

## A394

**TITLE:** Wire-Reinforced Endotracheal Tubes: Composition Affects the Response to External Compression and Kinking

**AUTHORS:** R.N. Wissler, MD, PhD,  
N. Gravenstein, MD, and M.J. Banner, PhD

**AFFILIATION:** Departments of Anesthesiology and Neurosurgery and Physiology, College of Medicine, University of Florida, Gainesville, Florida 32610-0254

**Introduction:** Wire-reinforced endotracheal tubes (ETT) are useful when the clinical situation includes the possibility of ETT compression or kinking. A laboratory model has been devised to determine if the composition of the wire-reinforced ETTs affects their performance under these conditions.

**Methods:** The external compression model consisted of 6-kg lead weights, 5 cm in length, sequentially stacked on the side of the ETT up to a total of 30 kg. The kinking model consisted of a 180° bend in the tube secured with adhesive tape. ETT patency was assessed under these experimental conditions by measuring the additional work (W) imposed on spontaneous breathing. W was determined by integrating the changes in airway pressure and tidal volume ( $V_T$ ) during simulated spontaneous room air breathing with a piston driven mechanical model. A sinusoidal peak inspiratory flow rate of 60 L/min was used,  $V_T$  was 1000 ml, and the inspiratory-to expiratory (I:E) ratio was 1:2. Non-reinforced (Mallinckrodt), metal wire-reinforced (Mallinckrodt and Sheridan), and nylon wire-reinforced (Leyland) ETTs (8.0-mm-ID) were evaluated ( $n=3$  for each ETT type). Data were analyzed by ANOVA with Duncan's multiple range for multiple comparisons of group means with alpha of 0.05.

**Results:** Significant differences in W were noted among the four types of ETTs during external compression from 6 to 30 kg at both peak inspiratory flow rates. The metal wire-reinforced ETTs had lower increases in W per unit of external compression (Table). The non-reinforced and nylon wire-reinforced ETTs had significantly higher W at 6 kg of external compression, as compared to the metal wire-reinforced ETTs at a 30 kg load. Preliminary data on 180° kinking of ETTs showed similar patterns of W, based on endotracheal tube composition.

**Discussion:** A new laboratory model demonstrates that commercially available wire-reinforced and non-reinforced ETTs vary in their response to external compression and kinking. Based on the laboratory data, reinforced ETTs containing metal wire may be most useful in maintaining airway patency in patients at risk for ETT compression or kinking.

**Table:** Additional Work Imposed on Spontaneous Breathing by External Compression of 8.0 mm ID Endotracheal Tubes

Endotracheal Tubes	Work/Breath (kg•m/L)			
	Baseline	External Compression Load (kg)		
		6	12	30
Non-Reinforced (Mallinckrodt)	0.074 <sub>a</sub>	0.206 <sub>b</sub>	> 1.0 <sub>d</sub>	> 1.0 <sub>d</sub>
Nylon (Leyland) Wire-Reinforced	0.080 <sub>a</sub>	0.244 <sub>c</sub>	> 1.0 <sub>d</sub>	> 1.0 <sub>d</sub>
Metal (Sheridan) Wire-Reinforced	0.082 <sub>a</sub>	0.086 <sub>a</sub>	0.088 <sub>a</sub>	0.137 <sub>e</sub>
Metal (Mallinckrodt) Wire-Reinforced	0.085 <sub>a</sub>	0.087 <sub>a</sub>	0.088 <sub>a</sub>	0.162 <sub>f</sub>

Work values are means. Means are significantly different unless labeled with the same letter ( $p < 0.05$ ).  
Peak flow rate = 60 L/min.

## A395

**TITLE:** PREVENTION OF CAUTERY-INDUCED FIRES WITH SPECIAL ENDOTRACHEAL TUBES

**AUTHORS:** Mitchel B. Sosia, M.D., Ph.D.,  
Berton Braverman, Ph.D.  
Anthony D. Ivankovich, M.D.

**AFFILIATION:** Rush-Presbyterian-St. Luke's Medical Center, Chicago, Illinois

In common with complications of laser airway surgery, the surgical cautery may ignite combustible endotracheal tubes during these cases. This investigation was designed to determine whether commercially available endotracheal tubes designed for use with the CO<sub>2</sub> laser are resistant to electrocautery induced combustion.

Six types of endotracheal tubes were examined in this investigation: (1) Sheridan (Argyle, New York) size 7.5 mm ID polyvinylchloride endotracheal tubes; (2) Rusch red rubber (Germany) 7.0 mm ID endotracheal tubes; (3) Phycon (Fuji Systems, Tokyo, Japan) 8.0 mm I.D. silicone/ceramic endotracheal tubes; (4) Xomed (Jacksonville, Florida) 6.0 mm ID silicone Laser Shield™ endotracheal tubes; (5) Bivona (Hammond, Indiana) 4.0 mm ID laser endotracheal tubes; (6) Mallinckrodt (Glens Falls, New York) 5.5 mm ID Laser Flex™ endotracheal tubes. The endotracheal tube under study was connected to a source of 5 liters-minute<sup>-1</sup> of oxygen and rested on wet towels in air during the investigation. A hand held cautery (no. 11311, Concept, Inc., Argo, Illinois) was applied perpendicularly to first the shaft and then the tip of the endotracheal tube being tested. It was activated until combustion had occurred or 2 minutes had elapsed.

A blowtorch fire occurred after 5.0 and 14.2 seconds of cautery application to the shaft and tip respectively of the polyvinylchloride endotracheal tube. The times to ignition of the red rubber endotracheal tube were 51.0 and 3.1 seconds for the shaft and tip respectively. No effect was noted after 120 seconds of cautery application to the shaft of the Phycon endotracheal tube. However, a blowtorch fire occurred after 9.2 seconds when the cautery was applied to the tip of the Phycon tube.

No combustion was seen during either trial evaluating the Xomed endotracheal tube. However, a small pit was noted at the point of cautery application to the shaft of this tube. Two minutes of cautery application did not cause combustion of the shaft of the Bivona endotracheal tube. The cautery did, however, cause superficial damage to the silicone covering of its shaft. When the cautery was applied to the tip of the Bivona endotracheal tube, a blowtorch fire occurred after 1.3 seconds. The shaft of the stainless steel Mallinckrodt endotracheal tube was unaffected by 120 seconds of cautery application. Its tip, however, constructed from polyvinylchloride, was ignited after 3.9 seconds, and a blowtorch fire occurred.

The occurrence of cautery induced endotracheal tube fires (1-3) suggests that special endotracheal tubes and techniques be used when the cautery is used near the airway. Our results show that under the conditions of this experiment, the Xomed Laser Shield™ endotracheal tube was the only one in which a fire could not be started on either the shaft or tip. However, a more powerful cautery might ignite this tube, as has been done with the CO<sub>2</sub> laser.

## References:

1. Simpson JI, Wolf GL: Endotracheal tube fire ignited by pharyngeal electrocautery. *Anesthesiology* 65:76-77, 1986.
2. Bowdle TA, Glenn M, Colston H, Eisele D: Fire following use of electrocautery during emergency percutaneous transtracheal ventilation. *Anesthesiology* 66:697-698, 1987.
3. Bailey MK, Bromley HR, Allison JG, Conroy JM, Krzyzaniak W: Electrocautery-induced airway fire during tracheostomy. *Anesth Analg* 71:702-704, 1990.