2016

Sensing Movement in Endotracheal Tubes

Mary Anisa Kannan
Virginia Commonwealth University

Krista Powell
Virginia Commonwealth University

Navami Ravindra
Virginia Commonwealth University

Tiffany Wong
Virginia Commonwealth University

Team Members: Mary Anisa Kannan, Krista Powell, Navami Ravindra, Tiffany Wong

Faculty Adviser: Dr. Paul A. Wetzel

BIOMEDICAL

Sensing Movement in Endotracheal Tubes

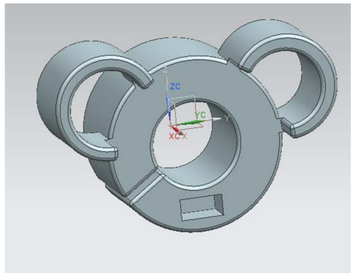
CAPSTONE DESIGN EXPO 2016

Problem

Intubation involves placing an endotracheal tube (ETT) in the trachea to open the airway for ventilation. In the U.S., about 200,000 intensive care patients experience an accidental extubation, which occurs when the ETT moves from its correct position in the trachea. This leads to a host of secondary conditions, increased hospitalization time, and increased cost for hospitals.

Solution

Our device aims to improve ETT securement, measure displacement, and notify caretakers when a dangerous amount of displacement has occurred.



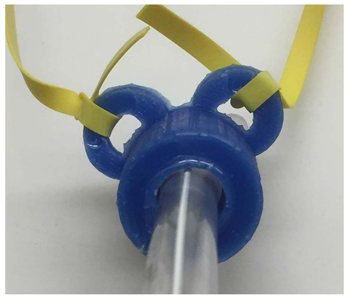


Figure 1: The CAD model and the final molded bite-block holder. Key features include: a slit for placing the device around the ETT, rectangular depression for the sensor, and head strap holders.

Future Plans

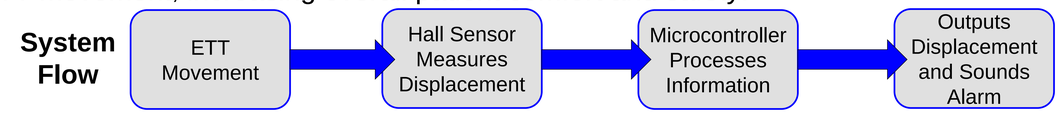
Future plans include a wireless solution to increase portability, an exterior antimicrobial coating to decrease bacteria accumulation, and consideration of wall port electrical safety measures to ensure patient safety.

Design

The small size and flexibility of the device allows for regular mouth care and limits soft tissue contact to decrease the formation of oral pressure ulcers. The tape around the tube secures the ETT to the device, limiting movement away from the head and increasing the accuracy of displacement sensing. The bite block is composed of a non-toxic, phthalate-free polyurethane that is flexible yet durable enough to withstand stresses.

The bite block houses a linear output, ratiometric Hall Effect sensor, which was chosen for its small size, inexpensiveness, and ability to change voltage output based on magnetic field strength. The sensor is located at the bottom of the bite block and is in close proximity to the magnet placed directly under the mouth.

The visual and auditory alarms incorporate human factors engineering to optimize usability for healthcare providers. The sensing mechanism will alert healthcare providers of unwanted ETT movement, increasing overall patient comfort and safety.



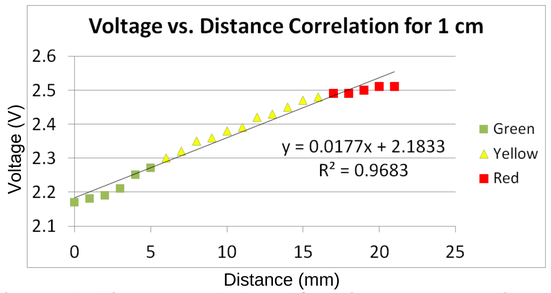


Figure 2: The magnet was placed 1 cm away from sensor. Linear regression was performed to determine the correlation and used for programming the Arduino.
Green: 0 - 5 mm
Yellow: 6 mm - 16 mm
Red: 17 mm or more, buzzer sounds

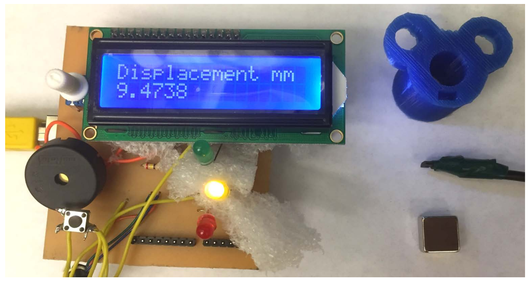


Figure 3: All circuitry, including LEDs and buzzer, were soldered onto an etched board, which shields the Arduino. Testing revealed that the LEDs and buzzer functioned properly, and that the correct displacement values were displayed after programming.

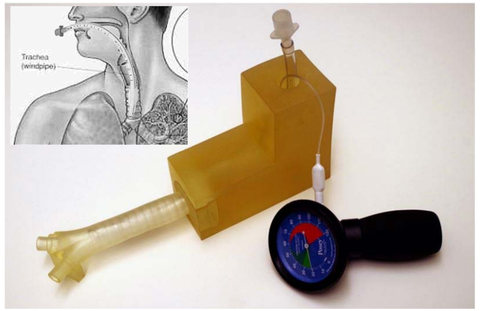


Figure 4: Biorealistic trachea model with inserted ETT. The model was used for initial understanding of ETT placement and device visualization.

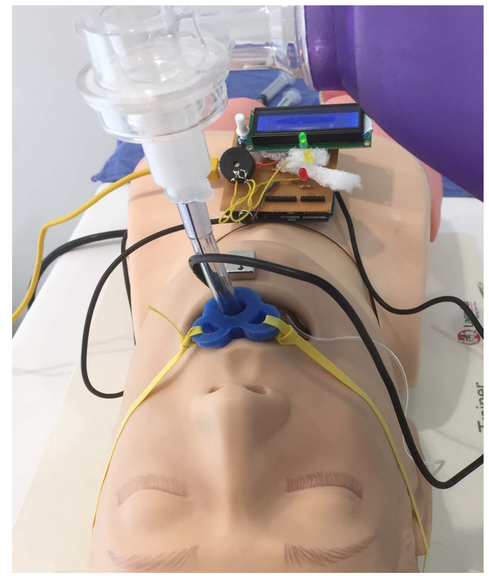


Figure 5: Device testing on an intubation dummy at the VCU Simulation Lab.

Our team would like to thank our advisor, Dr. Paul Wetzel, Dr. Curtis Sessler (Department of Internal Medicine), Mr. Matt King (School of Arts), Mr. Ted Carter from the VCU Simulation Lab, Dr. Worth Longest (Mechanical Engineering), and the VCU School of Engineering.

Reference: (1) Walenga, R.L., Longest, P.W., Sundaresean, G. (2014). Creation of an in vitro biomechanical model of the trachea using rapid prototyping. (2) Endotracheal tube sensor, US 20110031961 A1.