LASER Safety in the Operating Room

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LASER
LASER is an Acronym

- Light Amplification by Stimulated Emission of Radiation
- Lasers work on several principles in quantum physics and how lasers work is beyond the scope of this lecture
Applications of Laser Surgery

- Lasers have been utilized in almost every surgical specialty and allow precise microsurgery.
- Lasers allow the surgeon to focus enormous heat on a small area of tissue.
- Utilizing lasers also allows instantaneous sealing of small vessels and lymphatics with minimal damage to surrounding tissues.
Typical OR Laser in Use
Hazards of Laser Surgery in Non-Airway Surgery

- Laser plumes
  - Tissue vaporization by lasers creates plumes of fine particulates that can deposit in alveoli causing interstitial pneumonia, bronchiolitis and may be mutagenic
  - Inhaling one gram of tissue has been equated to smoking 6 cigarettes

- Organ/Vessel Perforation
  - Burn depth can be difficult to evaluate
  - Vessels >5mm cannot be coagulated by laser
Hazards of Laser Surgery in Non-Airway Surgery (cont’d)

- Inappropriate Heat Transfer
  - Laser energy can strike anything in the OR causing damage to patients, staff or equipment
  - Laser energy can also provide the spark for an operating room fire
Hazards of Laser Surgery in Airway Surgery

- All of the hazards listed above including and increased risk of airway fire or “blowtorch” fire
- Several factors contribute to overall risk of airway fire
  - Relative flammability of various ETTs
  - Gas composition – minimal FiO₂ to maintain O₂ and N₂O should be avoided
  - Specially designed ETTs
Airway Fire Hazard Trilogy

- Oxygen enriched atmosphere
  - >21%
- Ignition Source
  - Electrocautery
  - Lasers
  - Endoscopes
- Fuel Source
  - Sponges, drapes, gowns, preps, alcohol
Airway Fire Protocol

- Remove Source
- Disconnect Circuit
- Extubate
- Mask with 100% O2
- Start TIVA
- DL/Bronch for damage evaluation and removal of debris
- Reintubate if significant damage

- Fiberoptic bronchoscropy and lavage may be necessary for blowtorch fire
- Severe damage may require tracheostomy
- Assess oropharynx
- CXR
Anesthetic Goals for Laser Airway Surgery

- Provide:
  - Safe environment for patient and staff
  - Quiet surgical field
  - Analgesia and anesthesia
- Minimize Complications
Anesthetic Techniques for Laser Airway Surgery

- Non-intubation techniques
  - Apneic Oxygenation
  - Spontaneous Ventilation
  - Jet Ventilation
- Intubation Techniques
Apneic Oxygenation

Advantages
- Periods of apnea can alternate with periods of laser resection
- Excellent visibility of surgical field
- Potential trauma to airway is avoided

Disadvantages
- Surgical time limit
- Inadequate ventilation
- Aspiration risk
Spontaneous Ventilation

- Advantages
  - Evaluate vocal cord function
  - Excellent visualization of surgical field
  - Good for otherwise unstable patients with compromised airway

- Disadvantages
  - Oxygenation/ventilation more difficult to assess
  - Surgical field not still
  - Risk of aspiration
  - Depth of anesthesia not consistent
Jet Ventilation

Advantages
- Decreased risk of airway fire
- Improved surgical field visibility
- Atraumatic airway manipulation

Disadvantages
- Difficult to control ventilation, likely hypoventilation
- Oxygenation/ventilation cannot be assessed
- Muscle relaxation required
- Increased aspiration risk
- Inability to use anesthetic gases
- Misdirection of jet may cause gastric distension or barotrauma
Jet Ventilation
Intubation

- Advantages
  - Secure airway, less risk of aspiration
  - Controlled ventilation
  - Administer anesthetic gases
  - Monitor O2 and EtCO2 concentrations

- Disadvantages
  - ETT may obstruct surgical view
  - Airway trauma
  - ? Difficult Airway
  - No ETT exists which decreases risk of airway fire to zero
Endotracheal Tube Types

- Conventional Tubes
  - PVC (Polyvinyl Chloride)
  - Red Rubber
  - Silicone Rubber

- Laser Tubes
  - Norton
  - Bivona Fome-Cuff
  - Xomed Laser-Shield
  - Mallinckrodt Laser-Flex

- Metal Tubes
Conventional Tubes

Advantages
- No reflection of laser light
- No retention or transfer of heat to adjacent tissues
- Evidence of combustion can be seen within the lumen

Disadvantages
- These tubes readily ignite and maintain combustion
- In the event of fire, tube integrity may be compromised and components may be retained in tracheobronchial tree
Conventional Tubes

- Manufacturers discourage use of this type of tube for upper airway laser surgery
- Rubber and silicone rubber tubes more readily combust than PVC but are more resistant to puncture
Polyvinyl Chloride ETT
Red Rubber ETT
Endotracheal Tubes Designed for Laser Airway Surgery

- Norton
  - Spiral wound stainless steel ETT, no longer in use
- Bivona Fome-Cuff
  - Aluminum spiral tube with polyurethane foam cuff
  - Foam is self-inflating and prevents deflation in the event of cuff rupture
  - Only for use with a CO2 laser
- Xomed Laser-Shield
  - Silicone elastomer tube containing metallic powder designed for pulsed laser CO2
- Mallinckrodt Laser-Flex
  - Airtight stainless steel spiral wound tube with two PVC cuffs which can be filled with methylene blue to indicate rupture of cuff
  - Recommended for use with CO2 and KTP-Nd-YAG lasers
Mallinckrodt Laser-Flex

**Advantages**
- Provides protection against fire superior to other endotracheal tubes
- Indicate cuff rupture while maintaining cuff seal on airway

**Disadvantages**
- Expensive
- Bulky, relatively large outer diameter
- Cuff is flammable
- Metal may reflect laser onto non-targeted tissues
Mallinckrodt Laser-Flex
Metal Tubes

- Inflammable
- Thick wall, bulky
- Difficult to place
Other Laser Safety Concerns

- **Patient Safety**
  - Eye protection
  - Prepping solution
  - Laser plume

- **Personnel Safety**
  - Eye protection
  - Laser plume
  - Restricted traffic in operating room
  - Laser signs
Patient Safety

- Eye protection
  - Discuss with patient in holding wearing protective eyewear
  - Use moistened eye pads for patients receiving a general anesthetic

- Prepping solution
  - Nonflammable skin preparation should be used and allowed to dry before using the laser
Personnel Safety

- Eye Protection
  - Necessary for all personnel in OR
  - Differing wavelengths of lasers injure differing parts of the eye
    - Therefore, different eyewear is required for different types of lasers and must protect from the top, bottom, and all sides of the visual field
Contact lenses, half glasses, and user’s prescription lenses are NOT considered appropriate protection against eye injury.
Restricted traffic in operating room
  - Personnel entering area should be trained in laser safety
  - Windows or ports in the room need to be covered with a barrier

Laser Signs should be posted at every door
  - Hanging goggles near the laser sign at the entrance to the room increases compliance
Laser Signs

DANGER
INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE
TO DIRECT OR SCATTERED RADIATION
CARBON DIOXIDE LASER
100 W MAX OUTPUT at 10.6 μm
CLASS IV LASER PRODUCT

WARNING
LASER LIGHT
IN OPERATION

CAUTION

Big Scary Laser
Do not look into beam with remaining eye
Laser Safety Summary

- Lasers have contributed greatly to advancements in all types of surgeries
- The only way to completely avoid laser hazards and laser fires is to NOT use lasers
- Therefore, it is important to be cognizant of the risks and dangers of laser use, especially with airway surgery, and to use appropriate precautions when using a laser in the operating theater
Elephant Ventilator

- For elephants up to 18,000 lbs
- Tidal Volume 25 to 125 liters
- Inspiratory Flowrate up to 1,100 liters per minute
- Ventilator Controls
  - Inspiratory time .2 to 6 seconds
  - Maximum Inspiratory Flowrate 1,100 liters per minute
  - Peak Inspiratory Pressure 60cm H2O
  - Maximum Tidal volume 125 liters
  - Breathing rate 2-12 breaths per minute
Ellis, K. Fire and Laser Safety: Preventing and OR Catastrophe. [http://www.surgicenteronline.com](http://www.surgicenteronline.com) 04/01/2006

