Abstract

Background:
Reducing the risk of VAP is a major priority among healthcare facilities. Many ideas have been postulated to reduce VAP including modification of the ETT. Our facility switched from the Mallinckrodt Hi-Lo Evac® tube with a barrel-shaped polyvinyl chloride (PVC) cuff, to the Kimberly-Clark Micro-cuff™ tube which incorporates an elongated barrel-shaped polyurethane cuff (PUC). We were then presented with the new Mallinckrodt Sealgard™ tube which uses a novel tapered-down PUC. We then evaluated the cuff for leakage of subglottic fluid in these three branded ETTs.

Methodology:
A bench-model was achieved by using a mechanical ventilator (1.0L VT, RR = 10), lung simulator and simulated trachea made from a clear plastic tube with a 25mm ID. The ETT was placed in the simulated trachea and its cuff inflated to 30 cmH2O. The lung simulator was attached to the simulated trachea below the ETT. Five ml’s of blue-dyed water was instilled above each cuff and observed for 30 seconds prior to applying ventilation for a total of 3 minutes. We evaluated the Hafo® Sealgard™, Hi-Lo Hi-Lo Evac™, and the Hafo® and 9.0 Micro-cuff. Each ETT was tested 3 times and evaluated for visual leakage below the cuff before and during mechanical ventilation.

Results:
The Micro-cuff exhibited no visible leakage during each facet of testing. The remaining ETTs all had leakage. Interestingly, the Sealgard had a larger OD and cuff diameter than the Micro-cuff yet leaked all 5 ml’s of fluid in each of its 3 evaluations.

Conclusion:
It appears the PVC cuff creates greater folds or channels, which allow subglottic fluid leakage. The thinner PUC material appears to resist this channeling, thereby reducing leakage and potential microaspiration. Additionally, by using a tracheal model sized on the upper end of normal, we fed that cuff shape and overall surface area contact with the tracheal wall are contributing factors for leakage as well. The elongated PUC outperformed the new tapered-down PUC design in our testing model.

Methodology

Our bench-model was achieved using a Michigan Instruments Lung Simulator (5600i Dual Lung TTL) attached to a Puritan Bennett 7200 Ventilator with the following settings: VT: 1.0L, RR: 10, PEEP: 0, Flow: 60 lpm. A 25mm ID simulated trachea (coronal measurements consistent with normal anatomy) was made from a clear plastic tube (Pic. 1). The lung simulator (Compliance: 0.05 L/cmH2O and Resistance: 93 cmH2O/L/sec) was attached to the simulated trachea below the ETT (Pic 1). This scenario permitted simulated ventilation while simultaneously assessing for fluid leakage past the cuff.

Prior to insertion, each ETT cuff was inflated with 25cc of air to verify cuff integrity. After insertion of the ETT, each cuff was inflated with 25cc of air and then deflated via Porey Cufflator™ to a pressure of 30 cmH2O. Five milliliters of blue-dyed tap-water was instilled above each cuff and observed for 30 seconds prior to applying ventilation for a total of 3 minutes. We evaluated the Hafo® Sealgard™, Hi-Lo Hi-Lo Evac™, and both an Hafo® and 9.0 Micro-cuff™. Loc numbers were matched for each group of three tubes. Each tube was tested 3 times and evaluated for visual leakage below the cuff, before and during mechanical ventilation. Visible leakage was defined as any fluid leakage “visibly evident” in either the channels or below the cuff.

Conclusion

Realizing that strategies for decreasing VAP are difficult to quantify in many respects, we believe that our bench test demonstrated cuff performance to be at least one factor with a potential for positive outcomes. Our tracheal model is not without shortcomings. The human tracheas would clearly exhibit some level of dissimilarity that was not duplicated in this test. Oropharyngeal secretions are typically thicker than water; meaning that the increased viscosity might also reduce the potential for leakage or microaspiration. Although our tracheal model was sized on the upper end of normal; we noted that cuff shape and overall surface area contact with the tracheal wall contribute to the success or failure of the cuff itself. Clearly, in vivo clinical studies would address these questions.

Our bench model, while limited, demonstrates the issues inherent to cuff design. The elongated, barrel-shaped PUC cuff appears to outperform both the tapered PUC and the PVC cuff in this testing model.

References