Laser Surgery of the Larynx and Trachea

Introduction and History

Laser, an acronym for Light Amplification by Stimulated Emission of Radiation, is a device that emits coherent light via optical feedback and amplification. Lasers have been using in medical practice since the 1960's, when ruby lasers were first used. Since its first use in 1968, the carbon dioxide (CO2) laser has become the most commonly used laser for endoscopic laryngeal and tracheal surgeries. Use of the CO2 laser has evolved as innovations have improved the user characteristics for endoscopic procedures, such development of the micromanipulator, as well as improved optics, instrumentation, and delivery methods.

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Applications and Use of Lasers

Carbon Dioxide Laser

- Today, the CO2 laser can be used for ablative and non-ablative procedures both in-office and in the operating room. This allows for additional options for treating benign and malignant lesions beyond traditional cold surgical techniques. With a wavelength of 10,600 nm, the CO2 laser is absorbed by water, therefore making if favorable for treating a number of soft tissue lesions. For benign lesions, the CO2 laser can be applied to treat recurrent respiratory papillomatosis (RRP), using ablative techniques or via resection while preserving surrounding structures. It is also commonly used for treatment of stenosis at the level of the glottis and subglottis. For areas of stenosis, CO2 laser is often preferred to cold steel due to hemostatic properties and preservation of surrounding tissues. Hemorrhagic lesions and varices/ectasias have been treated with CO2 laser, though concern for increased epithelial stiffness at the level of the glottis often limits CO2 laser use for this purpose.

- Settings used for the CO2 laser are selected with keeping tissue cooling in mind, with most laryngologists using pulsed or super-pulsed modes for this purpose. Depending on the lesion size and location, CO2 laser settings can range from 3 to 10 Watts with 3 to 5 msec delay, based on surgeon discretion. Awareness of laser settings is critical to avoid thermal damage to target tissues, as well as surrounding tissues. One study on canine larynges revealed thermal injuries extending up to 285 μm into the lamina propria, which raises concern for fibrosis that could impact mucosal vibration during phonation. Surgeon mindfulness is critical to avoid such issues, enabling one to achieve the best possible vocal outcomes.
- **References:**

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Potassium-Titanyl-Phosphate (KTP) Laser

- Potassium-titanyl-phosphate (KTP) laser is another commonly used laser type for airway surgery. With a wavelength of 532 nm, KTP is absorbed by oxyhemoglobin, making it ideal for vascular lesions, including varices and ectasias. Pedunculated lesions, such as RRP, hemorrhagic polyps, Reinke's edema, and other polypoid lesions, can also be treated using KTP laser. Its' application has also been employed in select circumstances for vocal fold cyst, pseudocyst, scar, and leukoplakia/dysplasia.
- KTP laser can be used with minimal damage to surrounding tissue, allowing for preservation of overlying vocal fold epithelium. Typical settings used include 15 to 35 Watts, with 15 to 25 msec pulse width and 2 pulses delivered per second. Lower settings can be used for treating laryngeal varices and ectasias, using 5-10 Watts on pulsed setting. It can be used on pulsed or continuous modes, though pulsed modes are more commonly used, again, in order to reduce collateral thermal damage and promote tissue

cooling. Comparison of voice outcomes between KTP laser versus cold knife excision, specifically for polypoid lesions, did not reveal difference in voice outcomes, supporting this as an option for treatment of laryngeal lesions.

- **References:**

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Pulsed Dye Laser (PDL)

- Pulsed dye laser (PDL) has been also used, more often in a clinic setting, for treatment of benign laryngeal lesions. It has similar properties to the KTP laser, with a wavelength of 585 nm and absorption by oxyhemoglobin. PDL causes involution of lesions by disruption of the lesions' vascular supply, allowing for treatment of RRP, vascular polyps, and varices/ectasias, among others. It does have a shorter pulse width compared to KTP, leading to a higher risk of vessel wall rupture and, therefore, potential for difficulty in achieving hemostasis.
- Several studies have noted that PDL leads to less disruption of the superficial lamina propria, especially if used to treat vocal fold leukoplakias. Contradicting this, others feel that PDL can be used to excise thicker lesions, achieving deeper penetration into the

lamina propria. It has also been noted to have variable success in treating lesions such as hemorrhagic polyps (ranging between 38-100% success rates). The variability in success rates and outcomes and the more fragile nature of the PDL fiber makes PDL less favored for treatment of laryngeal lesions, though outcomes and uses differ in the hands of varying operating laryngologists.

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Laser Safety

- Use of lasers requires application of safety precautions in an effort to avoid injury to patients and staff. The surgeon must be knowledgeable about laser use and technique, but the surgeon also has a great responsibility of ensuring safety for all in the operating room. The surgeon and operating room team must communicate before and during the use of the laser in order to prevent laser injury.
- The anesthesiologist must be aware of the plan to use a laser, with the operating surgeon communicating the need for a laser-resistant endotracheal tube and maintenance of oxygen concentration in the anesthetic gas less than 30%. These precautions are critical in preventing airway fire. Other measures to avoid airway fire include reducing laser plume with smoke evacuation during the procedure; consideration of use of jet ventilation; and placement of saline-soaked cottonoids above the endotracheal tube cuff. Other precautions to avoid patient injury is placement of saline-soaked surgical towels over the patient's face, as well as saline-soaked gauze eye pads placed to protect the retina/cornea. Operating room personnel should wear laser-safe goggles, as well as the appropriate filters placed on any operating microscope lens to protect the surgeon's eyes, as well.

- In the event of ignition of the endotracheal tube, ventilation should be stopped immediately while simultaneously withdrawing the endotracheal tube and flushing the airway with saline. The airway should then be immediately reestablished, potentially with the aid of bronchoscopy, to assess injury and establish an airway prior to edema that could ensue following the injury. The patient should be transported to the ICU, with plans to remain intubated and receive intravenous steroids. Airway examinations should be repeated until the airway is stable for extubation.
- **References:**

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