The Journal of Emergency Medicine, Vol. 56, No. 4, pp. 426–430, 2019

0736-4679/$ - see front matter

https://doi.org/10.1016/j.jemermed.2018.12.023

Techniques and Procedures

THE REAL CRIC TRAINER: INSTRUCTIONS FOR BUILDING AN INEXPENSIVE, REALISTIC CRICOTHYROTOMY SIMULATOR WITH SKIN AND TISSUE, BLEEDING, AND FLASH OF AIR

Jonathan Kei, MD, MPH,* Donald P. Mebust, MD,* and Laura V. Duggan, MD†

*Department of Emergency Medicine, Kaiser Permanente Medical Center, San Diego, California and †Department of Anesthesiology, Pharmacology and Therapeutics, University of British Columbia, Vancouver, British Columbia, Canada

Corresponding Address: Jonathan Kei, MD, MPH, FACEP, Department of Emergency Medicine, Kaiser Permanente San Diego Medical Center, 4647 Zion Ave, San Digeo, CA 92120

☐ **Abstract—Background: Surgical cricothyrotomy is a rare procedure but it must be mastered by any physician who is involved in advanced airway management. Lack of experience and practice, the high-stress nature of a "can't intubate, can't oxygenate" emergency, and the unavailability of realistic simulators all contribute to physician hesitance and inaptitude while employing cricothyrotomy during difficult and failed airways. The REAL CRIC Trainer was created to alleviate some of the barriers surrounding a surgical airway. It is designed to provide the user an affordable, easy to replicate, reusable, and extremely realistic experience in cricothyrotomy to prepare for this rare event. Discussion: The REAL CRIC Trainer uses a 3-dimensional printed tracheal model that is covered with pork belly skin, replicating human neck tissue. Red dyed normal saline is connected to the pork belly using intravenous tubing to simulate bleeding as an incision is made into the porcine skin. A bag-valve-mask connected to an endotracheal tube and to the trachea model will simulate breathing and replicate the puff of air experienced as the cricothyroid membrane is pierced with a scalpel. This simulator is cost effective and easy to replicate. Detailed step-by-step instructions are provided so that physicians working in any specialty involved in advanced airway management can easily recreate this trainer. Conclusions: This simulator makes it practical for physicians in a variety of clinical settings to incorporate its use into regular practice sessions, thereby assuring that physicians are ready to perform an emergent cricothyrotomy if necessary.** © **2018 Elsevier Inc. All rights reserved.**

☐ **Keywords—airway; cricothyrotomy; education; procedure; simulation; trainer**

Reprints are not available from the authors.

INTRODUCTION

Cricothyrotomy is an essential skill to master for all health care providers who are engaged in advanced airway management. Studies have shown that approximately 1% of all attempted tracheal intubations in emergency medicine fail and ultimately require an emergent surgical airway (1). Physicians encountering a "can't intubate, can't oxygenate" scenario may be required to perform a cricothyrotomy (2). However, physicians are often hesitant to initiate a cricothyrotomy, in part because of a lack of familiarity with this rare yet life-saving procedure (3). The cognitive burden of performing a surgical airway perhaps only once in a career can lead to the perseveration of attempts to tracheally intubate the patient, delaying oxygenation and resulting in increased mortality and morbidity (4,5). Cricothyrotomy is further complicated by a wide array of suggested techniques, often with no evidence, difficulty in palpating neck landmarks in obese patients, and the presence of

RECEIVED: 19 July 2018; FINAL SUBMISSION RECEIVED: 18 November 2018;
ACCEPTED: 8 December 2018

copious amounts of blood once an incision in the neck is made (6,7).

Physicians who manage airways in their practice must have regular access to realistic airway simulators so that they can practice performing cricothyrotomy. Unfortunately, commercially available cricothyrotomy trainers often consist of expensive plastic and rubber mannequins, human cadavers, pig tracheas, and homemade tracheas using inexpensive but artificial-feeling hardware supplies. None of these traditional trainers can mimic the potential copious amount of blood or the flash of air that one encounters while performing a cricothyrotomy. All these simulators either lack a realistic feel, require constant replacement of parts, or are prohibitively expensive, making them impractical for the vast majority of physicians working in budget-conscious departments.

The REAL CRIC Trainer was designed and built to address these concerns. The goal was to develop an inexpensive, reusable cricothyrotomy simulator that is easy to replicate and that provides a realistic experience for its learners. The REAL CRIC Trainer is designed for students, resident physicians, and attending physicians in the fields of emergency medicine, critical care, surgery, otolaryngology, and anesthesiology. The purpose of this model is two-fold: first, to provide a realistic cricothyrotomy experience that is often lacking in current surgical airway trainers, and second, to make a cricothyrotomy model affordable for institutions to replicate.

DISCUSSION

The REAL CRIC Trainer takes approximately 10 min to assemble, and the approximate cost of the items needed to create this innovation is $50 to $70. This airway simulator uses porcine skin with underlying muscle and fascia to replicate the feel of real human flesh. A 3-dimensional (3D) printed trachea model made freely available as an STL file by one of the authors is used as the basis for the airway trainer (8). Pork belly with skin is placed directly over the trachea model and has the realistic feel of a human neck. Bags of normal saline dyed red will serve as blood. A bag valve mask (BVM) connected to an endotracheal tube (ETT) will provide the puff of air that is encountered once the scalpel enters the airway. The realism of this model originates from the tissue that participants must cut through and the amount of blood and air that can be simulated by the faculty member simply squeezing the intravenous bag and BVM. Thicker pieces of meat will mimic more obese patients and will make palpation of the cricothyroid membrane more difficult, which is often encountered in real-life surgical airway scenarios. This realistic simulator with copious amounts of bleeding may have a noticeable effect on the participants by increasing their stress level and causing them to complete the procedure with a greater sense of urgency compared with other commercially available static simulators. In addition, this trainer can be easily cleaned by simply rinsing the components in a sink because everything is made of plastic and rubber. Setup with a new piece of pork belly can be done in <5 min for use by another participant.

The following instructions provide users with detailed directions for building your own REAL CRIC Trainer. An accompanying video (available online at https://www.jem-journal.com/) online shows step by step instructions for building this simulator (9).

List of Supplies

The following list of supplies is needed to build a REAL CRIC Trainer.

A 3D-printed model of a trachea, printed from the following STL file: http://www.airwaycollaboration.org/3d-cric-trainer-1/ ($0–50, depending on where you print it).

1. A 15-cm piece of corrugated ventilator tubing
2. Duct tape
3. Roll of 3M Microfoam surgical tape (3M, Minneapolis, MN)
4. 8-0 ETT and bag valve mask
5. Mannequin head ($15 online)
6. Pork belly with skin still attached, about a 15- × 15-cm piece that is 3 cm thick ($5 from grocery store or local meat market)
7. Intravenous tubing and a 1-L bag of normal saline
8. Bottle of red food coloring
9. Blue sterile drapes
10. Plastic storage container to hold supplies and lid for base of trainer (or you may use some other plastic tray as the base to secure the trainer down and collect the fake blood)
11. Cricothyrotomy supplies: a no. 10 scalpel, 6-0 ETT, and a bougie

Detailed Instructions

Follow the instructions below for assembly.

1. Print or order a filament or resin 3D trachea (filament is cheaper but more brittle; the more expensive resin will last for >100 cricothyrotomy practice sessions). Attach a piece of corrugated tubing (ventilator plastic tubing) to the distal/inferior opening with duct tape. Seal the open end of the tubing with duct tape; this will serve as the carina. Puncture two air vents in the tubing by making two small holes with a scalpel; these holes must be smaller than the diameter of a bougie.

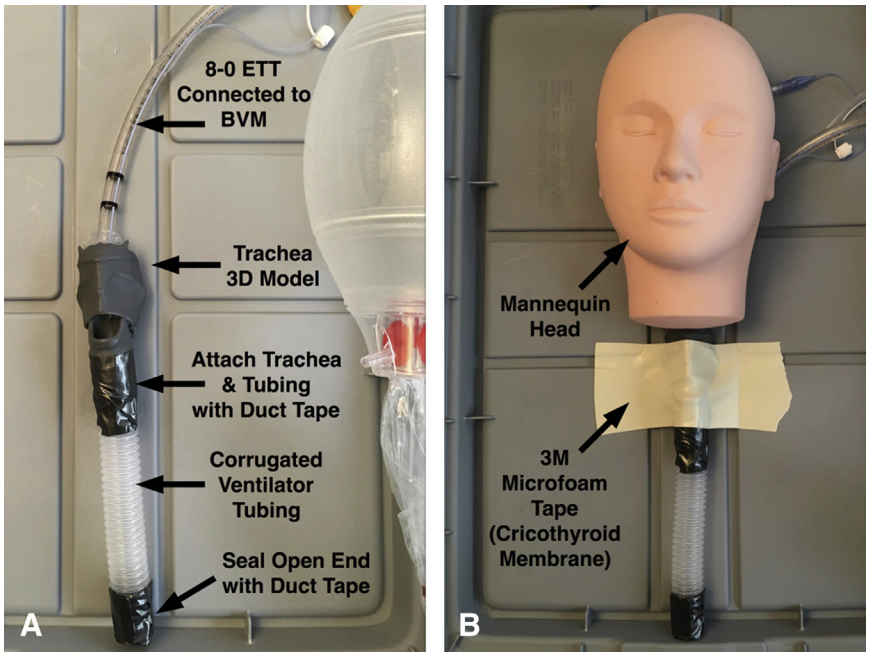

Figure 1. Initial REAL CRIC Trainer set up with (A) 3-dimensional printed trachea, corrugated tubing, and endotracheal tube (ETT) with bag valve mask (BVM), later adding the (B) mannequin head and 3M Microfoam tape.

2. Place an 8-0 ETT into the trachea model from the superior opening. Be sure that the ETT is not pushed too far down. The bevel of the ETT should be pointing up and not visible from the cricothyroid opening. The ETT should then be connected to a BVM, which will allow for a puff of air to be created when the cricothyroid membrane is pierced by the participant with a scalpel (Figure 1A).
3. Using a piece of 3M Microfoam surgical tape, secure the trachea setup to a fluid collection tray (for example, the lid of a plastic storage container/cookie tray/oil drip pan). The Microfoam tape will also serve as the cricothyroid membrane (if Microfoam tape is not available, duct tape, gaffer's tape or 3M Tegaderm can be used as a substitute).
4. Above the trachea, a mannequin head is placed to create a more realistic experience. Velcro can be used to secure the head to the tray. Place this trachea setup aside (Figure 1B).
5. Take a piece of fresh pork belly with skin still attached, measuring about 15- × 15-cm and about 3 cm thick. In the center of this piece of meat, subcutaneously inject 30 mL of fake blood with an 18-gauge needle; the fake blood can be made by injecting 10 mL of red food coloring dye into a liter bag of normal saline. Create a midline weal just under the skin in a linear vertical fashion that is about 5 cm in length. This subcutaneous fluid will mimic immediate bleeding as a scalpel cuts through the first few layers of dermis (Figure 2A). Be sure to create this weal just before the simulator is to be used.
6. Using a no. 10 scalpel, create a superficial tunneled incision that is parallel to the skin surface and about 0.5 cm beneath it. This incision should start at the inferior portion of the pork belly, directly midline, and end halfway up the piece of meat, stopping just under the weal you created (Figure 2B).
7. With your intravenous tubing starter kit, cut the tubing with scissors distally, just above the first injection port, removing all of the roller clamps and slide clamps. What should be remaining is the bag spike, drip chamber, and a long piece of plastic tubing with no other plastic hardware. Spike a liter bag of normal saline mixed with 10 mL of red food coloring. Slide the intravenous tubing into the pork belly incision you just created (Figure 2C). The faculty member running the simulator can replicate copious bleeding and control the amount of bleeding during the procedure by simply squeezing the bag of normal saline.
8. Finally, place this prepared piece of pork belly over the trachea model with the intravenous tubing side facing inferiorly (Figure 3A). Blue surgical drapes can be placed around the model for a more realistic appearance (Figure 3B). Your REAL CRIC Trainer is now ready for use.
9. Each trainer will need to be supervised by a faculty member. The faculty member can control the

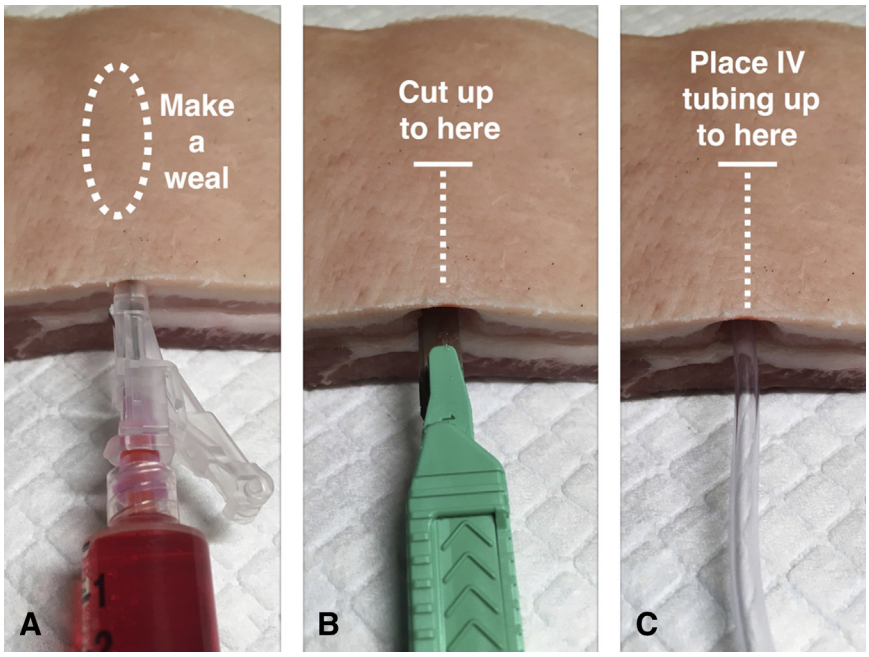

Figure 2. Preparing the pork belly with skin by (A) injecting a weal of subcutaneous "blood," (B) making an incision with the scalpel just under the skin, halfway up the piece of pork, and (C) placing intravenous tubing connected to fake blood into the track just created.

amount of bleeding by squeezing the intravenous bag with fake blood, and they can also create a flash of air by squeezing the BVM as the participant cuts through the cricothyroid membrane.

CONCLUSIONS

The REAL CRIC Trainer has been used in emergency medicine procedure laboratories with both residents and experienced physicians, and the feedback given by

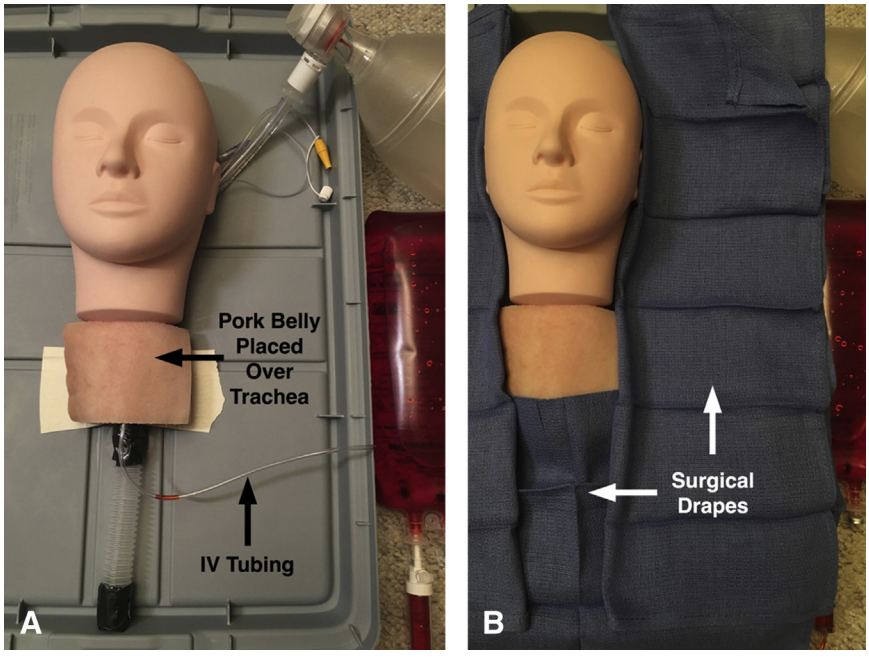

Figure 3. (A) Placing the prepared piece of pork belly with intravenous tubing over the trachea model and (B) covering the trainer with blue surgical drapes to make the simulator more realistic in appearance.

participants has been overwhelmingly positive. Participants reported that the pork belly skin and tissue makes for an extremely realistic feel as they attempt to palpate important airway landmarks, such as the cricothyroid membrane. The bleeding and puff of air when incising through the cricothyroid membrane adds to the realism of this low-cost, reusable simulator. This simulator is unique, simple to replicate, and inexpensive. The REAL CRIC Trainer is a practical answer for physicians who are looking to incorporate regular cricothyrotomy training sessions into their practice, thereby assuring that they are comfortable with performing an emergent cricothyrotomy if necessary.

REFERENCES

1. Brown CA, Bair AE, Pallin DJ, et al. Techniques, success, and adverse event of emergency department adult intubations. Ann Emerg Med 2015;65:363–70.
2. Law JA, Broemling N, Cooper RM, et al. The difficult airway with recommendations for management. Part 1. Difficult tracheal intubation encountered in an unconscious/induced patient. Can J Anaesth 2013;60:1089–118.
3. Wong DT, Lai K, Chung FF, Ho RY. Cannot intubate-cannot ventilate and difficult intubation strategies: results of a Canadian national survery. Anesth Analg 2005;100:1439–46.
4. Frerk C, Mitchell CS, McNarry AF, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubations in adults. Br J Anaesth 2015;115:827–48.
5. Phitayakorn R, Minehart RD, Hemingway MW, et al. Relationship between physiological and psychological measures of autonomic activation in operating room teams during a simulated airway emergency. Am J Surg 2015;209:86–92.
6. Benumof JL. Obstructive sleep apnea in the adult obese patient: implications for airway management. J Clin Anesth 2001;13:144–56.
7. Erlandson MJ, Clinton JE, Ruiz E, et al. Cricothyrotomy in the emergency department revisited. J Emerg Med 1989;7:115–8.
8. Duggan LV, Lockhart SL, Romano KR, et al. Front-of-neck airway meets front-of-neck simulation: improving cricothyroidotomy skills using a novel open-access three-dimensional model and the Airway App. Can J Anaesth 2017;64:1079–81.
9. Kei J. The REAL CRIC Trainer [video]. Available at: https://www.youtube.com/watch?v=B2QdD4k4rLI. Accessed February 11, 2018.