Innovations in Airway Training: 3D Printed Pediatric Needle Cricothyrotomy Trainers

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Introduction

Airway management is a critical skill in emergency medicine. Residents obtain plenty of practice with endotracheal intubation, but some may never perform advanced airway maneuvers such as open cricothyrotomy or needle cricothyrotomy. Fortunately, simulation has provided a platform for practicing these rare procedures. Studies have shown better performance of skills that are simulated[1]. Expert panels, academies, and committees also agree that simulation is an important aspect of resident education in emergency medicine, especially for rarely performed procedures[2].

Open cricothyrotomy has long been practiced via simulations[3]. Several journals have provided examples of reconstructing low cost models for simulation[4,5]. Several commercial products are also available that provide a high fidelity experience, although this usually comes with a higher cost[6,7,8].

While open cricothyrotomy is a staple in simulation, needle cricothyrotomy is rarely simulated. Despite rarely being practiced, it remains a relevant procedure that emergency physicians should be able to perform. There is a lack of literature in education and simulation journals describing ways to provide this training through simulation, which could be reflective of the trend away from needle cricothyrotomy in adult patients. Needle cricothyrotomy, however, remains the standard of care in pediatric patients who present in a can't intubate, can't ventilate scenario. Typically, this is in the setting of severe anaphylaxis or trauma. Stopyra et al showed a 71% increase in confidence performing needle cricothyrotomy when EMS providers were able to simulate the procedure for an anaphylactic 3 year old[9]. Given it's relevance to this population, residents should continue to train for this procedure. As it is a rare procedure, simulation offers a perfect environment to practice.

We present an innovation in airway management that will allow emergency medicine residents to practice needle cricothyrotomy, as well as open cricothyrotomy, through a range of ages from neonatal to adult. We aim to improve resident knowledge of this rare procedure through an easy to reproduce, high fidelity model. Using 3D printed laryngotracheal models, needle and surgical cricothyrotomy can be practiced on a variety of anatomically different models. This practice will allow residents to feel comfortable performing this procedure if the occasion were ever to arise in real practice.

Objectives

1. Discuss indications for needle cricothyrotomy in the pediatric population.
2. Understand the equipment needed to complete a needle cricothyrotomy.
3. Performance needle cricothyrotomy.
4. Understand and demonstrate open cricothyrotomy in adolescent patients.
5. Discuss post-procedure ventilation options.

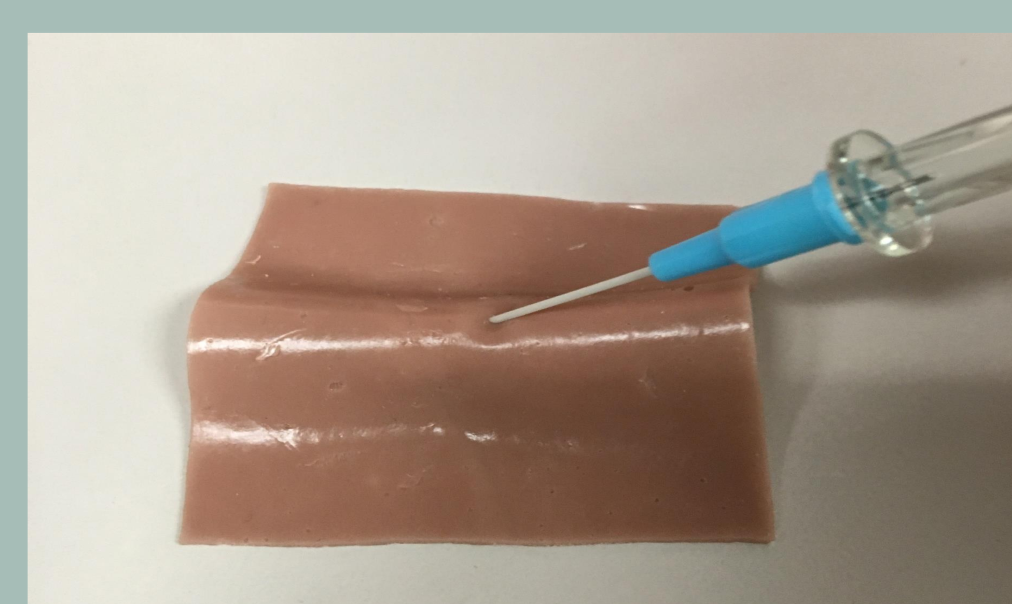
Supplies

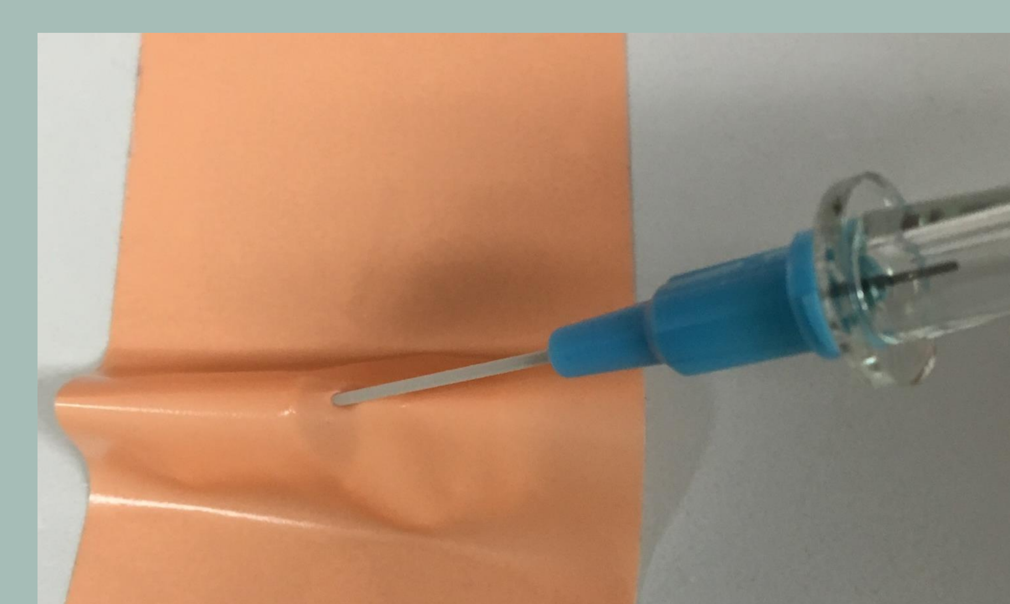
- 3D printer
- Airway App STL file
- Sim skin
- Angiocatheters
- 10cc saline flush
- 3 ml syringe
- 3.0 ET tube
- 7.0 ET tube
- Bag valve mask

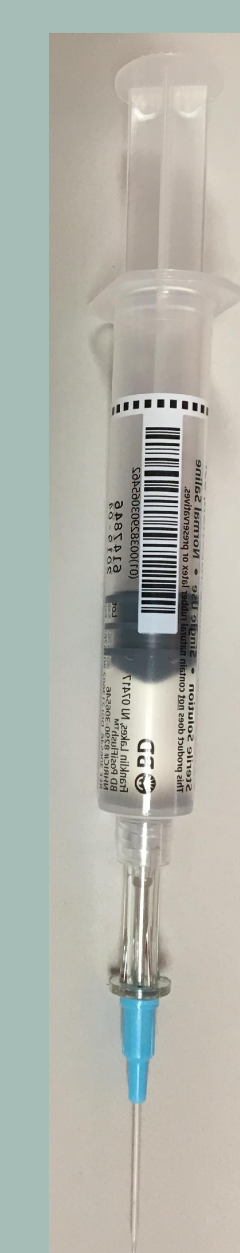
Cricothyrotomy Trainers and Membrane Dimensions

Trainer	Height (mm)	Width (mm)
Adult	15	17
Early Adolescent	7	10
School Aged	6	9
Neonate	4	5

Neonatal model demonstration: sim skin vs skin tape







Sim Skin

Skin Tape

Methods

In conjunction with the OhioHealth Simulation Department, a 3D printer was obtained for this project. Cricothyrotomy trainers had previously been purchased from The Airway App, a company specializing in airway management education. The company also allows for downloading of an STL (standard template library) file which contains code for 3D printing the cricothyrotomy trainers they sell online. We obtained this code, and began making changes to scale in order to create a smaller model that would resemble neonatal, school aged, and teenaged patients.

We used a paper published by Navsa et. al in 2005 to obtain anatomically accurate measurements of neonatal cricothyroid membranes. In their paper, 27 cadavers underwent dissection for cricothyroid membrane measurement. Their results showed that, on average, the cricothyroid membrane in these neonates measured 2.61 mm in height and 3.03 mm in width[10]. Scale models were created based on these measurements. Future models will include changes to the angulation of the trachea and cricoid to more accurately resemble neonatal anatomical structures. A tape measure was used to estimate cricothyrotomy dimensions in order to ensure anatomic validity. Once the neonatal trainers were created, several other trainers were created at various scales in order to simulate a variety of ages including school aged and adolescent airways.

Once our trainers were 3D printed, simulations stations were created for residents to use. This was simple and involved covering the trainers with simulation skin in order to hide the underlying structures. This set up will allow residents to practice needle cricothyrotomy, as well as open cricothyrotomy in all age groups from neonates to adults.

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