Safety Concerns of the Carbon Dioxide Laser in Traditional and OmniGuide Modes in Transoral Laser Microsurgery

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Abstract

Objective: Comparisons between line-of-sight and fiber-optic carbon dioxide (CO2) lasers with commonly used supplies in transoral laser microsurgery have not been previously reported.

Methods: The beams of a traditional and an OmniGuide fiber-based laser were focused on commonly used materials in transoral laser microsurgery. Three laser resistant endotracheal tubes (ETTs), a standard polyvinylchloride (PVC) ETT, and surgical patties were evaluated.

Results: Neither laser beam completely penetrated any of the laser resistant ETTs within 90s of contact. However, both instantaneously perforated the absorbent coating of the laser resistant tubes, exposing the underlying metal tape. The traditional laser perforated the PVC endotracheal tube at 0s and the OmniGuide laser did so within 3s. Both laser beams perforated dry patties instantaneously but were unable to penetrate excessively saturated patties.

Conclusions: In general, the time to penetrate materials was longer for the OmniGuide CO2 laser when used at the same power. The absorbent outer coating of all ETTs was easily penetrated with the laser, revealing highly reflective metallic tape that could potentially damage surrounding tissues.

Introduction

The introduction of the CO2 laser to otolaryngology revolutionized the way in which transoral surgery was performed. The CO2 laser allowed surgeons to cut and coagulate tissue precisely and simultaneously like never before. However, since its introduction, the laser has been recognized as having the potential of causing fire. During transoral laser surgery, the three components of the “fire triad” are all brought together into close proximity, thereby increasing the risk of an adverse event. To prevent this, safety protocols and resources have been developed to raise awareness of fire safety. In addition, laser-resistant ETTs and special ventilation techniques have been developed to minimize the risk of an airway fire.

The safety of the line of sight CO2 laser has been studied extensively, however there have been no studies to investigate the effects of the OmniGuide fiber-based laser, which was introduced in 2004. In this study, the safety of both lasers was tested on commonly used supplies in surgery including various ETTs, and ETT cuffs and Codman surgical patties.

Methods and Materials

Laser Source: Beams produced by a Lumenis Coherent 60 watt, 5000C carbon dioxide laser (Lumenis, #5000C, San Jose, CA) and an OmniGuide carbon dioxide laser fiber (OmniGuide, Cambridge, MA) were tested at 10 W continuously. The laser beam was focused from a distance of 2 cm from the target. Laser was applied for maximum 90s.

Target: Four laser-safe endotracheal tubes were tested: 1) A Xomed Laser-Shield II; 2) A Mallinckrodt Laser Oral/Nasal Tracheal Tube; 3) A Rusch Laserubus; and 4) Hudson RCI Sheridan Laser-Trach. A “standard” Mallinckrodt Hi-Lo PVC ETT was also tested. All tubes were 6.0 in size. Tubes were placed on wet towels throughout the experiment and an oven mitt was used to manipulate the supplies.

The Xomed and Rusch endotracheal tube cuffs were filled with 10mL of saline (Figure 1). A PVC ETT was filled with air or saline.

The time to perforation of ½” x 3” Codman surgical patties was also examined. These patties were tested in three conditions: dry, soaked in normal saline for 5s, and “sloppy wet”. Three trials were performed.

Results

None of the laser-resistant ETT shafts were perforated by the CO2 lasers. The lasers were able to perforate the outer absorbent layer of the Sheridan Laser-Trach, Xomed Laser-Shield II, and Rusch Laserubus instantaneously (Figure 1). In addition, the laser did produce a spark at the mean time of 18s of contact with the Rusch ETT. The CO2 laser was unable to perforate the metallic layer of any of the tubes. Following perforation of the absorbent layer, the beam reflected off of the tube and damaged surrounding safety equipment including the oven mitt used to hold the laser in place (Figure 2).

All cuffs were perforated by the CO2 laser. The Rusch cuff was the most resistant: it was nonreactive at 90s with OmniGuide and 15s average perforation time with the line-of-site. The other cuffs perforated instantaneously.

Table 1. Time to perforate Codman surgical patty with each laser

<table>
<thead>
<tr>
<th>Condition</th>
<th>OmniGuide laser</th>
<th>Line-of-sight laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>2s</td>
<td>Instantaneously</td>
</tr>
<tr>
<td>Saturated Wet</td>
<td>23s</td>
<td>16.9s</td>
</tr>
<tr>
<td>Sloppy Saturated</td>
<td>Nonreactive</td>
<td>Nonreactive</td>
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</tbody>
</table>

Discussion

The advent of the fiber based OmniGuide laser enabled the beam to be aimed towards difficult targets, including around corner or at angles. Despite how often this laser is used, its safety profile with standard operating supplies has not been tested.

In this study, all laser-resistant ETTs were ultimately resistant to the CO2 laser. However, the laser did perforate the outer absorbent layer, exposing a metallic layer beneath. Once this metallic layer is exposed the beam may be reflected. In this study the beam damaged the oven mitt used to hold supplies (Figure 3). Sosis and Dillon previously noted this and tested the reflective properties of different ETTs. Another safety hazard identified was that a spark produced by the laser after the absorbent coating of the Rusch tube was perforated.

In contrast, the ETT cuffs were able to be penetrated by the CO2 laser regardless of whether saline or air was used as filler. The ability of surgical patties to “protect” structures was tested as well. Supersaturated patties that were soaked immediately before testing were nonreactive. However dry and even patties soaked for 5s in saline were penetrated by both lasers. This highlights the importance of constantly irrigating surgical patties to prevent surgical fire.

In general, the time to penetrate materials was longer for the OmniGuide CO2 laser model when used at the same power as the traditional line-of-site laser.

Conclusions

Both the OmniGuide and the line-of-site CO2 laser may be used safely with a number of laser-safe ETTs. The outer absorbent layer of the ETTs was susceptible to perforation immediately, leaving a reflective metallic layer exposed. The most vulnerable portion of the ETT is the cuff which was immediately perforated in most trials. Keeping surgical patties constantly supersaturated with saline is a critical safety policy.

References