical weapons are by their nature indiscriminate, whereas lasers are by their nature highly discriminate. Regulations to discourage the legitimate use of lasers in combat might, therefore, have the unintended consequence of increasing unnecessary suffering.

There is a growing appreciation that psychological considerations are crucial to our understanding of modern combat and its consequences for combatants. Controversy over the health effects of Gulf War service helped to focus our attention on the psychological dimensions of modern warfare. The "signature wounds" of the Iraq War are *posttraumatic stress disorder* and *traumatic brain injury*, both of which pose unique diagnostic and treatment challenges involving the psychological dimensions of injury to the mind and brain. Individuals whose injuries are viewed as essentially psychological often struggle with stigma and may be mistreated by those who believe such injuries are merely imaginary. In recent years, the term *posttraumatic stress disorder* became the object of a vigorous campaign by General Peter Chiarelli, who argued that the name of the condition should be changed to *posttraumatic stress injury*.[6] An improved understanding of the potential psychological effects of military lasers may help us to manage more effectively the full range of health consequences for those exposed to lasers in the future.

In general, all modern wars have been associated with symptom clusters that appear as "syndromes," but whose etiologies are confounding.[7,8] For example, Jones et al[7] researched pension files of the British military from 1872 through 1991 and found three varieties of postcombat disorder:

1. *debility syndrome*—without psychological or cognitive symptoms associated with wars fought before 1918;
2. *somatic syndrome*—involving cardiorespiratory symptoms (eg, rapid heart beat, shortness of breath, fatigue, etc) associated with World War I; and
3. *neuropsychiatric syndrome*—involving neurological and psychiatric symptoms (eg, depression, anxiety, headaches, etc) associated with World War II through the first Gulf War.

There was no single presentation of symptoms common across the various wars studied. Moreover, none of the syndromes identified could be linked to a definitive etiological agent, such as exposure to microbial agents, depleted uranium, chemical agents, or uniquely identifiable psychological trauma. This led researchers to implicate cultural factors (eg, common health fears, compensation, trends in diagnostic labeling, etc) as contributors to these unexplainable illnesses.[9]

IMMEDIATE PSYCHOLOGICAL EFFECTS

The psychological effects of lasers in military operations can be classified as either *suppressive effects* or *exposure effects*. Suppressive effects are changes in behavior or performance that result from the fact that lasers are or may be present on the battlefield. Exposure effects are those that result from actual exposure to lasers.[10]

Suppressive Effects of Laser Use

The mere threat of laser exposure may affect the behavior of service members and thus can have a profound impact on military operations. For example, vision is vital to situational awareness on the battlefield. If the enemy can disrupt the normal use of vision, performance on the battlefield may suffer. The threat of direct ocular exposure may motivate soldiers, sailors, or pilots to alter their visual search strategies, disrupt their scanning patterns, or otherwise modify their efforts to visually extract information from the combat environment. There is some evidence that exactly such effects may have occurred in the Falklands War in 1982 and perhaps contributed to the destruction of three Argentinian aircraft.[11] Likewise, performance may be degraded by the use of protective equipment or evasive maneuvers. The subject of laser eye protection is not considered at length in this volume, but there is an active and extensive ongoing research program to develop protective systems. Such systems have been fielded to protect pilots, vehicle crews, and dismounted soldiers. Laser eye protection is itself a complex and difficult issue, and will remain a dynamic problem.[12–14]

The use of military lasers (or simulated lasers) may also have significant suppressive effects by straining the military medical system. Wessely et al[2] described several incidents in which healthcare delivery systems were affected when large numbers of people sought medical help after a rumor or a suggestion that they

may have been exposed to chemical weapons. In one case, 35 people in a Maryland subway station were sickened by an unknown substance that was later identified as window-cleaning solution sprayed under suspicious circumstances.[2] The appearance of harmless colored lights or eyesafe lasers might also easily be misinterpreted as potentially harmful on the battlefield. Large numbers of suspected laser injuries could impose a substantial burden on the battlefield triage and medical treatment system, even in the absence of any actual injuries.

Psychological Effects of Laser Exposure

The physical and medical effects of actual laser exposure have been dealt with extensively in other parts of this volume. Ocular laser injuries are rare, but reports of such injuries are numerous enough to describe their effects with some confidence.[15,16] In general, such injuries occur without pain at the time of injury and afterward. Accident victims who report a "popping sound" or a "light blow" to the affected eye do not describe these acute effects as painful. Such exposures are not followed by a lengthy postinjury period of ocular pain, periorbital pain, corneal grittiness, or headache. Although patients may experience symptoms secondary to rubbing their eyes in response to real or perceived visual changes, some victims of severe laser retinal injury remain unaware that they have been injured until some time has passed. It is possible for a bright laser flash to cause fleeting visual effects without injury. Conversely, a laser may produce no perceptible flash (or a very mild one) and cause significant visual changes or even long-lasting and severe injury. Uncertainty may be confounded by delayed notification of known or possible exposure, or by conflicting alarms from laser warning sensors.

When laser injuries do occur, immediate and lasting psychological effects are possible. Immediate effects may include fear, panic, agitation, or shock. These acute effects would be expected to subside quickly as the patient receives care and reassurance from others. However, if complete recovery from exposure is not possible, psychological adjustment to lasting disability may be difficult. In principle, these effects are not different from those to be expected in the case of traumatic amputations or other severe battlefield injuries. What makes lasers different is the degree of uncertainty involved in assessing the severity of the injury and its likely course of recovery, and the possibility that a victim of laser injury may show no outward signs of injury. As is often the case for individuals who suffer with other "invisible" injuries, such as posttraumatic stress disorder and mild brain trauma, individuals who live with laser-related disabilities may discover that their injuries are poorly understood, regarded skeptically, or not taken seriously by others.[6]

Certain terms have a psychological saliency that focuses collective attention on a concept (eg, radiation, laser, posttraumatic stress disorder, anthrax) in a manner that can overshadow alternatives and exceptions to the collective idea of that concept. This forces a competition between the deliberate practice of determining etiology and those of the common prevailing understanding. For example, in the case involving *Kapitan Man* in 1997, discussed in detail in the following section, the then prevailing theme was a concern for the indiscriminant use of lasers as blinding weapons. This concern prompted a series of meetings by the International Conference of the Red Cross culminating in 1994 with an agreement on the prohibition on the indiscriminate use of lasers for the purpose of blinding.[17] In the case of the *Kapitan Man*, given the heightened concern over lasers, complaints by the crew concerning their eyes and a suspicious red dot on the photographs, and a paucity of cases lending to the lack of understanding of laser tissue interaction influenced an initial diagnosis of laser eye injury given by the attending optometrist. Alternative explanations and exceptions were not easily accepted, even though further evaluation proved the initial diagnosis as inconsistent with the associated events. For the Navy commander involved, the initial misdiagnosis and subsequent Congressional hearings played out into 2003 with the Navy rejecting an award for a Purple Heart.

The severity of the laser-related injury itself may not play a dominant role in determining psychological outcome. Rather, the psychological effects of laser exposure will probably depend on the interaction of several factors:

- the nature and severity of the symptoms themselves,
- the circumstances under which the exposure occurred,
- the victim's cognitive appraisal of the implications of exposure (determined by existing knowledge and beliefs about lasers, and by postexposure diagnosis and information), and
- individual personality differences and response tendencies (eg, coping skills).

Similar injuries may have very different psychological effects on various people. Psychological response may also be shaped by the physical and psychological states of the victim at the time of injury. Complex relationships among these factors are illustrated by analysis and comparison of case reports from the relatively few laser exposures that have been documented to date.

CASE STUDIES

Although cases of accidental laser exposure and injury have been relatively infrequent, case analysis supports the idea that a victim's immediate response to laser injury may be most strongly influenced by his or her prior knowledge of lasers and laser injury mechanisms. Postinjury treatment and subsequent related events will significantly affect the character and intensity of long-term psychological response.

The Importance of Preexisting Knowledge About Lasers

Two cases (patients 1 and 2) reported in the literature support the hypothesis that preexisting knowledge of lasers affects initial response to laser-related injury. In each case, there occurred a relatively severe injury that led to permanent disability.

Patient 1: This patient was a laser scientist who was very knowledgeable about lasers and laser injury mechanisms.[18] He was accidentally exposed to a pulsed laser that produced an intraocular hemorrhage. He knew immediately that he had suffered a serious injury. However, at the time of this incident, few if any similar injuries had occurred or been documented in the literature. Little was known about the potential for recovery from laser injury. This patient experienced a powerful emotional reaction that he later described as worse than any reaction he had experienced as witness to horrific combat injuries in Vietnam.

Patient 2: This case offers a marked contrast in terms of immediate psychological response to laser eye injury.[19] A 21-year-old soldier was injured by a pulsed-laser rangefinder. He knew comparatively little about lasers or their potential consequences. The soldier sustained an injury that produced an immediate intraocular hemorrhage, but he reacted with relative calm. He observed blood in the vitreous humor of his eye and tried (unsuccessfully) to wash the blood away. He did not seek medical attention until several hours later.

Patients 1 and 2 both suffered immediate and obvious physical effects from their injuries, and both patients subsequently experienced substantial recovery. In each case, the initial resulting injuries were severe enough to produce significant, well-defined symptoms that could be directly and unambiguously attributed to the accidental laser exposure and its effects. Patient 1 experienced a profound, immediate, and disturbing psychological reaction. Patient 2 remained calm. Neither patient suffered lingering psychological effects.

Psychosomatic Responses to Suspected Laser Exposure

Laser exposures to the retina need not result in severe psychological reactions, but the potential for such reactions has long been recognized. In 1990, the US Army officially noted that "… soldiers who sustain minimal or even no injury from low-energy laser exposures may develop serious psychological problems and become ineffective in the performance of their duties."[20(p4)] At least one case of possible military laser exposure may have led to just such severe psychological consequences.

Patient 3: This patient was a crewman aboard a helicopter conducting a photographic surveillance mission of a ship suspected of espionage activities.

Patient 4: This patient was a pilot operating the helicopter at the time of the incident. Several hours after returning to base, a photo analyst noted a red light in one of the surveillance photographs that had been taken during the mission. The analyst concluded that the red light was a laser. Alarmed, he immediately contacted the crew, explained his observation, and urged them to seek medical attention for their eyes. In response, the crewmembers reported to a local hospital emergency room. They became concerned that they had sustained severe eye injuries, and they reported this to their chain of command. Because of the sensitive nature of the surveillance mission, the case drew immediate and intense interest at the highest levels of government.[21] The case became the subject of Congressional hearings and also led to a civil lawsuit against the owners of the ship from which the laser was alleged to have been fired.[22,23]

The US Navy eventually concluded that no laser exposure had occurred in this case and that the red light apparent in the surveillance photo was actually a navigational lamp on the ship. However, there remains legitimate controversy among knowledgeable experts as to whether patient 3 was ever actually exposed to a laser. If a laser exposure did occur, it is nevertheless clear that any resulting ocular damage was minor and subtle. Patient 3's visual acuity remains 20/20 in each eye. From a psychological point of view, however, the question of actual exposure is largely immaterial. Patient 3 reported persistent and severe symptoms of pain. Although his reported symptoms are not consistent with those that have occurred in cases of known

exposure, patient 3 remains convinced that he was exposed to a laser and that his pain is the direct result of that exposure.

It is worth noting that several similar, but more severe, incidents have been documented involving laser irradiation of civilian police helicopters and commercial airliners. In most cases of actual laser exposure, aircrewmen perceived a bright flash and subsequent afterimage, and they responded by taking immediate evasive action. The affected crewmembers often experienced anxiety about the potential long-term effects of the incident. Some members were reluctant to seek medical help because they feared that doing so might jeopardize their flying qualification. However, in none of these cases has there occurred a postincident course characterized by long-term severe pain and disability such as that reported by patient 3.

A recent review of reports of aircrew exposed to lasers showed that adverse effects (defined as distraction/annoyance, glare, flash blindness, afterimages, operational problems, or pain/injury) occurred in about 11% of the incidents.[24] This contrasts with a rate of 60% in some simulator studies and may reflect the greater variability of exposure parameters under real-world conditions. Pain/injury was reported in approximately 2% of the incidents. The severity and duration of the symptoms associated with the pain/injury reports were not detailed.

Functional Somatic Syndrome?

There are many examples of putative medical disorders that seem to exist and persist in spite of medical and scientific evidence casting doubt on their organic origin. Barsky and Borus refer to these disorders as *functional somatic syndromes* and describe them as "characterized more by symptoms, suffering, and disability than by disease-specific, demonstrable abnormalities of structure or function."[25(p910)] Examples may include multiple chemical sensitivity, Gulf War syndrome, or chronic whiplash, among others. Functional somatic syndromes may involve disagreement between the reporting patient and mainstream medical authorities with respect to the attribution of particular symptoms. The patient attributes symptoms to the putative syndrome. Medical authorities often do not.

Barsky and Borus argue that "somatic distress and medically unexplained symptoms have always been endemic to daily life, but the social and cultural characteristics of each era shape the expression, interpretation, and attribution of these symptoms."[25(p911)] Medical history includes many disorders or syndromes that have flourished for periods of time, only to disappear or be replaced by other syndromes. Shorter[26] provides a fascinating history of these psychosomatic disorders. Barsky and Borus[25] assert that patients with such syndromes today are even less likely than their historical counterparts to respond to medical explanation and treatment. They believe this shift in patient responsiveness can be traced to three factors:

1. an overall decline in physician authority;
2. an influence of the mass media, including the Internet; and
3. contemporary medicolegal and financial interests related to compensation, disability, and legal damage claims.

These factors apply to military personnel and the population at large.

The term *functional somatic syndrome* would seem to be best applied when a large number of people are involved. However, given the role of mass media and the medicolegal system, the development of such syndromes can probably be set in motion today by a relatively small number of individuals. Indeed, Gulf War syndrome apparently began with national attention to reports from members of a relatively small Army Reserve unit. Although no such syndrome related to laser exposure has yet been named, the responses of patients 3 and 4 described previously suggest the possibility that underlying mechanisms at work in the development of such syndromes may have been a factor in the eventual unhappy outcome of their cases. It is certainly possible that conditions could conspire to create such reactions again, perhaps on a larger scale.

Barsky and Borus[25] identify four psychosocial factors that lead to the amplification of symptoms and thus set the stage for attribution of those symptoms to a functional somatic syndrome:

1. *belief* that one is sick,
2. future expectations and the role of *suggestion*,
3. *sick role*, and
4. *stress* and distress.

The case of patient 3 can be interpreted in terms of these four processes.

Beliefs

Many studies have shown that an individual's beliefs about illness can exert a powerful effect on his or her symptoms and health. Patient 3's beliefs about the connection between laser exposure and ocular symptoms may well have begun with incorrect or incomplete knowledge, and with faulty expectations about the future course of laser injuries. If so, his

beliefs were probably strengthened by early, specialized examinations that revealed lesions in his right retina. These lesions were described as consistent with lesions that could result from laser exposure. Because accidental laser injury is rare, and because this particular case was so sensitive, the initial diagnostic findings were not broadly tested against the opinions of other knowledgeable specialists. Discussions about the case were limited to a relatively small circle of military laser experts who found themselves under extreme time pressure to report their findings. Experts in the field of laser injury have emphasized the difficulty of making a definite attribution of ambiguous retinal findings without lengthy, detailed, and highly sophisticated investigations.[27] In the case involving patient 3, the strong belief that laser exposure had occurred and caused detectable ocular damage may well have been at least partly iatrogenic.

Suggestion

The role of suggestion in the development of health symptoms has been extensively documented.[28] Patient 3 did not perceive his ocular symptoms as significant enough to require medical attention until he was phoned by the photographic analyst who had identified the red light in one of the mission photographs and concluded it was a laser. Additionally, some aspects of patient 3's initial symptom reports may point to the possible role of suggestion or social transmission. On examination, patient 4 had no abnormal or pathological findings in either eye. Nonetheless, he later reported severe symptoms remarkably like those reported by patient 3. Although such symptoms (eg, headache, severe eye pain, head pain) may result from organic causes, they have also been reported as part of psychosomatic syndromes in the past.[26]

News reports of aircraft illuminations often contain inaccurate or exaggerated information. For example, a story appearing in the *New York Post* reporting the apprehension of a man who pointed a laser at commercial aircraft approaching LaGuardia airport began by describing the laser used as a "military-grade" laser, an ominous-sounding label with no real meaning. Like civilian lasers, military lasers vary in output characteristics according to their intended use. One of the officers who used his police helicopter to (successfully) lure the perpetrator to point the laser at his aircraft described the effects of the exposure this way: "You feel a strong tingle in your eyes. You have a burnt spot where you can't see. It is very dangerous for any pilot to be blinded."[29] "Tingling" is not a likely consequence of such exposure, and the "burnt" spot was most likely a temporary afterimage.

In an article for CNN, Marsh and Brumfield said of lasers in cockpits, "A direct hit can burn the cornea and that has put pilots in the hospital."[30] The suggestion from the article is that ocular injuries severe enough to require hospitalization have ocurred as a result of cockpit laser exposures. In fact, corneal burns are highly unlikely in any cockpit scenario, because visible light passes through the cornea and is absorbed in the retina. Infrared lasers (not visible to the naked eye) could burn a cornea, but the cockpit windscreen would offer significant protection against such an injury. Retinal burns are possible in a cockpit exposure scenario, but we have been unable to find or document a single case in which a retinal burn has been verified.

The Sick Role

Adopting a sick role can produce secondary gain as sympathetic responses from others serve to reinforce and sustain sick behavior. Patients 3 and 4 received rapid and close attention from the media and from high levels of government. At least one media report portrayed the two military men as victims of Russian aggression and betrayal by the Clinton administration.[31] The supposed seriousness and permanence of the injuries reported by patients 3 and 4 conferred an air of significance to the case that surely would have been greatly diminished if the alleged victims had simply recovered in a day or so. Once the sick role is adopted, it cannot easily be relinquished without significant loss of standing.

Stress

Stress is well known to influence the perception of physical symptoms and their severity. People who experience chronic stress and/or acute stress that results from major life-changing events may perceive physical symptoms more negatively and more seriously than people who are not so stressed. As discussed previously, patients 3 and 4 found themselves in a very stressful situation. Patient 4 also experienced a major life-changing event when he lost his flying qualification, a devastating outcome for a pilot. Severe and chronic stress can produce somatic symptoms. Functional somatic syndromes provide apparently legitimate diagnostic labels for symptoms that may be due partially or wholly to stress. The possibility of laser exposure and its aftereffects may have provided a convenient and psychologically compelling explanatory outlet for the symptoms reported by patients 3 and 4.

The police officer who reported tingling and whom reporters described as injured[32] was in fact exposed to laser illumination after an immensely difficult and

presumably stressful chase at night, during which he maneuvered his helicopter to resemble an approaching jetliner specifically to provoke the laser exposure and identify its source location. The emotional and physiological arousal associated with such actions, which can only be described as heroic, might easily result in sensitization to a startling and feared stimulus.

A More Effective Response to Laser Injury

A few years after the incident involving patients 3 and 4, a similar incident occurred in Bosnia. Two aircrewmen, patients 5 and 6, observed a red light directed at them. Both men experienced visual disruption. There is little doubt among knowledgeable experts that these two crewmen were indeed exposed to a laser. Patients 5 and 6 both recovered fairly quickly from the incident. However, early media reports about the incident were incorrect in reporting its effects. Vinch erroneously reported that the crewmen had "sustained minor burns in their outer eye tissue, but are fully expected to recover."[33(p21)] In fact, no such burns were sustained and would not have been possible in any of the most likely laser scenarios. Because visible laser light is not absorbed strongly by the cornea, it could only produce such burns with extremely high power, which would have also produced profound retinal effects. Infrared radiation is absorbed by the cornea, but would probably have produced immediate pain in the victim. Moreover, infrared radiation would have been partially or completely blocked by the victims' night vision goggles.

Making reference to the earlier cases involving patients 3 and 4 as having suffered "permanent eye damage, *Washington Times* reporter Gertz[21,31] also incorrectly reported that the two aircrewmen in Bosnia had "suffered eye burns." In a report published in the *Wall Street Journal*, Ricks quoted an Army general as saying that patients 5 and 6 had suffered "mild-to-moderate burns" and further that there was "no indication of long-lasting effects such as retinal scarring, but it is too early to say. …"[34(p8)] Also disturbing was the imputation that (unnamed) "soldiers were disturbed by the lack of timely disclosure" and that the "Pentagon may not have wanted to call attention to the continuing U.S. mission on the eve of national elections in the U.S."[34(p8)] Such media reports are troublesome because they exploit lack of knowledge in their sources, as well as their readers, and because they fuel suspicion and mistrust in victims and others. Information withheld or distorted for political purposes can worsen the pain and disability suffered by those who may (or may not) have been injured. Given the inconsistent and incorrect early media reports in this case, a negative psychological outcome could easily have resulted. Fortunately, it appears that no lasting damage was done.

Perhaps the most important lesson from these cases is that actual and possible laser injuries must be handled very carefully, with early attention to the possibility of psychological effects. In 1990, the US Army acknowledged the importance of stress management and reassurance:

> Treatment following a laser injury is extremely important. Calm, professional treatment at each echelon of medical care is mandatory, including reassurance that the injury is not life-threatening and that chances for some, if not total recovery, are good. The potential psychological effects of lasers could be enormous. It is imperative that secondary gain be minimized by prompt return to duty of those individuals with temporary flash-blindness or noncritical (non-foveal) burns of the retina without hemorrhage. If an error is to be made, it should be on the side of return to duty of questionable injuries. Medical management of stress reactions for patients suffering from real or imagined laser injuries is like stress management of other injuries. Repeat the reassurance that symptoms will improve with rest, nutrition, hygiene, and the expectancy of an early return to the soldier's unit."[20(p18)]

Other chapters in this volume detail the painstaking research undertaken to explain the mechanisms of laser–tissue interaction and to develop effective therapies for physical laser-related injuries. Yet the cases illustrated here force us to recognize that even the most sophisticated scientific knowledge may be overcome by casual inaccuracies introduced and perpetuated by people who do not fully understand lasers and their potential effects on human beings.

PREPARING FOR THE FUTURE

To date, laser accidents and injuries involving military personnel have been extremely rare. If there were a shift toward the use of antipersonnel or antioptic lasers on the battlefield, we could expect to see an increase in casualties. Of course, it is impossible to estimate the magnitude or nature of the effects of weapons whose specific characteristics, strengths, and weaknesses are not yet known. The International Convention of the Red Cross on Certain Unconventional Weapons compared the indiscriminant use of lasers to that of the use of mustard gas in World War I. As with any ubiquitous agent used indisciminantly, there is often a reporting of symptoms that are a result of the risk communication rather than a direct result of exposure.

Two processes seem to be involved in the evolution of symptom clusters associated with modern wars. One process is the rapid spread of notions concerning health-related problems. These health-related notions are best described as "memes" (a unit of cultural transmission or imitation).[35,36] Memes are memorable, have strong psychological appeal, and speak to the concerns of a specific generation. They can replicate with relative high-copying fidelity (note consistency of symptom clusters within a war period) at sometimes alarming rates. The meme process spreads horizontally, within a generation or time-bounded category,[6,37] and resonates with the presently held notions. As an example, Gulf War syndrome has been persistently attributed to toxin exposure,[38] which in turn has sustained arguments such as those concerning its possible relationship to a mycoplasma species infection. This attribution has been proven incorrect, but not before Gulf War I veterans were inappropriately treated with doxycycline as part of a clinical trial.[39] (In February 2001, the US Army Medical Research and Materiel Command conducted an external peer review of the Department of Defense-funded work on mycoplasma and found no putative role of *Mycoplasma fermentans* in the etiology of illness in veterans presenting with symptoms akin to chronic fatigue syndrome. Further, ethical concerns were raised in the use of a non-US Food and Drug Administration-approved technique used to enroll personnel in the course of antibiotic treatment.) The point is that as with any poorly understood symptom cluster or weapons that produce mass indiscriminant casualty, we might expect symptom reporting greater than what one would expect from those directly exposed.[40,41]

Planning for the Psychological Aspects of Laser Casualties

A review of injury cases yields a few basic heuristics to guide an effective response to laser casualties. These focus on the paramount importance of providing state-of-the-art medical and supportive care to victims of laser injury. From a psychological viewpoint, the special context that surrounds laser injuries must be recognized and carefully considered when plans are developed to deal with laser casualties.

Immediate, Appropriate Care

Fortunately, none of the cases reviewed here involved any significant or avoidable delay in the provision of medical care. The interval between battlefield injury and treatment has been dramatically reduced by advances in military medicine. Injured troops can now receive specialty care from well-trained, well-equipped military medical personnel very far forward in the combat zone. Faster treatment and a remarkable medical evacuation system have led to improved survival and faster return to duty. Service members are well aware of these advances, and they know they can expect excellent treatment. This helps to build and sustain morale and confidence. Service members must be confident that the military medical system is prepared to deal with laser injuries as effectively and efficiently as it does other types of combat-related injuries. It is important that the military medical system anticipates and be appropriately prepared for laser-related injuries.

First-line medical personnel must be appropriately trained and equipped to deliver relevant care for victims of laser injury. Certainly, there is much yet to learn about laser injuries and their treatment. However, from a psychological point of view, what matters most is that the injured service member understands that he or she is receiving state-of-the-art medical care. An injury victim can reach this determination by assessing the skill and confidence of healthcare providers. The best way to convince service members that they are being well cared for is to care for them well. This objective cannot be met without continuing research into the treatment of laser-related injuries.

Accurate Information About Laser Injury and Recovery

Victims of a traumatic injury will likely pay very close attention to all that is said about the injury and its prognosis. It is essential that commanders, healthcare providers, and others provide laser injury victims with the most complete and accurate information that is available about their injuries and prospects for recovery. Injury victims will detect inconsistencies in the quality or character of such information and may attribute perceived discrepancies to incompetence or manipulation on the part of medical and military personnel.

Training is crucial to preparing service members for the stresses of deployment and combat. However, it is important to understand that informing service members about the potential for laser injury may have positive as well as negative consequences. There is the potential that by emphasizing the risks and hazards of battlefield lasers, we may create the possibility for misattribution of symptoms to laser exposure. It is likely that in any large-scale deployment, at least some returning service members will be affected by somatic complaints. We cannot discount the possibility that some will be misunderstood and

misattributed. Nonetheless, the likely benefits of expanded awareness (by combatants) and readiness (of military medical personnel) would seem to outweigh these potential risks.

Positive Therapeutic Relationship

A number of factors may tend to heighten the sense of alarm experienced by victims of accidental exposure. Unfortunately, the "high-tech" and unfamiliar nature of lasers may tend to reinforce negative expectations concerning the seriousness of laser-related injuries. The popular portrayal of lasers and "death rays" in movies and books does little to relieve such fears. The exceptional nature of laser injuries might contribute to the intensity of psychological responses. Ironically, laser injuries would probably seem much less threatening if they were more common. The rarity of true laser injuries on the battlefield, and the military and (potential) legal issues associated with laser use necessarily involve military secrecy, intelligence, and security, which may add a further measure of cynicism and stress to an already complicated psychological circumstance.

Of course, we can only hope that laser injuries continue to be rare and that they become less frightening by the intelligent exercise of accurate information and effective treatment. If laser injury victims are well informed and treated well, the stage is set for positive outcomes. Even serious laser injuries to the retina may show a surprising degree of recovery. Less serious injuries often resolve quickly with little or no permanent disability. Soldiers should be given this fundamental information to relieve their fear of the unknown. Based on what is currently known and possible with respect to laser injury care and treatment, service members can feel reasonably confident that, in the unlikely event that they sustain a laser-related injury, they will receive appropriate and state-of-the-art care as quickly as possible, recover quickly, and return to duty. Soldiers should also be reassured that they will be given complete and accurate information about the nature of their injuries and prospects for recovery.

CHALLENGES

We face significant challenges in the treatment of laser injuries and in the development of effective strategies to minimize physical, functional, and psychological morbidity in laser injury victims. These challenges arise primarily from the potential requirement to respond to dramatic increases in the number of laser injuries that occur on the battlefield and from the new realities of the information age.

Issues of Scale

To date, battlefield laser-related injuries have been sufficiently rare and noteworthy that they have received extraordinary resources, attention, and care from specialists and experts. The cases reviewed in this chapter received extensive resources and fast attention and involvement from individuals at the highest levels of the US government. Patients were transported thousands of miles to receive special medical examinations. The case involving patients 3 and 4 set in motion a wide-ranging response that involved the military, the State Department, and the US Congress. The case involving patients 5 and 6 led to a temporary shutdown of night aviation training operations in Bosnia. Responses such as these may have military, legal, or political importance, but they also have implications for the psychological status of laser accident victims. This raises the question of how our responses might or should differ in the unfortunate event that laser-related injuries become more common on the battlefield.

One potentially effective response would be to establish a medical surveillance program (periodic ophthalmic examinations) for vulnerable military personnel. Such a program would

- contribute to our knowledge of laser hazards on the battlefield,
- support improved individualized treatment decisions in cases of suspected laser injury, and
- enable more thorough and accurate assessment of postinjury disabilities.

An ophthalmic surveillance database would be particularly helpful because virtually every ophthalmic examination reveals abnormalities of some sort. Although most such abnormalities are trivial, many (eg, "window defects") are consistent with clinical findings that might also be expected to occur after laser exposure. Thus, the availability of a preinjury baseline examination would be quite helpful to identify preexisting defects that should not be considered as evidence of laser exposure. This would also help to reduce diagnostic uncertainty, which can have important psychological consequences for victims of laser injury.

The US Air Force has adopted an aggressive surveillance program for certain pilots, but the program is currently limited to a relatively small number of individuals. On one hand, the costs of broad medical surveillance would be much higher. On the other hand,

such a program may significantly reduce the costs that would be associated with treating and compensating large numbers of laser-injured troops.

Role of the Media

Media reports of most incidents have been worrisome. Knowledgeable experts would disagree with much of the information contained in most media reports. For example, news reports about patients 3 and 4 generally do not acknowledge doubt as to whether a laser exposure ever really occurred, but instead report as fact that patients 3 and 4 are permanently disabled due to their alleged exposure.[21,28,31] Similarly, reports about patients 5 and 6 describe the presence of "corneal burns" and ocular damage, in spite of the fact that no such findings were ever made. More recent reports almost always include the false assertion that pilots in cockpit laser exposure scenarios have suffered injuries or burns, leaving readers with the impression that such serious injuries have also occurred in the incidents being reported.

Journalists are limited by the space, time, and people available to them as resources. Competition is intense for air time or column inches of print space; therefore, reporters develop short, hard-hitting stories that will demand attention. Information readily available to the reporter in the aftermath of an incident often comes from the pilots themselves or from law enforcement authorities. Neither necessarily possesses the expertise necessary to fully and clearly explain what happened or what may not have happened. Understanding a real-world laser exposure incident requires

- sophisticated knowledge of the type of laser used and its output characteristics (eg, power, beam divergence, wavelength, and pulse characteristics),
- the angle from which the beam was directed into the cockpit, and
- whether the pilot viewed the beam on- or off-axis and for how long.

Complex calculations based on these and other parameters can then estimate the probable laser exposure. Understanding the medical consequences of laser exposure is similarly complicated, though here the past should offer some comfort: very few laser incidents in cockpits result in any adverse consequence for the pilot.[24] An unknown, but small, proportion of this 2% may experience short-term changes in visual function that most commonly resolve quickly. Permanent disability is highly unlikely.

Politics of Laser Injuries

Inaccurate media coverage may be the result of many factors, including politics. For example, the incident involving patients 3 and 4 became a cause célèbre among certain individuals and organizations already firmly opposed to the foreign policy of the Clinton administration. As a result, patients 3 and 4 were portrayed by some as heroic soldiers who had been betrayed by political interests in foreign policy. This simplistic presentation left little room for a full and fair discussion of the manifold ambiguities of the incident itself. Unfortunately, the resulting controversy may have contributed substantially to the continuing disability of two men who might otherwise have quickly and fully recovered from their symptoms.

Inaccurate press has also been fueled by humanitarian campaigns to regulate the use of laser weapons. The ICRC (Washington, DC) published a book and a pamphlet titled *Blinding Weapons*, which contain reports of a series of meetings convened by the ICRC more than 20 years ago. The pamphlet is a campaign brochure. It presents a photograph of poison gas victims from World War I, with the caption, "Gas 1918 … Lasers 1999?" The dramatic text of the pamphlet begins as follows: "Sudden, endless, inescapable darkness. You cannot walk, eat, work, or read without help … ever again. You do not know how you look, and you will never see your children smile. Day and night merge into one. … There will be no recovery, only coping for the rest of your life with the effects of a split-second attack on your eyes."[5(p1)]

The ICRC devoted considerable effort to its campaign to ban blinding weapons and assembled an extensive documentation of the devastating consequences of blindness. The campaign was predicated on the beliefs that

1. lasers used to specifically attack human vision could produce large numbers of military personnel who would be immediately blinded;
2. even weapons designed to produce only temporary effects must be expected to cause blindness notwithstanding their intended effect; and
3. a regulatory regime could be instituted that would proscribe intentional blinding, but permit "legitimate" uses of lasers.

The profound psychological effects of blindness hold a prominent place in the ICRC reports and serve as an important justification of its campaign.

Because we have no experience with lasers used purposely as weapons, it is difficult to evaluate the assumptions that underlie the ICRC campaign.

We do know that after many years of laser use, some few hundred reported laser accidents have yet to produce a result even similar to that so vividly described by the ICRC's pamphlet. We also know that despite the widespread use of lasers on the battlefield in adjunctive roles, very few injuries have occurred. Whether lasers used as weapons would have the devastating effects predicted by the ICRC is simply unknown.

The politics of lasers are relevant to their psychological impact. To the extent that politics are presented through the media, discussions of military lasers in the media help to establish and reinforce beliefs, expectations, and fears among service members and their families. When such discussions portray laser-related injuries as having unavoidably serious and permanent effects (eg, blindness), this sets the stage for dissonance between preexisting beliefs and more accurate information that may later be delivered by medics and physicians who care for victims of injury. Injury victims may thus experience confusion, fear, and ultimately doubt and suspicion that in turn can have serious negative psychological consequences. Functional somatic syndromes may also be reinforced through media attention that is driven by individual or organizational political efforts and interests.

SUMMARY

Three specific areas emerge as potential opportunities for immediate action:

1. training,
2. surveillance, and
3. media relations.

Training

Probably the most important theme to emerge from this chapter is the criticality of information and trust. When victims of laser injury are well informed about the nature of laser injuries and prospects for recovery, they will be well positioned to cope with the medical and visual challenges that may be involved in recovery. Complete and accurate information will help to relieve troops of the unnecessary complications associated with mistrust, suspicion, and anger. Beliefs matter. Our best opportunity to affect beliefs is during training. Soldiers at every level should be familiarized with lasers and their role in modern warfare, hazards associated with their use, the nature of possible laser-related injuries, and the prospects and promise of treatment.

Surveillance

A carefully targeted surveillance program would make it possible to document the preexisting and postincident ocular status of troops who are most vulnerable to accidental laser exposure. Information from such a surveillance program would also directly support the needs of researchers who continue to investigate laser injury mechanisms and consequences. Individual information would support individualized treatment and, additionally, would provide extremely valuable data for the adjudication of any medicolegal claims that may arise from such injuries.

Media Relations

It is incumbent upon us to ensure that accurate information be transmitted to the public sector as quickly as possible. Misleading information can be harmful. Moreover, the Internet makes it possible to store information (accurate or inaccurate) that may then be retrieved and repeated for many years, contributing to the impression that there exists a pattern of consistent evidence. Although journalists bear the ultimate responsibility for the accuracy of their coverage, we must also accept our responsibility to provide reporters with scientifically valid information, a balanced perspective, and knowledgeable guidance.

Although staggering advances in the technology used in warfare have transformed the face of modern conflict, combat remains an intensely personal affair. The ever-increasing sophistication of military technology should not blind us to the human characteristics of the men and women who operate advanced military devices and systems. On the battlefield, the service member is our most precious resource. Thus, it is essential that we understand how the presence of lasers on the modern battlefield may affect the psychological well-being, effectiveness, and readiness of those who serve.

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