3D Printing Airway Trainers

Design Excellence Executive Summary

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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. 7-Sigma makes different airway management training tools, but these trainers lack significant modularity that can make them useful for medical practitioners beyond very specific use cases. One of these trainers also costs around $2000, which can price out certain potential clients that require many different airway trainers to practice on.

Design

The final design outlines the process to deliver a highly-personalized airway trainer on which health professionals can practice intubation. The production process begins with a CT/MRI scan of a patient's airway. Using 3D Slicer, the portion of the airway from just above the epiglottis to the split of the trachea at the carina is segmented. This involves using a gradient threshold to generate a 3D model of all of the air in the airway, cleaning this up with cutting and smoothing features on 3D Slicer, and generating a shell of tissue around this air. The shell is then exported as an STL mesh where it is converted to a .3mf file using AutoDesk Fusion360 by rebuilding the file as a solid object so it can be 3D printed. The file is then 3D printed using Formlabs Flexible 80A Resin once the appropriate supports are added using the PreForm software. Once printed, the airway is installed into the training manikin. The manikin represents an ideal trainer for airway management of a difficult airway. The integration of an anatomically accurate airway into an airway manikin presents a unique and repeatable process through which health professionals can gain valuable training experience. Its durability was measured via repeated intubation with focus given to the connection points and overall material damage. This design can 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 with a 3D printed model that is an accurate representation of the abnormal 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.