An in vitro evaluation of endotracheal tube cuff leak and suction performance using a bio-realistic model

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Background
Endotracheal tube (ETT) design may influence mucus clearance and nosocomial respiratory infections in intubated patients.

Objectives
The aim of this study was to evaluate the cuff seal and suction performance of commercial ETTs using a ventilated, bio-realistic mouth-trachea (MT) model.

Methods

Bio-realistic model
The MT model was developed from CT data of the tracheal airway of an adult male and prototyped in a viscoelastic material to match reported pressure/volume tracheal response.

Cuff seal
ETT cuff seal was assessed for the KIMVENT Microcuff, TaperGuard, and Sheridan HVT (SHVT). The model, angled 30° above horizontal, was intubated and ventilated using heated, humidified air. 5mL 0.25% Polyox (Dow Chemical), with salivary consistency, was inserted and return tidal volume (rVT) and percent leak of simulant were measured at different cuff and PEEP pressures.

Suction performance
TaperGuard EVAC and ISIS/HVT were evaluated at low, continuous pressures (15 and 20 mmHg) and at high, intermittent pressures (100 and 120 mmHg). Suction efficiency was determined by time to clear 7ml 0.5% Polyox solution and was evaluated in supine and lateral (rotated 90°) positions. Any inward deviation of the posterior tracheal wall during suctioning was noted.

Results

I. Cuff seal
Figure 2. SHVT had more simulant leak at cuff pressure of 5 cmH2O with zero PEEP. This was the only condition that the ETTs leaked.

II. Suction performance
Figure 4. Low continuous pressure of 20 mmHg was faster in clearing simulant than 15 mmHg. High, intermittent suction was significantly faster compared to low, continuous. There was no significant differences in 100 and 120 mmHg pressures.

Discussion

Cuff seal
• No secretion leak past cuff until 5 cmH2O cuff pressure with zero PEEP. SHVT leaked significantly more (Fig 2).
• No ETT models had secretion leak with 10 cmH2O cuff pressure, below clinically recommended.
• No simulant leak at low cuff pressures when PEEP increased to 5 cmH2O (Fig 3). Thus, higher PEEP allows for lower cuff pressure without compromising seal.
• Higher cuff pressure was needed to maintain ≥80% rVT at higher PEEP levels. The KIMVENT Microcuff and TaperGuard could maintain a better air seal (Fig 3).

Suction performance
• High, intermittent pressure aspirated secretions more rapidly than low, continuous pressure in both ETT models (Fig 4).
• ISIS/HVT was more effective with low, continuous pressure in the lateral position compared to the TaperGuard EVAC (Fig 5).
• There was no difference in ETT performance with high, intermittent suction in either position (Fig 4).
• More frequent tracheal occlusion was noted with the ISIS/HVT at this high pressure, however suction was never compromised.
• To maximize speed and minimize tracheal damage, suctioning with low, continuous pressure in the lateral position was best for both ETT models.

References