You're the Flight Surgeon

This article was prepared by Daniel C. Ensley, M.D.

You're the flight surgeon on call when you're woken up by the sound of your phone. A pilot on a T-6 cross-country had just been "lased." At approximately 22:00 local time, he was on final approach to land at a commercial airport when he noticed a green light off his left wing. Initially taking the green light for a beacon, he did a double take, as he was not expecting an airfield off to his left. It was at that time the laser moved across his line of sight. He immediately informed Air Traffic Control of the situation and his approximate location. The remainder of the approach, landing, and taxi were uneventful. He reported no subjective visual changes and denied any flash effect directly following the exposure. He was seen at a local emergency room by the emergency physician. A cursory vision exam did not yield any findings except his visual acuity changed from 20/20 in both eyes to 20/50 in the left eye and 20/25 in the right eye. The next morning he was seen by an ophthalmologist, who was able to perform a complete fundoscopic exam, including optical coherence tomography. His visual acuity had returned to normal baseline and there was no evidence of ocular damage.

1. You were called about the incident at 01:00 local time. Who should have been contacted at that time?

A. The Wing commander.
B. Your Chief of Aerospace Medicine.
C. Tri-Service Laser Hotline.
D. 911.

ANSWER/DISCUSSION

1. C. The Tri-Service Laser Hotline is available 24/7 for treatment guidance and coordination of laser injuries. While the event is an emergency, this particular event does not require emergency medical technician services, as there are no life-threatening injuries. In lieu of 911, the patient should be directed to seek immediate treatment at the nearest facility. As the on-call physician, you can facilitate this process by locating a local center with an on-call optometrist or ophthalmologist. The Wing commander and Chief of Aerospace Medicine should be contacted at their earliest convenience, but this can wait until the patient is stable and safe. In addition, the hotline will be able to assist you in completing and submitting the "Laser Incident Questionnaire."

Despite the dramatic rise in laser exposures, retinal injuries remain exceedingly uncommon (<15 reported cases per year).[9] According to the Federal Aviation Administration, in a 5-yr period from 2005 to 2010, pilots reporting laser events increased by nearly 10-fold. In 2012, the Commander-in-Chief signed Public Law 112-95 prohibiting the use of lasers aimed at an aircraft. Title 18 of the U.S. Code section 39A makes it a federal crime to aim a laser pointer at an aircraft.[8] The maximum civil penalty the Federal Aviation Administration can impose on an individual is $11,000 per violation.[1]

Retinal damage is due to a number of factors, including the wavelength of the light, spot size, duration, and irradiance. Shorter light wavelength is more damaging to retinal tissue.[5] Green light is 495–570 nm in wavelength, while red light falls on the 620- to 750-nm end of the spectrum. Green light is much more damaging to the eye at a given milliwatt and is generally classified as a 3a or 3b laser. Lasers are divided into four classes in the United States: 1, 2, 3 (a and b), and 4. Class 1 lasers are considered incapable of producing damaging radiation levels even with long exposure times. Class 2 lasers may cause damage if exposure time exceeds 10 s (at close range). Damage is usually avoided, however, because of several protection mechanisms such as the aversion response. This natural blink reflex limits exposure to less than 0.25 s. Class 3a lasers will normally cause damage if viewed with optic aids such as telescopes and are generally 1–5 mW, while class 3b lasers can cause severe eye injuries and are 5–500 mW. Class 4 lasers cause damage to the eyes as well as the skin and pose a fire hazard.[10]

2. How do lasers damage the eye?

A. Through thermal, mechanical, and chemical mechanisms.
B. The laser excites electrons in the cells, causing them to jump into higher subshells. As they return to their subshell, the change in energy states is released, damaging the retina.
C. Lasers raise the vitreous fluid temperature through convection, destroying cells.
D. Direct physical trauma.

DOI: https://doi.org/10.3357/AMHP.4739.2017

ANSWER/DISCUSSION

2. A. Size of the optical zone, wavelength of light source, total energy delivered to the tissue, and duration of exposure will all contribute to photothermal, photomechanical, and photochemical damage of the eye.[3] Photothermal damage is denaturation of proteins secondary to the elevated temperature. There is a threshold where heat no longer dissipates in the tissue, but builds up and can either denature proteins or vaporize the tissue depending on the degree of temperature or temperature elevation. Photomechanical damage is from compression of tissues in response to the rapid rise in temperature. Provided the energy is sufficient, the temperature can increase so quickly such that a thermoelastic shock wave is created within the eye. This particular injury is associated with short-pulse lasers given their delivery of immense energy over a short period of time. Photochemical damage occurs when photons of light possess enough energy to break chemical bonds. This principle is used in refractive surgery through ablation of tissue. It can also, however, cause oxidative damage to cells as evidenced by ultraviolet light.[3]

3. What are common presentations that should make one suspect retinal injury?

A. Obvious corneal ulcers with conjunctival hemorrhage.
B. Subtle injuries that may be indicated by pain and Amsler grid findings.
C. Static injuries such as cataracts that are immediately obvious to the patient.
D. Laser eye trauma is so unusual, there are insufficient reports to characterize injuries.

ANSWER/DISCUSSION

3. B. Patients with suspected laser exposure may present with eye pain, redness, and irritation.[9] The patient may complain of scotomas, photophobia, metamorphopsia, chromatopsia, or decreased visual acuity, which can occur hours after exposure or retinal damage. The retina is the most susceptible tissue to light damage. This is, in large part, due to the amplification of irradiance through the cornea and lens, focusing the light on the retina. Retinal damage can be very subtle, making diagnosis difficult. Damage and visual derangement are very location dependent. If the laser injury spares the fovea, prognosis is generally good. Retinal injuries often heal on their own over time, although vision may never return to baseline. There appears to be only limited usefulness of corticosteroids.[9]

4. Retinal injuries cause visual impairment that is immediately apparent.

A. True.
B. False.

ANSWER/DISCUSSION

4. B. It is important to understand that as the injury undergoes the healing process, vision can change as well.[4] Therefore, initial injury is not predictive of final outcome. Lasers damage the retinal pigment epithelium through photothermal and photomechanical mechanisms. Laser burns can disrupt the choroid, causing subretinal hemorrhage and edema.[13] The retinal pigment epithelium changes from its static state to a migratory proliferative state in response to laser insults, causing vitreoretinopathy. Its migration can cause lesion expansion, extending the scar beyond the initial injury. Retinal injuries can present as blurred and distorted vision followed by worsening symptoms due to scar formation and choroidal neovascularization. Should the scar extend into the macula, central vision can become disrupted.[4] Spectral domain optical coherence tomography may show hyperfluorescent window defects surrounding hypofluorescent areas of pigment clumping due to photocoagulation typical in thermal laser injuries.

The ophthalmic exams are completed and no injuries have developed over the past 72 h. The Tri-Service Laser Hotline and Aeromedical Consultation Service have been immensely helpful and the patient is now eagerly waiting for you to clear him to return home. In discussion with the Aeromedical Consultation Service physicians, it comes to light that there is no Air Force Instruction regulating the grounding period following pupil dilation. The ophthalmologist believes the patient is ready to fly after 6-8 h of rest. Most flight surgeons observe the 24-h rule-of-thumb and you explain this to the flyer. He knows to follow up with you in clinic the moment he lands tomorrow to schedule an interval exam with the optometrist.

AEROMEDICAL DISPOSITION

As with the U.S. Air Force, Army, Navy, or Marine Corps, pilots involved in a lasing incident must contact the Tri-Service Laser Hotline immediately and seek an optometrist or ophthalmologist evaluation at the nearest medical treatment facility within 24 h. The evaluating physician and the patient will need to fill out the online reporting form found on the Tri-Service Laser Hotline website under "Radiation Safety." Army personnel will also need to contact the Safety Officer to report the incident.[12] Naval aviators need to notify the Bureau of Medicine and Surgery and file the appropriate report in accordance with Navy policy.[7] No service branch has waiver protocol specific to laser exposure; aviators may return to flying status if they meet their respective branch's visual standards: the Air Force Medical Standards Directory;* Army Regulation 40-501, Standards of Medical Fitness;[11] or the U.S. Navy Aeromedical Reference and Waiver Guide.[6] Civilian pilots are to contact Air Traffic Control, have an eye doctor examine them only if visual symptoms persist after landing, and fill out a similar exposure reporting form, AC 70-2, "Laser Beam Exposure Questionnaire."[2]

Ensley D. *You're the flight surgeon: green laser event*. Aerosp Med Hum Perform. 2017; 88(4):437–439.

* U.S. Air Force. Medical standards directory. Washington (DC): Department of the Air Force; 2015. [Accessed 1 Feb. 2016]. Available to those with access from https://kx2.afms.mil/kj/kx4/FlightMedicine/Documents/Medical%20Standards%20Directory%20(MSD)/MSD%20Jul%202015%20(final).pdf.

ACKNOWLEDGMENTS

The author would like to thank Capt. Benjamin Kolle, Chief of Optometry, 47th Medical Group, Laughlin AFB, TX, for his review of this article. The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Air Force, the Department of Defense, or the U.S. Government.

REFERENCES

1. Federal Aviation Administration. Press release – FAA to impose civil penalties for pointing lasers into cockpits. 2011. [Accessed 1 Sept. 2015]. Available from https://www.faa.gov/news/press_releases/news_story.cfm?newsId=12765.
2. Federal Aviation Administration, Civil Aerospace Medical Institute. Laser hazards in navigable airspace. Oklahoma City (OK): Civil Aerospace Medical Institute; (n.d.). [Accessed 1 Feb. 2016]. Available from http://www.faa.gov/pilots/safety/pilotsafetybrochures/media/laser_hazards_web.pdf.
3. Glickman RD. Phototoxicity to the retina: mechanisms of damage. Int J Toxicol. 2002; 21(6):473–490.
4. Kasaoka M, Ma J, Lashkari K. c-Met modulates RPE migratory response to laser-induced retinal injury. PLoS One. 2012; 7(7):e40771.
5. Lim ME, Suelzer J, Moorthy RS, Vemuri G. Thermal macular injury from a 154 mW green laser pointer. J AAPOS. 2014; 18(6):612–614.
6. Naval Aerospace Medical Institute. U.S. Navy aeromedical reference and waiver guide. Pensacola (FL): Naval Aerospace Medical Institute; 2016. [Accessed 1 Feb. 2016]. Available from http://www.med.navy.mil/sites/nmotc/nami/arwg/Pages/default.aspx.
7. Office of the Chief of Naval Operations. Naval aviation safety management system. Washington (DC): Department of the Navy; 2014. Report No.: OPNAVINST 3750.6S.
8. Office of the Law Revision Counsel of the U.S. House of Representatives. Aiming a laser pointer at an aircraft. 18 U.S.C, § 39A (2012).
9. Shenoy R, Bialasiewicz AA, Bandara A, Isaac R. Retinal damage from laser pointer misuse – case series from the military sector in Oman. Middle East Afr J Ophthalmol. 2015; 22(3):399–403.
10. Stanford University. Stanford University laser safety manual. 2012. [Accessed 1 Sept. 2015]. Available from http://web.stanford.edu/dept/EHS/prod/researchlab/radlaser/laser/program/.
11. U.S. Army. Standards of medical fitness. Washington (DC): Department of the Army; 2011. Army Regulation 40-501. [Accessed 1 Feb. 2016]. Available from http://armypubs.army.mil/epubs/pdf/r40_501.pdf.
12. U.S. Army Public Health Command. LASER exposure incident reporting. Aberdeen Proving Ground (MD): U.S. Army Public Health Command; (n.d.). Fact Sheet 24-028-0615. [Accessed 1 Feb. 2016]. Available from https://phc.amedd.army.mil/PHC%20Resource%20Library/LASERExposureReporting_FS_24-028-0615.pdf.
13. Wyrsch S, Baenninger PB, Schmid MK. Retinal injuries from a handheld laser pointer. N Engl J Med. 2010; 363(11):1089–1091.

This article was prepared by Michelle R. Milner, M.D., M.P.H.

You are in the middle of a busy clinic day when you get an instant message from one of your helicopter pilots asking if you have time to see him. You take a quick look at the notes from his previous visits and notice he's seen a few other docs in the clinic for recurrent pharyngitis while you were on temporary duty the past few weeks.

1. Which of the following is a reason to maintain primary care manager continuity of care[1,7] for this patient?

A. Decreased emergency department visits.
B. Increased efficiency.
C. Improved screening and behavior modifications.
D. ALL of the above are excellent reasons to maintain continuity of care.

ANSWER/DISCUSSION

1. D. You always want to see your patients, and one of the best parts of being a flight doc is that your patients prefer to see you as well. You've learned through research and experience that a single primary care doc improves patient-physician communication, increases trust, and decreases emergency room visits. You also know that if you truly know your patients, you will be able to advocate for them when needed and you will be first to notice subtle changes.

Of course, you ask him to come to the clinic at his convenience. You review his notes more thoroughly to remind yourself he is a 26-yr-old healthy helicopter pilot. He appears to have had a sore throat for several weeks and was seen by two colleagues who ordered lab work. He uses "dip" and alcohol once or twice weekly.

2. What is your very generic differential diagnosis in an otherwise healthy 26-yr-old male pilot presenting with sore throat, intermittent fever, no cough, and no diarrhea?

A. Viral pharyngitis.
B. Infectious mononucleosis.
C. Gonococcal pharyngitis.
D. Streptococcal pharyngitis.
E. ALL should be on your early differential diagnosis.

ANSWER/DISCUSSION

2. E. Viral pharyngitis typically presents with a headache, coryza, conjunctivitis, and fatigue and is the most common diagnosis for this cluster of symptoms. While this potentially sounds like our patient,

DOI: https://doi.org/10.3357/AMHP.4767.2017