Coaxial Endotracheal Tube for Single Lung Ventilation

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Abstract

I. Introduction

Thoracic surgery and broncospirometry require single-lung ventilation to keep the patient alive. There are two current devices used to perform single-lung ventilation: the bronchial blocker and the double lumen endotracheal tube. Both devices have intricacies that complicate the surgical technique. The bronchial blocker requires the use of a guide loop while the double lumen tube requires swivel ports and a Y-connector to provide single-lung ventilation. This paper will propose a new coaxial tube design that attempts to streamline the existing designs. The study will determine the feasibility of the coaxial tube design and whether it can provide proper ventilation while decreasing the overall endotracheal tube size.

II. Design

A typical intubation procedure for single-lung ventilation involves the insertion of a tube through the trachea and into the left or right mainstem bronchus as shown in Fig. 1. Auscultation and fiberoptic bronchoscopy are techniques used to determine proper placement of the tube. Once confirmed, the cuffs are slowly inflated. The coaxial endotracheal tube design utilizes the same technique. For double-lung ventilation, the internal balloon remains at the deflated state. This allows air to flow through the two windows and the inner tube. When the balloon is inflated, the air flows through the annulus and blocks the windows, thus achieving single-ventilation with air flow through the inner tube only. The concept is depicted in Fig. 2.

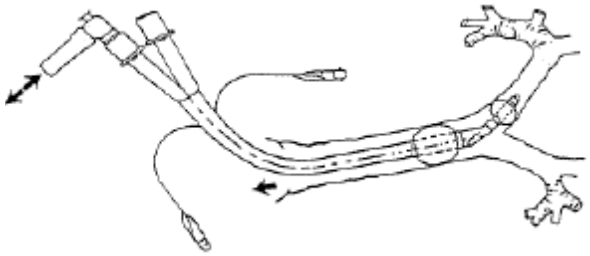

Fig. 1. Typical placement for a double-lumen endotracheal tube. [1]

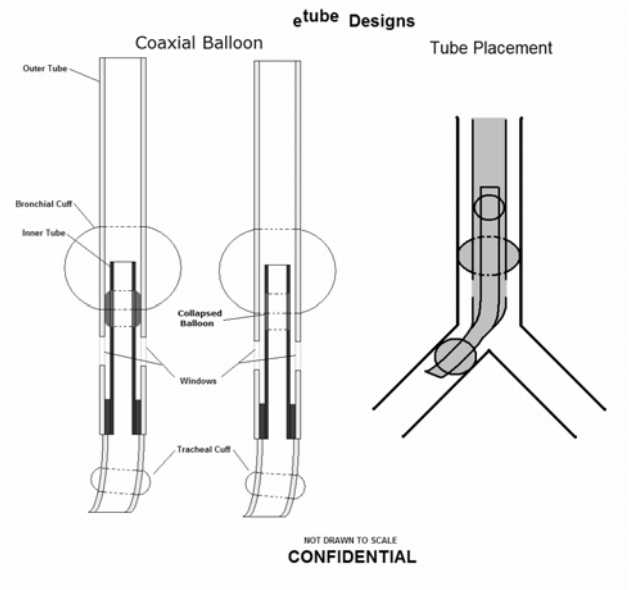

Fig. 2. The Coaxial Endotracheal Tube design.

III. Methods

Three coaxial endotracheal tube prototypes were created using a 9 mm endotracheal tube as the outer tube and a 4.5 mm as the inner tube. These were tested on a 90 degree bend-testing fixture. Kinking and un-kinking effects were analyzed using the setup. Various stability tests were also performed on the prototypes to examine proper air pressure and airtight seal. The prototype was connected onto a pediatric ambu bag and the distal end was attached to a mock lung and pressure gauge. The pressures were recorded and compared to normal values. In addition, fatigue tests were conducted to examine the reliability of the product. The internal balloon was subjected to 25 cycles of inflation/deflation and the air flow was measured after each cycle. Finally, an inflated internal balloon was tested to determine how much air leaked after 10 hours.

IV. Results

Initial tests have shown the design provides both an airtight seal and proper pressure values, required for single and double-lung ventilation. No significant fatigue in the internal

balloon and the coaxial tubes were observed. All prototypes passed kinking as well as a ten hour air leak test. Further testing will confirm the results of the initial tests. Exact values will also be determined once thorough secondary testing is fully completed.

V. CONCLUSIONS

These results indicate that the coaxial endotracheal tube design passes stability, reliability, and ventilation test protocols permitting proper single and double-lung ventilation. In addition to satisfying ventilation requirements, this design also simplifies the surgical technique compared to the current bronchial tubes. The simplification reduces intubation time and gives the coaxial endotracheal tube design an advantage that may provide both a safer and simpler means of providing single-lung ventilation.

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[1] Russell, W. John. "Insertion of a Double Lumen Tube." http://www.usyd.edu.au/su/anaes/lectures/dlt.html. May 17, 2000.