THE AIR FLOW RESISTANCE PROFILE OF THE UNIVERSAL AIRWAY CIRCUIT CAP CONNECTOR (TIBBLECAP™) COMPARED TO VARIOUS ENDOTRACHEAL TUBE SIZES

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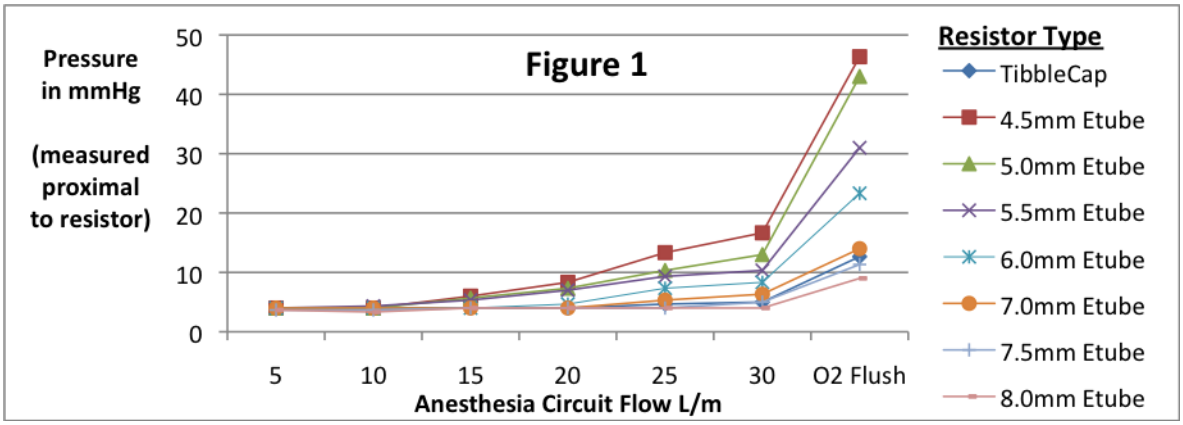
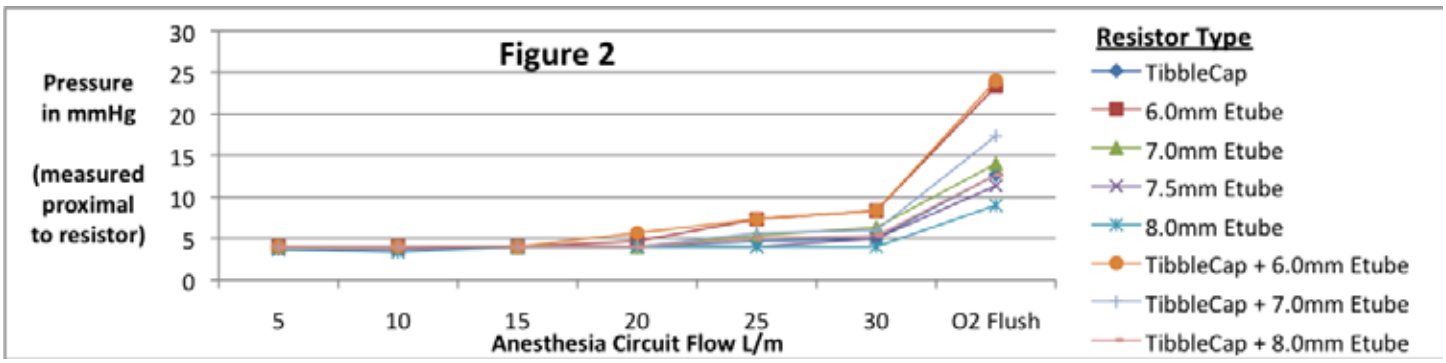
Background: The TibbleCap™ (ActMD Inc., San Diego, CA) is a novel universal airway circuit cap connector that allows "classic" style laryngeal masks to function as intubating conduits, provides life-saving oxygen through the outer cannula of a tracheostomy, doubles as a replacement endotracheal tube cap, and finally, simplifies transtracheal jet ventilation[1]. Upon first examination of its structure, the practitioner often voices legitimate concerns regarding the air flow resistance imparted by the TibbleCap™ . In this study, the resistance profile of the TibbleCap™ is compared to various endotracheal tube sizes. Using Ohm's law that resistance is directly related to the change in pressure divided by flow ($R=\Delta P/Flow$)[2], a proximal pressure created by each resistor was measured at identical air flow rates to obtain resistance profiles for each tube or cap.

Materials and Methods: After passing a machine check-out, a Datex-Ohmeda™ Aestiva (model 17002-EX) anesthesia machine was attached to a standard circle system and set to hand ventilation mode. The pop-off valve was closed and the bag port was occluded, thus negating the compliance of the breathing bag, and keeping all air flow within the competent circuit. An arterial line pressure transducer was connected to the Y piece at the CO2 connection port. Identical airflows determined by flowmeters (5, 10, 15, 20, 25, 30 Liters/min) and the O2 flush valve (oxygen direct to breathing circuit from central oxygen supply after passing first stage regulator) were run through the TibbleCap™ and assorted Mallinckrodt™ endotracheal tube sizes. The proximal ends of the resistors were connected to the anesthesia circuit at a secured location just above the transducer. The distal ends were left open to air/atmospheric pressure. Each flow rate was maintained for 30 seconds and the proximal pressures transduced by the arterial line were recorded and verified by two authors and two independent observers. Three trials were taken at each flow rate and averaged.

Results: The novel universal airway circuit cap connector (TibbleCap™) demonstrates a resistance profile between that of a 7.0mm endotracheal tube and a 7.5mm endotracheal tube (Figure 1). Additional data (Figure 2) showed that a TibbleCap attached to a 6.0mm tube creates pressures similar to a plain 6.0mm endotracheal tube. The TibbleCap attached to a 7.0mm tube mirrored the pressures between a 6.0mm and 7.0mm tube. Finally, the TibbleCap attached to an 8.0mm tube shows a resistance profile nearly identical to the TibbleCap alone (between a 7.0mm tube and a 7.5mm tube).





Discussion: Previously well-founded principles such as Bernoulli's effect and turbulent air-flow characteristics are demonstrated in this study. Increased pressure/potential energy is seen proximal to each resistor (Bernoulli); and pressure increases exponentially rather than linearly with increased flow, indicating that flow through the resistor is turbulent (turbulent flow: $\Delta P \propto Flow^2$).

References:

1. Tibble A, Lee A, Mazzei W, Benumof J. A Universal Airway Circuit Cap Connector (TibbleCap). Abstract Submission. Society for Technology in Anesthesia – Anesthesia & Analgesia. January 2011.
2. Schwartzstein R. Respiratory Physiology: a clinical approach. Lipincott Williams & Wilkins. 2006. Pg 62.