

TITLE: INCENDIARY CHARACTERISTICS OF A NEW LASER-RESISTANT ENDOTRACHEAL TUBE

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INTRODUCTION: Laser-induced fires in endotracheal tubes are the most frequently reported complication of laryngeal laser surgery (1). Various techniques have been suggested to avoid this problem (2), but each has significant disadvantages. We investigated the incendiary characteristics of a pliable laser resistant (LR) (Xomed, Inc., Laser Shield) endotracheal tube (ET) compared with a polyvinyl chloride (PVC) (National Catheter, HI-Lo) ET, and a red rubber (RR) ET.

METHODS: Oxygen was diluted with N₂ or N₂O to achieve O₂ concentrations from 30 to 100%, and delivered through the ET at 3 - 6 liters/minute. Gas flow circulated around the tube in an open-ended protective enclosure. Each tube was struck five times at adjacent sites by a single laser pulse of from 5 to 25 watts for a duration of between 0.1 and 1.0 seconds. At each laser energy level (energy = watts x seconds) and gas composition, an assessment was made of the penetrability of the tube and the probability of ignition of a sustained fire (any fire that persisted after termination of the laser beam). Blow torch fires were those in which vigorous combustion propagated in a jet proximal and distal to the ignition site.

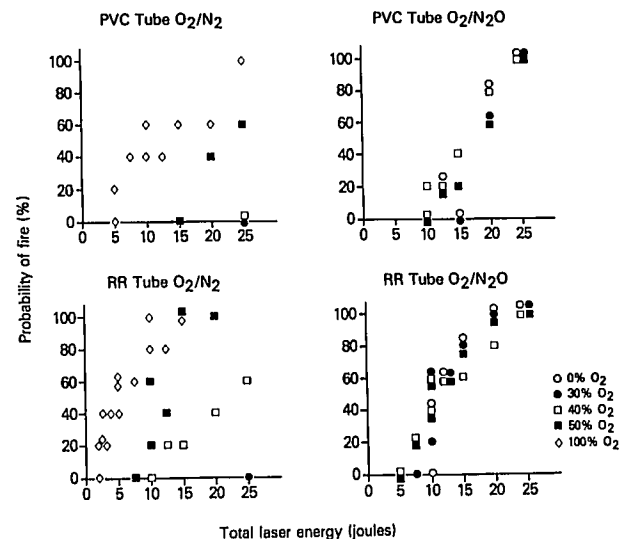
RESULTS: Penetration or ignition of the LR tube was not possible in any gas mixture with a single laser pulse regardless of total energy. Penetration and ignition were achieved with continuous laser irradiation of between 2.0 and 6.0 seconds. In N₂ this required 56 joules at 100% O₂, 70 joules at 50% O₂, and 88 joules at 30% O₂. In N₂O it took 58 joules at 50% O₂, and 60 joules at 30% O₂. The probability of fire with single pulses at each laser energy in different gas mixtures for the PVC and RR tubes is shown in figure 1. Blow torch fires were common with PVC tubes. Non-sustained surface fires emitting black smoke occurred on RR tubes in high O₂ atmospheres but the tube was not penetrated with any single laser pulse. With lower oxygen concentrations lower minimum energies were required for the production of sustained fires in PVC tubes. Mixtures of O₂ and N₂O readily supported sustained blow torch combustion and 30% O₂ in N₂O was as flammable as 50% O₂ in N₂. Interruption of gas flow by clamp occlusion of the proximal portion of the endotracheal tube immediately halted all blow torch fires.

DISCUSSION: Ignition of sustained fires clearly required penetration of the tube and a combustible atmosphere. We confirmed previous findings (3) that N₂O readily supported combustion and that low O₂ in N₂, but not N₂O, minimizes the risk of fire using a PVC or RR ET. The laser resistant tube we tested has safer incendiary properties than do other tubes, and may offer improved safety for laryngeal laser surgery. An additional safety measure is to have a clamp on the ET for rapid occlusion of gas flow in case of fire.

REFERENCES:

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FIGURE 1.
INCENDIARY CHARACTERISTICS OF POLYVINYL CHLORIDE (PVC) AND RED RUBBER (RR) ENDOTRACHEAL TUBES



Comparison of PVC and RR tubes in different gas mixtures. All combinations of O₂ and N₂O are virtually the same as 100% O₂.