SESSION NAME  Surgical Lasers: Understanding Lasers, Tissue Response, and Safety in the OR

 SPEAKER  Leslie J. Pollard, BSMT, LEOT, CMLSO

 SESSION NUMBER  0049

 DATE/TIME  Tuesday, April 1, 2014, 2:30-4pm

 CONTACT HOURS (CH)  1.5

 SESSION OVERVIEW:
When potentially dangerous Class 3b or Class 4 lasers are used in the OR, the safety of both the patient and staff is partially built upon a basic understanding by staff members of what a laser is, how it works, how this unique energy source interacts with tissue, and the understanding of the team and individual responsibility to support the facility laser safety program. As more sophisticated laser technology becomes available, the need for laser safety awareness becomes even more important. This presentation will provide the perioperative nurse or educator with the required foundation of laser introduction, tissue interaction, and laser safety in the OR. Gain a basic understanding of lasers and laser safety as required by Occupational Safety Health Administration (OSHA) and recommended by American National Standards Institute (ANSI) Z136.3 as well as AORN Standards and Recommended Practices. Gain the basic understanding necessary to work safely and confidently within the Class 4 surgical laser environment.

 OBJECTIVES:
1. Identify three major laser media types used today in the OR.
2. Explain how different laser wavelengths from different laser medias affect both the target in patient tissue, as well as accidental exposure to the skin and eyes of patients and staff.
3. Describe four laser safety practices designed to protect from accidental exposure to patients and staff or to prevent fires in the OR due to a Class 4 surgical laser fire ignition source.

 SPEAKER CONTACT INFORMATION:
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 FACULTY DISCLOSURE:
Leslie Pollard: 7. No conflict
SPEAKER BIOGRAPHY:

Leslie J. Pollard, BSMT, LEOT, CMLSO, earned a BS in medical technology from the University of Texas, Galveston with certification by the American Society of Clinical Pathologist. She also earned an AD in laser electro optics technology from Texas State Technical College and is certified by the NCLE as a CMLSO (Certified Medical Laser Safety Officer). She has 25 years' experience in the OR working as the director of a minimally invasive surgical program with all surgical specialties, including cardiovascular, neurosurgery, ENT, Ob-GYN, plastics/dermatology, ophthalmology, general surgery, urology, orthopedics, and gastroenterology for laser applications and a variety of MIS procedures and programs. Ms. Pollard established a successful medical laser consulting program assisting ORs and physician offices across the nation to set up surgical laser and minimally invasive surgical programs, as well as providing educational and credentialing programs for physicians. Ms. Pollard is currently president of Southwest Innovative Solutions, Inc. (SIS), an educational and consulting firm for ORs, device manufacturers, and physician offices. She is listed in Who’s Who in Medicine & Healthcare. SIS specializes in education associated with medical/ surgical laser systems, laser safety, and the federal and evolving state laser regulatory issues and questions. SIS works closely with hospitals, physician offices, and other health care facilities on a national level to assist in the education and the establishment of basic laser safety programs and documentation protocols based on both federal and specific state laser safety rules and State Medical Board Directives. Ms. Pollard currently serves on the LIA MLSO Medical Laser Safety Officer Board of Excellence Development and served as a program chair and presenter at the 2011 International Laser Safety Conference, as well as the 2013 International Laser Safety Conference. Leslie is registered with the Board of Laser Safety as a Certified Medical Laser Safety Officer and is a co-author of the 2012 "Certified Medical Laser Safety Officer Best Practices."

COMMERCIAL SUPPORT:

*Gift-in-Kind: Southwest Innovative Solutions, Inc. (SIS) (travel expenses)*
What is a Laser?

**Light Amplification by the Stimulated Emission of Radiation**


What is a Laser Wavelength?

![Diagram of laser wavelength and photon](image.png)
How are laser light photons generated?

- **Power Supply or Excitation Mechanism**

- **Created Photon**

- **Primary and Stimulated Photons**

**Example Types of Laser Media**

- **Solid State**
  - Ho:YAG (Holmium), Nd:YAG (YAG), KTP, Er:YAG
  - Alexandrite
  - Ruby

- **Liquid**
  - Dye Lasers (Coumarin, Rhodamine 6G)

- **Gas**
  - Excimer
  - CO₂ (molecular)
  - Argon
  - Krypton
  - HeNe

- **Semiconductor**
  - Semiconductor or Diode Laser Family
  - Be Aware of This Laser Media for Future Trends!
Laser Physics

Laser Block Diagram Example

The He-Ne Laser

Examining Laser “Names” or Media Types

Laser Physics

Examinining Laser “Names” or Media Types
Laser Physics

Laser Light vs. White Light

Where do your Lasers “Lase”?  

Infrared: near infrared 750 nm - 3000 nm  
far infrared 3000 nm - 1 mm  
Visible: 400 nm - 750 nm  
Ultraviolet: 100 nm - 400 nm
Laser Physics

What are laser output modes?

“Why is this important?”

Laser Biophysics

Medical/ Surgical Laser Tissue Interaction Basics

Thought: What is Light?
Lasers Irradiate Germinated and Healthy Tissue!

“I saw a spider in the bathtub, so I took a tissue and very, very carefully burned the house down!”
Four ways laser light can interact with *matter* (tissue)

![Diagram showing laser interaction with tissue](image)

- Scatter, Transmission, Absorption, Reflection
- or Combination

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**Laser Biophysics**

**Five Common Target or Tissue Chromophores**

- **Reduced & Oxy-hemoglobin**
  - vascular, blood
- **Melanin**
  - pigmented lesions
- **Water**
  - general tissue incision, excision, ablation
- **Fat or Lipids**
- **Exogenous**
  - tattoo ink, PDT, *nanotechnology* (*endless potential targets!*)
What is Tissue’s Reaction to Laser Energy? Methods of General Tissue Response

- **Photo Chemical**
  - Photodynamic Therapy (PDT)
  - *The New World of Nanotechnology and Lasers in Medicine & Surgery*

- **Photo Acoustic** (*photoablation, plasma-induced ablation, and photodisruption*)
  - Tattoo Treatment
  - Laser Lithotripsy
  - Water based cavitation mechanics (Holmium:YAG Litho, Soft Tissue Scrubbing)
  - *The New World of Electronic Based Semiconductor Lasers*

- **Photo Thermal**
  - Majority of Surgical Applications
  - Weld, coagulate, ablate, vaporize

- **Combination!**

- **With new technology come new challenges**
Laser Biophysics

Spectral Response of Tissue from Specific Wavelength of Laser Energy

Visible spectrum devices respond best to their color opposite.

Near and Mid Infra Red pulsed laser systems may show to be able to dominate the future of laser medicine and surgery!

Laser Biophysics

How Laser Wavelengths are Chosen

Absorption Spectra of Tissue*

Laser Operator should know your laser wavelengths!

*HW Lim, NA Soter, editors, Clinical Photomedicine, New York, 1993
Ideal Pulse Range for a Specific Target

Time on Tissue

Ideal Pulse Time is based on two concepts:
- Volume of the tissue to be treated with Transmitted Heat
- Time required to resolve conducted heat

Laser Biophysics

Power Density and Spot Size “Irradiance” \( P_D = \frac{W}{cm^2} \)

At any given power level the larger the spot size the lower the density. The smaller the spot size the higher the density.
Review of Energy Absorption Chart

Target End Point Thermal Thresholds (Power Density)

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Effect</th>
<th>Power Density (w/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1700</td>
<td>carbonization</td>
<td>+100,000</td>
</tr>
<tr>
<td>400</td>
<td>ablation</td>
<td>15,000</td>
</tr>
<tr>
<td>100</td>
<td>cutting</td>
<td>1,200</td>
</tr>
<tr>
<td>90</td>
<td>dessication</td>
<td>500</td>
</tr>
<tr>
<td>65</td>
<td>necrosis</td>
<td>300</td>
</tr>
<tr>
<td>60</td>
<td>coagulation</td>
<td>5</td>
</tr>
<tr>
<td>37</td>
<td>normal</td>
<td></td>
</tr>
</tbody>
</table>
Laser Biophysics

Remember: Response on Tissue dependent upon the relationship of these variables! SPTL

Laser Biophysics

Predicting Tissue Response to Laser Energy

![Diagram of Laser-Tissue Interactions]
Magic Bubble of Laser Surgery!

- Entering the Photo Disruption Arena
- Pulsed IR water absorbers
- Cavitation Phenomena: Unique light application in water environment
- Example Applications:
  - Ho:YAG in laser lithotripsy
  - 1470nm Diode in soft tissue
  - Q Switched Nd:YAG for secondary cataracts

Common Surgical Laser Applications

- Cardiovascular
- Gynecology
- Urology
- Neurosurgery
- Podiatry
- ENT (otorhinolaryngology)
- Ophthalmology
- Plastics/ Dermatology/ Cosmetics
- Oral Maxillofacial
- Orthopedics
- General Diagnostics
New and Hot!

Light Based Legacy Lasers vs. Semiconductor or “Diode” Laser Media: 
*A Quick but Necessary Decipher*

New and Hot!

What is a Semiconductor or “Diode” Laser?
New and Hot!

Med/Surge Laser Diode Option Examples of Today

New and Hot!

Diode Lasers Fit the Needs!

• How?
  – Variety of Compounds = Wavelength/Frequency variations
  – Array Matrix = Higher Output Powers
  – Small, Portable, Durable
  – Air cool is definite possibility
  – Pulses modulated easily
  – Industry and Defense driving the technology advancements
Seven (6) Major Areas of Concern for Surgical Laser Safety

1. Eye/ Skin
2. Room Protection
3. Education/ Training
4. Fire
5. Environmental Air
6. Administrative
Laser Safety

Laser Classes

• Class 1
  – Safe under all conditions of normal use.

• Class 2
  – Risk over prolonged exposure. (Low output power, visible wavelengths)

• Class 3
  – Risk of permanent injury if viewed directly.

• Class 4
  – Risk of permanent injury viewed directly or indirectly.

Most all Medical and Surgical Lasers are Class 3b or Class 4 Lasers

Class 4 Laser Definition

• Class 4 (high power)
  – Hazardous to eye or skin from direct beam exposure
  – May also be hazard from direct reflection or from diffuse reflection of beam
  – May create LGAC or smoke plume
  – Fire Hazard
  – Most Surgical LASERS
Ocular hazards can result from direct, reflected, or scattered laser exposure

- Direct exposure
- Specular reflection
- Reflected off diffused surface

Bio-effects of Laser: Eye Hazards

Laser Wavelength (nm)

- Ultra Violet
- Infra Red
- Far IR

- Photokeratitis
- Retinal Damage
- Corneal Burns
Laser Danger to the Eye Summary

Wavelength determines eye affect

**UV** - chemical, 1st 20 microns of eye surface

**Visible** and **IR Near** – damage to internal components of eye (retina)

*Nd:YAG, Holmium YAG*

**IR Far** - ablative, damage to surface of eye or cornea

*CO2 Laser*

Labeling of Laser Safety Eyewear

Eyewear must be properly tested and labeled by the manufacturer with the specific **wavelength** and **OD** or optical density for beam attenuation
Understanding **OD** of Laser Eye Protection

Optical Density is a mathematical way of describing the ability of a filter material to reduce the intensity of light transmitted. Optical density numbers represent “orders of magnitude” or “powers of 10”. This means that increasing the OD number by 1 increases the attenuation of the filter by a factor of 10.

\[ \text{OD} = \log_{10} \left( \frac{H_p}{\text{MPE}} \right) \]

**\( H_p \)** = Potential Eye Exposure

\[ \text{OD} = \log_{10} \left( \frac{H_p}{\text{MPE}} \right) \]
Laser Safety

Once the NHZ is Determined:
Laser Treatment Controlled Area (LTCA)
for Practical Use is Established for Policy

- Proper Eyewear Provided (labeled with $\lambda$ and OD)
- Postings or laser signage (outside eyewear)
- Supervised by MLSO or Designee
- Properly trained and protected personnel
- Windows & Glass protected
- Doorways & Entries protected
- Laser Beam Path Protected from flammables
- Fire Extinguisher available
- Water available for drape or paper fires
- Appropriate Laser Standard Operating Procedures and office
  Laser Safety Policies are Followed
- ENT Laser Safety Protocols in place when appropriate

Laser Safety

Overview of Laser Eye Protection

- Should protect from direct, diffuse, reflected, scattered
- Worn within NHZ or LTCA
- Selection based on wavelength, OD, manufacturers
  recommendations
- Eyewear, filters, other eye protection for laser devices
  must be approved by credentialed MLSO, and inspected
  regularly

“All people in the NHZ should wear appropriate eyewear selected and
approved by the LSO.” AORN RP IV
Laser Safety

Purpose and Choosing Laser Safety Eyewear

• Use of Eyewear is intended as LAST line of defense
• To be worn within the Laser Treatment Controlled Area
• Different wavelengths/ laser/ delivery systems may require different eyewear.
  • Multiple wavelength lasers
  • Multiple wavelength eyewear
  • Wavelength first, OD second
  • Comfort and durability.
  • Proper testing and labeling
• Orders by facility MLSO or assigned delegate
• Appropriate patient eye protection a must (alternatives discussed)
• Importance of proper care and maintenance of the laser safety eyewear

Laser Safety

Laser Eye Protection Risk Assessment Scenarios

• Unique Properties of the CO2 Class 4 Surgical Laser
  – Microscope In Line Electronic Filters
  – Filter location is important!
• Unique Nature of the Holmium:YAG Laser CO2 Lasers
  – Microscope Lenses (operating physician only)
  – Personal eyewear for CO2?
  – Contact lenses are never protection from CO2 Laser energy.
  – Physician Loops
Laser Safety

The NEW Look for Class 4 Laser Signage!

Post in prominent position on OR access doors only when laser is in use.

Laser Safety

Other Categories of Laser Hazards

• Beam Related
  – Laser Energy Exposure to eyes and skin

• Non Beam Related
  – Fire
  – Smoke Plume
  – Electrical
  – Chemical
  – Explosion
Understanding the “Aversion Response”

Visible Light Lasers
Human “Aversion Response” can decrease exposure. Only associated with Class 2 lasers!

Class 4 Lasers can cause serious injury regardless of AR.

Myths about Laser Eye Safety & Protection

• No need for eyewear! You can Blink!
• No need to cover the windows!
• This wavelength is safe! No eyewear is required!

... Really?

Ask yourself or your facility MLSO what the facts are to support these statements with each individual situation. Always remember your audience. Err on the side of caution.
Understanding the Concepts of:
Open vs. Closed Beam Systems

This is the same laser system being used in each OR.
Which system is open? Which is closed?
Which is a safe practice?
Which is an accepted practice? Which is a legal practice?
Which practice represents use of a prudent standard of practice?

Laser Safety

Bio-effects of Laser: Skin Hazards

Laser Wavelength (nm)

Ultra Violet  | Infra Red  | Far IR

0  | 15  | 31  | 40  | 78  | 1400  | 3000  | 11000

- Erythema
  - Accelerated skin aging process
  - Increased pigmentation

- Photosensitive reactions

- Skin Burn
Laser Safety

No Flinching!

Prevention of Skin Burns

- Wetted coverings surrounding operative site for ablative technologies
- Avoid tinted scrubs & preparations
- OR Team Coordination
- Operational Training
- Damp and/or non flammable drapes
- Equipment Routine Maintenance
- Emergency Water on back table!
General Laser Related Fire Prevention

- Standby Button Utilization
- Care of Fibers
- Non flammable Drapes
- Water Source Immediately Available
- Ready Access to Proper Fire Extinguisher
- Proper Hazards Analysis and Procedural Protocols
- Avoid Flammable Preps, tinctures, collodion, PMM, any alcohol based solutions
- Proper training, commensurate to responsibility level
- Look out for light cords!
- Proper device care, operation, training, and maintenance
- Moistened drapes, sponges, non flammable drapes
- Beware of Methane Gas!
- Know where fire extinguishers are, and how to use them
- Use proper ENT laser protocols, time out periods, team prep

AIRWAY/ Flammability Concerns

- Lasing IN Airway
  - Correct metallic or protected endotracheal tube
  - “Laser Resistant Tube”
  - Wavelength & Power Density Specific
  - FIO₂ below 30%
  - if tolerated
  - Trach cart on standby
  - Concern of Flammable Liquids, Drapes & Anesthesia Gases
  - Excellent Coordination between Surgeon, Laser Operator, & Anesthetist
  - ENT Laser Safety Policy
- Lasing NEAR Airway
  - Examples: Laser Skin Resurfacing, Laser Turbinate Ablation
  - Concern is either potential exposure to laser from Direct Hit or Indirect Hit
  - (Example: Broken Fiber, New or Used!)
Preventing Laser Airway Fires

100% Preventable?

• Training Involvement:
  • Anesthesia MDs, CRNAs, Anesthesia Techs
  • OR Staff
  • Credentialed Physicians
• Dry Runs for both Cases & Fires
• Emergency Trach Sets Available
• Emergency Procedures
• Emergency Supplies in Room
• Trained Facility MLSO

• Appropriate Laser Resistant ET Tubes Available and Utilized Properly
• ENT Patient Draping Procedures and Protocols
  • Eyes
  • Face
  • ENT/ Neuro Pads & Strings
  • All WET
• Each laser facility should have an ENT Laser Safety Policy implemented & monitored.

Continue Your Training to Prevent Laser Airway Fires

• Train for Prevention
  – ENT Laser Safety Policy
  – Team ENT Laser Safety Training
  – Involve surgeons, anesthesia staff, surgical staff, administration, risk management
  – Engage your Medical Laser Safety Committee

• Prepare for the Worst
  – Team ENT Laser Safety Training
  – ENT Laser Safety Policy
  – ENT Laser Team Fire Drills
  – Check out: www.surgicalfire.org

Laser Safety

Oxidizer

Fuel

Air/alcohol based Skin Prep, Surgical Drapes, Patient
General Patient Safety Checklist Drive

• By the WHO
• Patient Safety Checklist with Time Out
• Consider inclusion of high risk laser apps, like ENT
• Acceptance spreading fast, because when implemented with thought and common sense, it works!

What are Control Measures?

• Types of Control Measures
  – Procedural
  – Environmental
  – Engineering

Examples

• Laser Safety Policy
  – Eye Safety
  – Skin Safety
  – Fire Safety
• Credentialing
  – MLSO
  – Laser Operators
  – Physicians
  – Staff Members
  – Specialty Laser Teams
• SOPs
• Laser Care & Maintenance
• Environmental Issues
**Laser Safety**

**Understanding Window Protection, Protective Barriers, NHZ vs. LTCA**

- CO2 laser energy will not penetrate windows within a surgical suite.
- All other wavelengths will penetrate glass.
- Some lasers have longer NHZs than others.
- MLSO may have authority to determine LTCA as NHZ ONLY, or the entire laser treatment room.
- Critical thinking scenarios

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**Laser Safety**

**Touching on Educational Requirements**

- Education & Training
  - MLSO
  - Physicians
  - Laser Operators
  - Staff Members
  - Specialty Teams (ENT)

- How important is it to “know your laser wavelengths”?
- Amazing benefits of the Laser Safety Committee
- Dealing with Non Compliance Issues
It’s All About Competencies!

Facilities should institute procedural and administrative controls that require a demonstration of competency commensurate with individual responsibilities.

A Word about “Competing Responsibilities”

- Laser user vs. Laser operator
- **Best Practices:** Dedicated Laser Operator
- Reality may require “critical thinking skills”
  - Patient assessment
  - Type of laser used
  - Complexity and type of procedure
  - Risk level of procedure
  - Experience and competency of laser user, laser operator and support staff members
  - Dedicated Responsibilities
Proper Use of the Standby Button

Most Important mechanism to prevent eye injuries, skin burns, or laser related OR fires!

Qualified Laser Operator, Communication, Following Protocols

Laser Generated Airborne Contaminates (LGAC) PLUME

Surgical Laser SMOKE BLOWS!
Surgical Laser Smoke
(LGAC Laser Generated Airborne Contaminates)

• Laser Smoke Contains:
  – Toxic gas and vapors (benzene, hydrogen cyanide, formaldehyde)
  – Bioaerosols (dead and living cell material)
  – Odor
  – Bacterial and Viral Contamination
  – Visibility Issues

• NIOSH Recommends
  – Smoke Evacuator System
    • ULPA or HEPA
    • LEV
    • Control cell fragments as small as 0.3 μm
  – Position of Wand Device
  – Care of Smoke Evac System
  – Use of wall suction with filter
  – High Filtration Masks
    • Purpose of HF Masks
    • HF Masks vs. N95 Respirator

Laser Energy Resistant Instrumentation

Laser Key Security
Continue to *Focus* Your Laser Learning!

*Thank You for Attending this Session!*

*Don’t Stop Here! It is an exciting time for Medical/ Surgical Lasers!*

**References**

- ANSI Z136.3 2011 “Safe Use of Lasers in Healthcare Facilities”
- ANSI Z136.1 2011 “Safe Use of Lasers”
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- "Fundamental of Light and Lasers, Elements of Photonics", OpTech, National Center for Optics and Photonics Education