3D Printing Airway Trainers

Design Excellence Executive Summary

Lance Johnson, Dan Altschuler, Cody Kryzer, Matt Sheridan, Elle Thom

Background

Emergency airway management is crucial during instances of respiratory distress, as clinicians have, on average, 15-30 seconds to secure an airway before possible onset of hypoxia and brain damage. According to Maguire et al. 2023, 400,000 intubations occur in the United States each year, with 12.7% of them failing on the first attempt. Failure on the first attempt to intubate has been linked to severe complications from lack of oxygen. Since the amount of endotracheal intubation experience is directly correlated with successful intubations, it is crucial to provide ample practice material for medical practitioners.

Existing Products

While there exists a wide range of airway trainers on the market, these trainers typically provide a more narrow training experience for all practitioners. For practice on difficult airways, there are significantly fewer products available. The Decent Simulators trainer retains normal facial structure and anatomical design while including significant modularity in their design. Decent Simulators trainers also include crucial landmarks in the upper airway with vocal cords and an epiglottis. However, a trainer costs around $1,700, which is significantly more expensive than what our current design process costs.

Design

The final design outlines the process to deliver a highly-personalizable and adjustable airway trainer on which health professionals can practice intubation. The process starts with preoperative MRI scanning of the patient's airway and manual inspection of the airway to determine and locate difficulties. The design is based off of a generic airway trainer made with open source files, and the difficulties found in preoperative scanning are used to make modulations. The first of these modulation techniques is an adjustable vocal cord slide with varying shapes and stiffnesses. This is done by adding a negative into the model where the existing vocal folds are, allowing insertion of varying slides simulating laryngitis, vocal cord palsy, nodules, etc. Another modulation is the adjustable jaw, which hinges and locks in certain positions to emulate overbites, underbites, and limited jaw mobilities. Lastly, the trainer has balloons emerging into the upper airway cavity that can be inflated to create growths that impede the intubation process. The adjustability of this trainer in the hands of anaesthesiologists who can accurately diagnose difficult airway features, will create a powerful tool for personalized intubation practice. This design will be tested by healthcare students and professionals of varying abilities to ensure it is effective and improves on existing designs.

Impact

Medical practitioners will perform intubations with a higher success rate after having practiced on an adjusted trainer that accurately models the difficulties of the airway at hand. The final design allows for professionals to have hands-on experience, which is invaluable in the medical field, prior to performing surgery. Problems like hypoxia and airway trauma are less likely to occur with the implementation of this device. This allows for surgeons and patients to be safer and more confident navigating procedures.