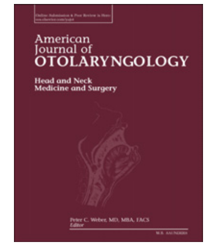
AMERICAN JOURNAL OF OTOLARYNGOLOGY–HEAD AND NECK MEDICINE AND SURGERY 36 (2015) 63–66

Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/amjoto



Prevention of airway fires: testing the safety of endotracheal tubes and surgical devices in a mechanical model

Soham Roy, MD, FACS, FAAP[a], Lee P. Smith, MD, FACS[b,*]

[a] *Pediatric Otolaryngology, Children's Memorial Hermann Hospital, Associate Professor of Otolaryngology, University of Texas-Houston School of Medicine, Houston, TX, USA*

[b] *Pediatric Otolaryngology, Steven and Alexandra Cohen Children's Medical Center, Assistant Professor of Otolaryngology, Hofstra North Shore - LIJ School of Medicine, Hempstead, NY, USA*

ARTICLE INFO

Article history:
Received 5 August 2014

ABSTRACT

Objectives: This study was designed to assess the ability of carbon dioxide (CO2) lasers and radiofrequency ablation devices (Coblator) (ArthoCare Corporation, Sunnyvale, CA) to ignite either a non-reinforced (polyvinylchloride) endotracheal tube (ETT) or an aluminum and fluoroplastic wrapped silicon ("laser safe") ETT at varying titrations of oxygen in a mechanical model of airway surgery.

Methods: Non-reinforced and laser safe ETTs were suspended in a mechanical model imitating endoscopic airway surgery. A CO2 laser set at 5–30 watts was fired at the ETT at oxygen concentrations ranging from 21% to 88%. The process was repeated using a radiofrequency ablation (RFA) device. All trials were repeated to ensure accuracy.

Results: The CO2 laser ignited a fire when contacting a non-reinforced ETT in under 2 seconds at oxygen concentrations as low as 44%. The CO2 laser could not ignite a laser safe ETT under any conditions, unless it struck the non-reinforced distal tip of the ETT. With the RFA, a fire could not be ignited with either reinforced or non-reinforced ETTs.

Conclusions: RFA presents no risk of ignition in simulated airway surgery. CO2 lasers should be utilized with a reinforced ETT or no ETT, as fires can easily ignite when lasers strike a non-reinforced ETT. Decreasing the fraction of inspired oxygen reduces the risk of fire.

1. Introduction

Fires in the operating room remain a potentially devastating mechanism of injury and even mortality. Annually, anywhere from 250 to 600 operating room (OR) fires occur in the United States; an exact number remains unknown, as there is no central reporting system for fires in the operating room. Critical injuries have been documented throughout the popular news media. Procedures in otolaryngology remain one of the highest risk areas for OR fires.

Our previous work has evaluated risk factors for fires in mechanical models of oral cavity/oropharyngeal surgery [1,2] and burn injuries from endoscopic light cables [3]. However, a recent spate of OR fires during laser airway surgery has cast light on the dangers involved in laryngeal and airway surgery. Fires require three elements for ignition and propagation; an

* *Corresponding author at:* Pediatric Otolaryngology, Steven and Alexandra Cohen Children's Medical Center, Assistant Professor of Otolaryngology, Hofstra North Shore - LIJ School of Medicine.

http://dx.doi.org/10.1016/j.amjoto.2014.10.009
0196-0709/

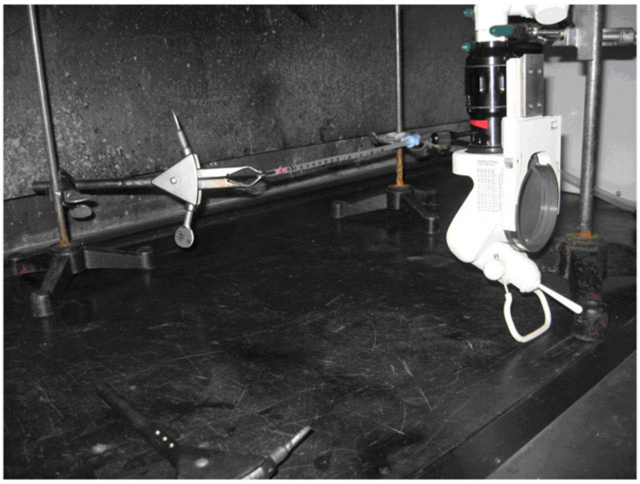


Fig. 1 – The experimental setup.

ignition source (examples include lasers, cautery devices and electrical instruments), flammable fuels (these can be both intrinsic and extrinsic, including fat, muscle, drapes, sponges, endotracheal tubes and other instruments) and oxidizers (traditionally supplemental oxygen, but may also include nitrous oxide or other gasses that support combustion). In laser airway surgery, these three elements are in close proximity. In our previous study evaluating the incidence of OR fires in otolaryngology procedures, 27 of a reported 100 cases of OR fire occurred during endoscopic laryngeal and airway surgery, and of those, 26 occurred while using a laser, 15 involved ignition of the endotracheal tube, and 25 were in the presence of supplemental oxygen [4]. In the present study, we set out to assess the potential fire risk in a mechanical model of laser airway surgery, evaluating both “laser safe” and regular tubes, laser wattage settings and the presence of supplemental oxygen.

2. Methods

A “laser safe” endotracheal tube (Laser Shield II, Medtronic, Minneapolis, MN) was compared to a traditional endotracheal tube (Mallinckrodt, Covidien, Mansfield, MA) in a mechanical environment (Fig. 1). The endotracheal tubes (ETT) were hooked to an anesthesia machine, where supplemental oxygen was supplied at varying oxygen concentrations.

Initially, a carbon dioxide (CO2) laser at 5 watts was fired at various locations at the tube. Time to ignition followed by a sustained flame was recorded.

After these first trials, attention was paid to testing the penetrability of the “laser safe” endotracheal tube. Supplemental oxygen was titrated to 100%, and the CO2 laser was fired at the laser safe shaft of the ETT at increasing power. The tubes were assessed to evaluate penetration and damage.

Finally, the above trials were repeated with both ETTs using a radiofrequency plasma ablation (RFA) wand (Coblator, ArthoCare Corporation, Sunnyvale, CA). Endotracheal tube damage was assessed by both authors after completion of each trial, and each trial was repeated twice to ensure accuracy. If no ignition or sustained flames were seen after 2 minutes of the ignition source being activated (“maximum time”), a trial was considered to be negative.

3. Results

3.1. *Phase I*

CO2 laser fired directly at a “regular” (non-reinforced) endotracheal tube at a setting of 5 watts. Table 1 shows the results of the CO2 laser at 5 watts. At 21% and 29% O2, an ignition was seen, but no sustained flame was created. However, at 44%, 53%, at 60%, immediate sustained flames were noted emanating from the endotracheal tube. Of note, at lower oxygen concentrations, longer times were required to create a visible ignition (7–8 seconds) while at higher concentrations, immediate sustained flames were created in 1–2 seconds, suggesting that fires can be ignited very quickly in higher oxygen-enriched environments.

3.2. *Phase II*

CO2 laser fired at the body of a “laser safe” tube at a CO2 laser setting of 5 watts. As seen in Table 1, firing the laser at a “laser safe” tube resulted in no ignition or sustained flame at any level of supplemental oxygen, up to the maximum time (2 minutes) of activation of the ignition source. However, firing the laser at the distal most tip of the “laser safe” tube (which is not metallically reinforced), resulted in ignition and sustained flames at the same oxygen levels as a non-reinforced (regular) ETT.

Table 1 – Results of CO2 laser fired at Non-Reinforced and Reinforced ETT.

O2 Concentration	Non-laser safe ETT		Reinforced (laser safe tube)	
	Result	Average time	Result	Average time
21%	Ignition without sustained flame	7.5 Seconds	No ignition	Max time
29%	Ignition without sustained flame	8 Seconds	No ignition	Max time
44%	Ignition and sustained flame	2 Seconds	No ignition	Max time
53%	Ignition and sustained flame	1 Second	No ignition	Max time
60%	Ignition and sustained flame	1.5 Seconds	No ignition	Max time