3D Printing Airway Trainers

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Problem Statement

- Airway management is an integral part of stabilizing a patient in many medical environments
- While training medical practitioners with simple airway trainers can improve patient outcomes, these trainers can cost upwards of $1700 [1]
- 3D printing to create modifiable and difficult airway manikins would assist medical professionals to practice airway management skills

Intubation & Airway Trainers

- Clinicians typically only have on average 15-30 seconds to secure an airway before possible onset of hypoxia and brain damage [2]
- 50% of intubations on difficult airways fail on the first attempt in emergency settings [2]
- The failure to successfully intubate a patient on the first attempt leads to a 33% increase in likelihood for patients to experience complications from lack of oxygen [2]
- The amount of clinician endotracheal intubation experience is directly correlated to patient outcomes [3]
- The process of using medical imaging to diagnose airway difficulties will assist manikin modification while familiarizing the clinician with the airway

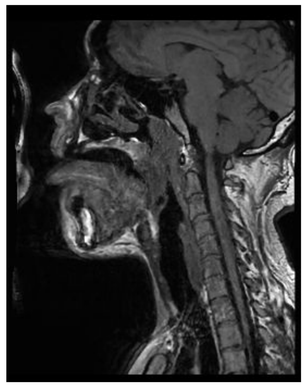

Figure 2: Volunteer Airway MRI

Figure 1: Decent Simulators Trainer [1]

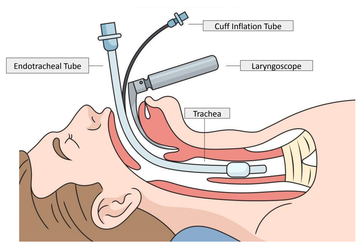

Figure 3: Tracheal Intubation [4]

Design Specifications

- The airway trainer materials should withstand 20,000 intubation cycles to be comparable with other trainers on the market [5]
- The overall price should be kept under $200 to reflect the affordability of 3D printing and allow the design to be effectively marketed
- The final trainer should have general anatomical accuracy, with alterations allowing anatomy to be specific to most patients
- Difficulty adjustments should be quick and intuitive
- The final trainer should pose moderate to extreme difficulty to the user, without reflecting unrealistic intubation conditions

Final Design

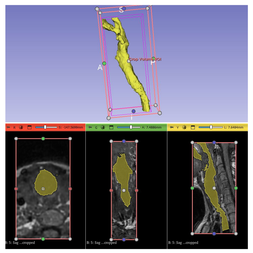

Figure 4: Patient Imaging

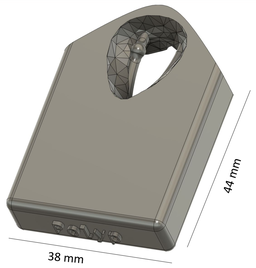

Figure 5: Insert Isometric View

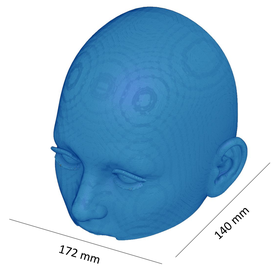

Figure 6: Manikin Face

Figure 7: Silicone Mold Casting

Figure 8: Airway Manikin Prototype

Testing

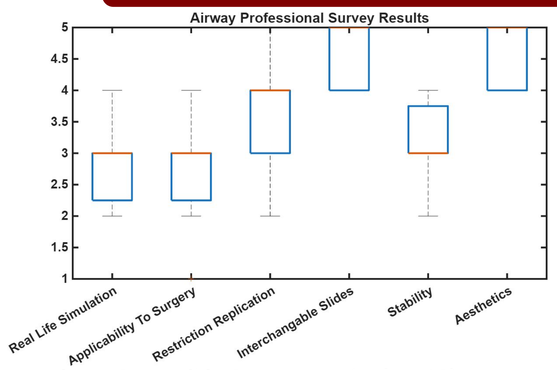

Figure 9: Manikin Survey Results (n = 10)

- Airway professionals at the UW Health Department of Anesthesiology practiced intubating using:
  - Varied neck angles
  - Three airway slides
- Results were generated from feedback collected through a form after intubation

- Four team members conducted repeated intubation on the manikin at varying angles
- Mean intubation time was calculated and plotted versus neck flexion angle
- Suggests a trend toward increased intubation time at extreme flexion angles, though not consistently significant across participants

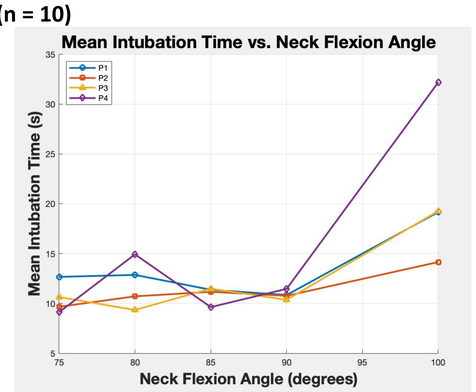

Figure 10: Time to Intubate Results

Results & Conclusions

- **Positive Professional Feedback**
  - Everything is in the correct anatomical position
  - The visuals are very accurate, especially the vocal cord inserts
  - The motions required are similar to real life intubation
  - Very cost effective
- **Negative Professional Feedback**
  - The extreme flexibility of the soft tissue makes intubation simpler
  - The head should be heavier to reflect accurate intubation in practice
  - There should be force required to open the mouth
  - Some airway inserts cannot be intubated
- **Time to Intubate**
  - There was a direct relationship between neck angle and user intubation time, where increasing the neck flexion angle increased the time to intubate
  - There was a steep learning curve during time to intubate testing as the blocks were adjusted to modify the neck flexion angle
- **Conclusions**
  - Neck flexion angle is a crucial aspect of modulating airway management diffiulty

Discussion & Future Work

- **Accomplishments**
  - Created a cost-effective, adjustable airway trainer capable of mimicking various difficult airway features
  - Developed interchangeable vocal cord inserts that accurately represent different vocal cord afflictions
  - Manikin in current state could be reasonably utilized as a supplemental trainer for airway management professionals
- **Drawbacks of Current Design/Process**
  - Tradeoff between accurate vocal cord visuals and the ability to pass ET tube through the insert
  - Creating pseudo-patient specificity relies on physical assessment, medical imaging, and specific 3D printing filaments, all of which are expensive
- **Future Work**
  - Create variations of the silicone airway to modulate glottis location
  - Incorporate a mechanism to keep the head and jaw in a flexed position that requires user force to extend the neck and access the airway
  - Add features for modularity in tongue size and tooth sensitivity

References

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