EQUIPMENT AND MONITORING II — THE AIRWAY

A392

TITLE: EVALUATION OF A NEW FOIL WRAPPED SILICONE ENDOTRACHEAL TUBE DESIGNED FOR LASER AIRWAY SURGERY

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Airway fires from the inadvertent contact of medical lasers with combustible endotracheal tubes are a relatively common serious complication of carbon dioxide (CO₂) and neodymium-yttrium-aluminum garnet (Nd:YAG) laser airway surgery. 1 Xomed Treace R (Jacksonville, Fl) has introduced a laser-resistant, adhesive-free aluminum and Teflon R covered silicone rubber endotracheal tube (Laser Shield II) for laser airway surgery. We evaluated the combustibility of this device and compared its combustibility with a 3M (St. Paul, MN) no. 425 aluminum foil-wrapped combustible polyvinyl chloride (PVC) tube.

A Cooper LaserSonic 2500 (Santa Clara, CA) CO₂ laser equipped with hand-held probe was used for all CO₂ trials. A Cooper LaserSonic 8000 Nd:YAG laser (with Zeiss (Germany) optical microscope guidance) was used for the Nd:YAG trials. Both lasers were set to 60W in the continuous mode. All laser beams were directed perpendicularly at the endotracheal tubes. Five liters/min of oxygen flowed through the endotracheal tubes during laser exposure. The laser was continued until combustion occurred or until 60 sec elapsed. Xomed Laser Shield II tubes and foil-wrapped 7.5mm ID Mallinckrodt PVC tubes were used for four series of ten trials. Undamaged sections of the endotracheal tubes were exposed to laser fire in each trial.

In ten trials, when the foil-covered shafts of either type of endotracheal tube were exposed to 50W of CO₂ radiation for 60 sec, no combustion occurred. When the foil-covered shafts of the Laser Shield II were exposed to 50W of Nd:YAG (n=10) radiation, no combustion occurred but thermal decomposition of the Teflon R has been seen, exposing the aluminum foil beneath it. In one trial of Nd:YAG exposure to the 3M no. 425-covered PVC tube (out of 10 trials) combustion occurred after 53 sec. In this case, evidence of combustion was seen at the site of overlap between two turns of metallic foil tape.

Exposure of bare PVC endotracheal tubes to either laser caused rapid combustion: in 4.5±5.6sec (mean±SD) after Nd:YAG exposure and in 0.8±0.2 sec after CO₂ exposure (p<0.05). Exposure of the bare silicone rubber part of the Laser Shield II endotracheal tube to CO₂ laser radiation caused combustion in 2.1±0.7 sec; Nd:YAG radiation induced combustion in 3.3±4.5 sec (p<0.05).

We conclude that the Laser Shield II endotracheal tube provides adequate protection against high wattage, continuous mode Nd:YAG and CO₂ laser radiation, as does the 3M no. 425-covered PVC endotracheal tube. Because adhesives on foil tape have been shown to contribute to laser induced endotracheal tube combustion,2 the Laser Shield II endotracheal tube offers the potential advantage of an adhesive-free foil wrapping.


A393

TITLE: THE PROTECTIVE EFFECT OF HELIUM ON SILICONE ENDOTRACHEAL TUBE FLAMMABILITY DURING CO₂ LASER SURGERY

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INTRODUCTION: The most common and potentially disastrous complication of CO₂ laser surgery of the airway is an endotracheal tube explosion. 3 Stainless steel tubes with polyvinylchloride (PVC) tips (Laser-Flax, Mallinckrodt) are available and offer increased resistance to ignition. However, metal endotracheal tubes have a large external surface which yields the surgeon's access to the larynx. Furthermore, they can reflect the laser beam and also cause mechanical traumas to laryngeal structures. Pashayan and Graevenstein have demonstrated that mixtures of helium and oxygen are significantly less likely to ignite the PVC endotracheal tube.4 However, PVC tubes produce hydrochloric acid during combustion.5 A silicone endotracheal tube (Laser Shield II (silicone tube covered with metal tape and teflon), Xomed Treace) has recently become available. This tube would avoid these problems. However, the susceptibility of this tube to ignition in varying gas mixtures has not been tested. Therefore, this study was undertaken to test whether helium would delay ignition of silicone endotracheal tubes.

MATERIALS AND METHODS: A 5 l/min gas flow (from a North American Drager Harwood 2B anesthesia machine with a heliox (70% helium/30% oxygen) third gas option) was directed through a 4 cm long endotracheal tube segments. The tube segments were from plain silicone main shafts used in construction of Laser Shield II endotracheal tubes, and were provided by the Xomed-Treace Company. Gas mixtures consisted of either air or helium with oxygen such that the oxygen concentration was either 30% or 40% (5% confirmed with an oxygen analyzer). The CO₂ laser (Sharplan 1100) was set in a continuous mode at a power setting of 15 watts. The tubes were washed and dried prior to testing to ensure that skin oil contamination did not affect the results. The segments were placed at the focal length (400 mm) and the beam diameter was 0.6 mm. The above setting was selected because the segments would not ignite with 30% or 40% oxygen at 10 or 12 watts. For each gas mixture 10 segments were exposed at the above setting for 60 seconds or until ignition.

RESULTS: The ignition time was considerably prolonged with helium and oxygen mixtures as compared with air and oxygen mixtures for both air and helium times are given below:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Ignition Time (seconds)</th>
<th>Measurement (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>38.6</td>
<td>(32.7 - 53.6)</td>
</tr>
<tr>
<td>30% Helium</td>
<td>10/10 *</td>
<td>-</td>
</tr>
<tr>
<td>40% Helium</td>
<td>17.7</td>
<td>(8.6 - 30.8)</td>
</tr>
</tbody>
</table>

*Significant at .01 level by Fisher's Exact Test

DISCUSSION: Our results with silicone tubes are similar to Pashayan and Graevenstein's results with PVC tubes. However, the above authors could not demonstrate a prolonged ignition time with helium at 12.5 watts (the highest power setting in their study). In contrast, this report demonstrates increased resistance to ignition at a power setting of 15 watts with either 30% or 40% oxygen. This difference is most likely attributable to the increased external surface area of silicone vs. silicone, and also to a difference in methods. External portions of tube segments in Pashayan and Graevenstein's study were exposed to gas concentrations identical to the internal concentrations, whereas our tube segments were externally exposed to room air. Our design more closely resembles the adult clinical setting where auffed endotracheal tube is used. Furthermore, our data suggests that power settings up to 15 watts may be safely used with helium and oxygen mixtures (30% and 40% oxygen concentrations) if there is no cuff leak.