Disclosure Statement:
I am an active duty service member. This lecture was prepared outside of my normal duties and does not reflect an official endorsement by or the views of the United States Government, Department of Defense, or Department of the Navy.
Overview

• Current threats and trends to aircrews
• Laser terminology
• Eye protection considerations
• Clinical case reports
• Clinical pearls
• $10,000 reward for information leading to an arrest.

• Federal felony

• Arrest Video

Current Threats and Trends

- In 2017 6,753 laser illumination events reported to the FAA.
  - 2016: 7,442
  - 2015: 7,703

- 2017 Averaged 18.5 events/day
- 2018 Jan-Jun 2,797 events
- Overall trending 5% decrease from 2017.

Source: Laserpointersafety.com  Last accessed 20 Oct 2018
Current Threats and Trends

Color of laser illuminations reported to FAA in 2017, percent

Lasers in the News

Laser pointers can't permanently damage pilots' eyes, study says

By Thom Patterson, CNN

“There is no evidence to suggest that lasers pointed at airplane cockpits damage pilots’ eyesight. But obviously if directed at critical moments, the dazzle from the beam and ensuing distraction could prove disastrous for crew and passengers”

FAA Laser Free Zones:

Commercial Off The Shelf Lasers

- BigLaser.com
  - Carries only the highest quality hand held lasers
  - Red/Green/Blue

**Specifications**

<table>
<thead>
<tr>
<th>Laser Type</th>
<th>Wavelength</th>
<th>Power (mW)</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BigLasers.com</td>
<td>445 nm CW</td>
<td>2,000 mW</td>
<td>$300</td>
</tr>
<tr>
<td>BigLasers.com</td>
<td>532 nm CW</td>
<td>500 mW</td>
<td>$490</td>
</tr>
<tr>
<td>BigLasers.com</td>
<td>658 nm CW</td>
<td>500 mW</td>
<td>$850</td>
</tr>
</tbody>
</table>

- Normal Scene: No laser
- Glare Effects: 5 uW/cm²

≈ 95% of threat lasers are 532 nm green sources
Laser Classification

• **Class I**- no cautions, no injury (< 0.39 mW)
  - Grocery store scanner

• **Class IIa**- laser pointers, caution label (< 1 mW)
  - Blink reflex usually sufficient
  - Eye injury unlikely unless prolonged exposure (> 0.25 sec)

• **Class IIIR**- medical, research, CAUTION (1-4.99 mW)
  - Eye injury possible < 0.25 sec

• **Class IIIb**- weapons, WARNING (5-500 mW)
  - Eye injury likely, blink reflex too slow

• **Class IV**- weapons, surgical, DANGER (> 500 mW)
  - Reflections dangerous
  - Skin injury and burns to exposed areas
  - Fire hazard
Hazard Increases Closer to Laser

- NOHD
- Unsafe
- Safe
- Laser
- Hemorrhages/Lesions
- Flashblindness/Afterimage
- Glare (if visible)
- Startle/Distraction
Laser Eye Protection RDT&E

- Design Challenges
  - Where do you put the protection
  - Cockpit compatibility issues
  - Is enough light getting through
  - Visual correction
  - Haze
  - Environmental effects

Glare Effects: 5 uW/cm²
Normal Scene: No laser
Journal Reports of Laser Injury
1987 – 2012 (10 total over 15 years)


Journal Reports of Laser Injury  
2014 (10)


While on the school bus, one of her classmates had attempted to determine whether a laser pointer would cause pupillary constriction.

- Commenced on treatment against toxoplasma, with oral steroid cover (20mg prednisolone/day).
- Three days later, the vitelliform-like changes resolved to leave RPE changes at the left macula.

Amsler grid showed central scotoma. Treated with a 1-month tapering course of oral prednisone, with subjective improvement of central scotoma. One year after injury, visual acuity improved to 20/60+2 in the left eye. Examination of the left eye revealed pigmentary clumping in the foveal center surrounded by RPE atrophy.
Flight attendant who bought 3 laser pointers during a trip to China. The patient admitted to playing with these lasers in her bedroom including staring directly at the laser beam.

At 1 month,
- Top row, Color photographs show bilateral formation of asymmetric gray-white linear streak lesions at the level of the outer retina and retinal pigment epithelium (RPE) in the macula
- Second row. Fluorescein angiography well delineates the linear hyperfluorescent lesions that stained in later phases of the angiogram
- Third row, Spectral-domain optical coherence tomography (SD-OCT) showed lamellar hole formation OD
- Third and Fourth rows, as well as ellipsoid disruption and hyper-reflective bands extending from the ellipsoid zone through the outer nuclear layer

5 weeks later

- Top left. Lesions developed in the superior periphery of both eyes

- Top right and Bottom left. Central and peripheral lesions were hyper-autofluorescent

- Bottom right. Full-thickness macular hole OD with hyper-reflective material within the base of the hole that corresponded to pigment hyperplasia

Only left eye damage.
- Upper left, deep foveal yellow lesion and prominent gray-white linear streaks at the level of the outer retina in the superior macula of the left eye.
- Lower right, upper image, initially revealed significant disruption of the ellipsoid zone and external limiting membrane at the fovea and vertical hyper-reflective bands.
- Lower right, lower image, 1 month later, re-formation of the external limiting membrane, patchy restructuring of the ellipsoid zone, and full resolution of the vertical hyper-reflective bands.

- Treated with an oral steroid (Prednisone; H.J. Harkins Company, Inc., Grover Beach, CA, USA) 1 mg/ kg for 4 weeks then tapered over 2 months.
- At 3 months, visual acuity remained impaired but improved to 20/30 in the right eye and 20/25 in the left eye.

- On further inquiry, he reported directing a handheld laser into a mirror to create a laser light show and staring directly at the reflected beam for multiple episodes, each lasting for minutes.
- Acutely treated with a 6-day methylprednisolone dose pack.
- Six months after exposure, best corrected vision 20/200 in each eye, and he reported persistent central scotomas bilaterally.
- Fundoscopic examination showed replacement of the yellow foveal lesion with central RPE clumping surrounded by pigment loss and mottling (Figure E and H).

• 1 watt, 445 nanometer (blue) laser
• December 6, 2011
• The injury required unspecified surgery,
  Two days after the surgery, the hobbyist
  reported a blurry dark circle in his central
  vision.
• His doctor told him he would always have
  a small off-center blind spot
• “And just to show that I’m not going to let
  a little something like blindness in one eye
  keep me down, I finished the contraption
  that started this whole mess, except this
  time using a <100mW greenie instead.”

wickedlaser.com
1W: $299.95
1.2 W: $399.95

The handheld laser pointer reportedly was being used to set paper and clothing on fire at the time the patient’s eye was exposed.

“Patient reported that the bilateral injury occurred when he was attempting to light a cigarette with simultaneous foveal exposure, it is more likely that each eye was separately exposed to the full beam while his gaze was at the output aperture. Surgical treatment with vitrectomy, internal limiting membrane peeling, and gas tamponade was offered, but the patient declined.

To our knowledge, this is the first report of a continuous wave laser in the visible spectrum—damaging retinal vessels without affecting the retinal pigment epithelium. Fortunately, vision gradually returned to 20/20 in the left eye after a week and to 20/25 in the right eye after 2 months.

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (yrs)</th>
<th>Interval between Exposure and Presentation</th>
<th>Approximate Distance (m)</th>
<th>Diagnosis</th>
<th>Initial Visual Acuity</th>
<th>Intervention</th>
<th>Last Follow-up after Intervention</th>
<th>Last Visual Acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>1 week</td>
<td>2e3</td>
<td>Outer retinal disruption FTMH</td>
<td>20/40</td>
<td>None</td>
<td>8 wks*</td>
<td>20/20</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>2 months</td>
<td>0.5</td>
<td>FTMH</td>
<td>20/70</td>
<td>PPV&gt;ILM peeling&gt;SF6 20%</td>
<td>4 wks</td>
<td>20/30</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>1 week</td>
<td>0.5e1</td>
<td>FTMH</td>
<td>20/300;PH 20/200</td>
<td>PPV&gt;ILM peeling&gt;silicone oil PPV&gt;ILM peeling&gt;SF6 20%</td>
<td>10 wks</td>
<td>20/160</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>2 days</td>
<td>NA</td>
<td>FTMH</td>
<td>20/400</td>
<td>PPV&gt;ILM peeling&gt;SF6 20%</td>
<td>3 wks</td>
<td>20/50</td>
</tr>
<tr>
<td>5</td>
<td>18</td>
<td>2 months</td>
<td>0.5</td>
<td>FTMH</td>
<td>20/200</td>
<td>PPV&gt;ILM peeling&gt;C3F8 15%</td>
<td>4 wks</td>
<td>20/40</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>5 days</td>
<td>1</td>
<td>Foveal sub-ILM hemorrhage Subhyaloid hemorrhage</td>
<td>20/300</td>
<td>None</td>
<td>12 wks*</td>
<td>20/20</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>3 days</td>
<td>NA</td>
<td>Subhyaloid hemorrhage Subhyaloid hemorrhage</td>
<td>4/200</td>
<td>Nd:YAG hyaloidotomy</td>
<td>6 wks</td>
<td>20/40</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
<td>5 days</td>
<td>2e3</td>
<td>Subhyaloid hemorrhage Subhyaloid hemorrhage</td>
<td>4/200</td>
<td>Attempted Nd:YAG hyaloidotomy</td>
<td>5 mos</td>
<td>20/25</td>
</tr>
<tr>
<td>9</td>
<td>18</td>
<td>2 hours</td>
<td>5e6</td>
<td>Subhyaloid hemorrhage Subhyaloid hemorrhage</td>
<td>4/200</td>
<td>Nd:YAG hyaloidotomy</td>
<td>4 wks</td>
<td>20/25</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>6 days</td>
<td>0.5</td>
<td>Sub-ILM hemorrhage Subhyaloid hemorrhage</td>
<td>20/100</td>
<td>None</td>
<td>3 wks</td>
<td>20/40</td>
</tr>
<tr>
<td>11</td>
<td>17</td>
<td>4 hours</td>
<td>1</td>
<td>Subhyaloid hemorrhage Subhyaloid hemorrhage</td>
<td>5/200</td>
<td>Nd:YAG hyaloidotomy</td>
<td>6 wks</td>
<td>20/15</td>
</tr>
<tr>
<td>12</td>
<td>17</td>
<td>1 day</td>
<td>2</td>
<td>Subhyaloid hemorrhage Subhyaloid hemorrhage</td>
<td>3/200</td>
<td>Attempted Nd:YAG hyaloidotomy</td>
<td>2 mos</td>
<td>20/50</td>
</tr>
<tr>
<td>13</td>
<td>18</td>
<td>2 months</td>
<td>1</td>
<td>ERM with SRF</td>
<td>20/200</td>
<td>PPV&gt;ERM peeling&gt;ILM peeling</td>
<td>3 mos</td>
<td>20/70</td>
</tr>
<tr>
<td>14</td>
<td>16</td>
<td>4 days</td>
<td>2e3</td>
<td>Schisis-like cavity</td>
<td>with SRF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

“Six Questions that Facilitate the Diagnosis of Alleged Retinal Injuries”

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Are there ocular abnormalities that could have been caused by a known laser-tissue interaction at the time of the reported incident?</td>
</tr>
<tr>
<td>2. If the answer to 1 is “yes,” have those abnormalities been documented by a reliable technique, such as fundus photography, fluorescein angiography, or optical coherence tomography?</td>
</tr>
<tr>
<td>3. If the answers to 1 and 2 are “yes,” do findings from ophthalmoscopy and retinal imaging evolve after the incident in a manner consistent with a laser injury?</td>
</tr>
<tr>
<td>4. If the answer to 1 is “yes” and substantial visual or somatic complaints are present, is there any scientific evidence that the objective ocular findings could cause the reported subjective complaints?</td>
</tr>
<tr>
<td>5. If the answer to 1 is “yes” and substantial visual complaints are present, is the location of Amsler grid or visual field defects stable and consistent with the location of the retinal abnormalities supposedly responsible for causing them?</td>
</tr>
<tr>
<td>6. If the laser source involved in the alleged injury is available or known, is it capable of producing the observed clinical findings under the reported exposure conditions?</td>
</tr>
</tbody>
</table>

“Doc! We’ve been lased. What do we do now?”

Source: LaserPointerSafety.com
In-Flight Exposure Procedures

- Look Away & shield eyes (don LEP if available)
- DO NOT rub the eyes – increases irritation
- Turn up instrument lights
- Mark the position, time, and report to ATC
- Unexposed co-pilot gets on instruments
- Query other crew members for exposure
- Self-examination using small print or Amsler grid (if available)
- ‘Self-triage’ vision
  - able to read small print,
  - check individual eyes,
  - check pocket Amsler grid, nav charts, HUD or MFD for any visual defects
After-Landing Crew Procedures

• Complete FAA laser exposure web report

• Ophthalmic exam if persistent symptoms or visual changes
Laser Safety Surveillance Program

• County Sherriff, local police, pilot associations
  – Remember maintainers and technicians that work on equipment

• Baseline exam:
  – Visual Acuity
  – Amsler Grid
  – Retinal Evaluation
    • OCT/Photos