Strengthening Expertise Among Experts: A Cricothyrotomy Simulation to Improve Confidence Among Anesthesia Providers

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Author Note

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This paper is based on data from the DNP Project completed as partial fulfilment of the Doctor of Nursing Practice degree with the guidance and supervision of the following:

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Abstract

Cricothyrotomy is a high-risk, low-frequency procedure that the anesthesia provider must emergently perform in cannot intubate, cannot oxygenate (CICO) scenarios. CICO events requiring cricothyrotomy are rare, however they account for up to 25% of anesthesia related deaths. The literature suggests a lack of confidence exists on the part of anesthesia providers in performing this skill, and little opportunity exists for anesthesia providers to practice and develop proficiency with cricothyrotomy. To address this problem, a cricothyrotomy simulation using a realistic and cost-effective model featuring porcine tissue, bleeding, and a flash of air was implemented to improve confidence among anesthesia providers. Using a pre-test, post-test design, self-perceived confidence with cricothyrotomy was measured before and after simulation. Data analysis demonstrated that simulation significantly improved anesthesia provider self-perceived confidence with cricothyrotomy. Educational videos on the cricothyrotomy procedure as well as on the replication of the model was developed for adoption and sustainability.

Keywords: anesthesia, cricothyrotomy, simulation, confidence, airway management

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Chapter I: Introduction and Overview of Problem of Interest

Cricothyrotomy is a last-resort, life-saving intervention which must be performed to prevent hypoxia and death in cannot-intubate, cannot oxygenate (CICO) events. While this procedure falls under the scope of practice of anesthesiologists and certified registered nurse anesthetists (CRNAs), the infrequency of its occurrence results in a lack of skill proficiency and confidence among anesthesia providers, and patient outcomes related to CICO events are poor. An intervention to improve provider confidence is needed to mitigate this clinician proficiency, and therefore, patient safety issue.

Background and Significance

The ability to establish and maintain a patent airway for ventilation and oxygenation is one of the most critical and fundamental responsibilities of the anesthesia provider (Heiner, 2018). Whether an artificial airway is needed for a scheduled procedure requiring anesthesia, or in an emergent situation in which a patient has lost the ability to maintain their own ventilation and oxygenation, anesthesia providers are called upon as the “airway experts” to intervene. Depending on the circumstance, a variety of airways may be utilized, from endotracheal tubes to supraglottic airway devices. In addition, innovations such as lighted stylets and video laryngoscopes have aided the anesthesia provider’s ability to navigate a difficult airway (Apfelbaum, et al., 2013). As long as the patient can be effectively mask-ventilated, the anesthesia provider has ample time to establish the airway without imminent crisis. However, due to anatomical abnormalities, trauma, foreign bodies, tumors, or hematomas obscuring the airway, mask ventilation and endotracheal intubation may be impossible, and a CICO scenario ensues (Butterworth, et al., 2018). If not promptly remedied, CICO events can rapidly lead to hypoxia, permanent brain damage, and/or death (Clark, et al., 2021). The American Society of Anesthesiologists (ASA) has developed a difficult airway algorithm (Appendix A), of which the final intervention is emergency surgical airway (ESA) via cricothyrotomy (Apfelbaum, 2013). Therefore, cricothyrotomy is a skill which falls within the anesthesiologists' and CRNAs' scope of practice, and one that they are expected to be able to perform in a CICO event.

Fortunately, CICO events leading to ESA are rare, occurring in 1 in 50,000 general anesthetics, and 1 in 600 emergency department intubations (Cook & McDougal-Davis, 2012). Hence, they are considered high risk, low-frequency events. Despite their infrequency, CICO events account for up to 25% of anesthesia related deaths, according to the ASA Closed Claims Project (ASACCP) (Cook & McDougal-Davis, 2012). In addition, the ASACCP reports that over one-third of cricothyrotomies performed in CICO events were performed too late to prevent adverse outcomes (Joffe, et al., 2019). These dismal outcomes are believed to be largely related to human factors on the part of the anesthesia provider, and a reluctance to perform cricothyrotomy is thought to be the most common cause of delay in performing the procedure when it is clinically called for (Greenland, et al., 2011). Alarmingly, the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society (NAP4) reports that of cricothyrotomies attempted by anesthesia providers, 65% of them failed (Cook, et al., 2011). A Canadian national survey of 971 anesthesiologists found that only about 57% of respondents feel confident in having to perform an ESA (Wong, et al., 2005). Due to their infrequency, cricothyrotomy is a skill that anesthesia providers have little to no opportunity in which to practice and become confident and proficient. Simply put, the airway experts do not have the opportunity to develop their expertise in this life-saving skill.

PICO Question Guiding Inquiry

The lack of confidence among anesthesia providers in their ability to perform a cricothyrotomy as well as the limited ability to practice and develop proficiency in this skill leaves patients in CICO scenarios at increased risk for adverse outcomes and death. In order to increase confidence and competence among anesthesia providers' in performing an emergent cricothyrotomy, measures must be taken to afford clinicians the opportunity to practice this skill. With this problem in mind, the PICO question guiding this DNP project is as follows: Among anesthesia providers, does the implementation of a cricothyrotomy simulation improve self-perceived confidence in performing emergent cricothyrotomy? Using a pre-test post-test design, the project authors intend to host a cricothyrotomy simulation using a realistic model and evaluate its effect on anesthesia provider self-perceived confidence to answer the PICO question.

System and Population Impact

The documented lack of confidence to initiate emergency surgical airways reflects a health-system wide issue that leaves patients at risk of serious harm or death if they find themselves unable to be ventilated and oxygenated at the hands of their anesthesia providers. Related to the population, the anticipated impact of this DNP project will be an increase in patient safety and quality of care, as participating anesthesia providers will increase their confidence in performing a life-saving skill. Furthermore, the poor outcomes related to failed airway management in CICO events no doubt result in increased treatment costs, hospitalization, and litigation. According to Cook, et al. (2010), litigation against anesthesia providers from 1995-2007 related to airway events accounted for 27% of cost and amounted to millions of dollars. The impact of increased provider confidence and competence in emergency surgical airway will help to mitigate the health system costs created as a result of failed airway management in CICO events.

Purpose

The purpose of this evidenced based project is to determine if the implementation of cricothyrotomy simulation improves self-perceived confidence among anesthesia providers in their ability to perform an emergent cricothyrotomy. In doing so, the implementation of this project will hopefully help to address the problem of failed airway management in CICO events, specifically related to poor provider confidence in performing an emergency surgical airway. This project will evaluate the efficacy of a realistic, cost effective, and replicable cricothyrotomy simulation model. In addition, in order to facilitate adoption and sustained practice utilization of cricothyrotomy simulation, a step-by-step instructional video on the assembly of the cricothyrotomy model will be developed and presented to participants to reference for their future replication of the simulation within their institutions.

Objectives

The ultimate goal of the proposed evidence-based practice project is to improve provider confidence to perform cricothyrotomy in real "cannot intubate-cannot oxygenate" scenarios by implementation of a realistic cricothyrotomy simulation. Objectives in achieving this goal include:

1. Anesthesia provider self-perceived confidence in performing emergent cricothyrotomy will be improved after participation in a realistic cricothyrotomy simulation, as evidenced by data collected from pre- and post- intervention surveys collected by the DNP student.
2. Anesthesia provider self-perceived confidence to recreate a realistic and cost-effective cricothyrotomy simulation model for adoption at their institution will be improved

following a video demonstration on model assembly, as evidenced by data collected from pre- and post-intervention surveys collected by the DNP student.

Chapter II: Review of Evidence/Literature

Search Methodology

In order to assess the efficacy of simulation in improving self-perceived confidence, a literature search was performed using the databases Google Scholar, CINAHL, and PubMed, with access through Cedar Crest College's Cressman Library. Keywords used in the search included cricothyrotomy, simulation, confidence, anesthesia, and emergency surgical airway. The search was limited to articles published from 2014 to the present. This search yielded 382 results in Google Scholar, 38 results in CINAHL, and 4 results in PubMed. Inclusion criteria were randomized controlled trials (RCTs), cohort studies, quasi-experimental studies, and quality improvement projects with cricothyrotomy simulation as the intervention, and the measurement of provider self-efficacy, comfort level, competence and/or confidence as outcomes. In addition, populations were not limited to anesthesia providers alone, but included physicians, paramedics, and military medics for whom cricothyrotomy also falls within their scope. Exclusion criteria were editorials, expert opinion pieces, and studies with student registered nurse anesthetists (SRNAs) as the study population. Using these criteria, 7 studies were chosen to answer the PICO question.

Evidence Synthesis

In all studies, some form of cricothyrotomy simulation was implemented as the intervention. The studies of Rajwani, et al. (2019), Scott-Herring, et al. (2020), and Shaw and Hughes (2020) included critical care physicians, CRNAs, and paramedics, respectively. Participants in these studies took a pre-intervention survey to assess self-perceived confidence in performing cricothyrotomy and a post-intervention survey measuring the same variable. All studies demonstrated significant improvement in self perceived confidence after the simulation training ($p < .005$, $p < .001$, and $p < .001$, respectively) (Rajwani, et al, 2019; Scott-Herring, et al., 2020; Shaw & Hughes, 2020). The studies of Hall, et al. (2014) and Wray, et al. (2019) included Air Force medics and emergency medicine physicians, respectively. Both studies randomized participants into an artificial sim model group or a bleeding model group, and also assessed self-perceived confidence and self-efficacy. Hall, et al. (2014) and Wray, et al. (2019) found no statistical difference between the different types of models, however both groups in both studies demonstrated significantly improved confidence levels after training ($p < .0001$, and $p=0.021$ respectively). In the study of Kashat, et al. (2020), anesthesiology residents and otolaryngology residents took pre- and post-intervention surveys to assess familiarity and comfort level with airway procedures including cricothyrotomy. A significant ($p < .001$) improvement was found in familiarity and comfort level with cricothyrotomy after simulation (Kashat, et al., 2020). Lastly, the study of Berwick, et al. (2019) included 10 anesthesia providers who underwent cricothyrotomy simulation. Participants rated their confidence levels before and after the simulation, which improved from 50% to 87% ($p < .001$) (Berwick, et al., 2019). In addition, the participants underwent qualitative interviews before and after the intervention. Themes that were identified before training included reluctance to initiate cricothyrotomy and concern about performing it, while themes identified after training included feeling confident about performing cricothyrotomy and less reluctance to initiate the procedure (Berwick, et al., 2019). For an evidence table including project design, population, strength and quality, see Appendix B.

Limitations of Literature Review

Several limitations of the literature review were identified. First, limited studies exist exclusively among our targeted population – anesthesia providers. Therefore, the studies selected encompassed populations beyond anesthesia providers including critical care physicians, emergency medicine physicians, and military medics. However, because cricothyrotomy falls under the scope of practice of all of the aforementioned groups and remains a rare event, the findings of those studies can be translated to our population of anesthesia providers. Another limitation of the literature review is that the type of model utilized for the cricothyrotomy simulations were not consistent across all the studies. However, this limitation was determined to be inconsequential to our purposes, as each study demonstrated improved provider confidence despite variations in the models used, pointing to the efficacy of any form of practice in improving provider confidence in performing cricothyrotomy.

Chapter III: Theoretical Framework

As the practices of research utilization, evidence translation, and implementation science have evolved, it has become apparent that practices and outcomes are improved with the employment of an implementation framework (Katende & Donnelly, 2016; Graham & Logan, 2004). Frameworks and models provide the evidence translation effort with structure through a systematic process of development, execution, and evaluation (Brownson, et al., 2018). Therefore, to facilitate the implementation of this evidenced based practice, a framework was commissioned. The Ottawa Model for Research Utilization (OMRU) was ultimately chosen to guide the project (Appendix C) (Graham & Logan, 2004). The rationale for choosing the OMRU model was related to its pragmatic yet comprehensive approach towards effecting change. Another factor considered in selecting this model was its adaptability, which enables it to be applied to nearly any situation or context. The authors of the model, Logan and Graham (1998), state that it is meant to be used as a guide rather than a recipe. Thus, from its conception, the OMRU model was intended to be adaptable for use across varied applications.

The OMRU model consists of three core actions: Assess, monitor, and evaluate (AME) (Graham & Logan, 2004). More specifically, it consists of assessing barriers and supports to change, monitoring intervention and use, and evaluating outcomes (Katende & Donnelly, 2016). In utilizing the OMRU model to implement practice change, six fundamental elements are considered: The evidenced based innovation, potential adopters, the practice environment or setting, implementation intervention strategies, adoption, and outcomes (Graham & Logan, 2004). An example of the OMRU model's successful application can be seen by Katende & Donnelly's (2016) implementation of the World Health Organization's hypertension education interventions in Uganda. Katende & Donnelly (2016) state that of particular importance for the success of their implementation was the model's structure for identification of facilitators and barriers, as well as the selection, monitoring, and evaluation of interventions and outcomes.

In the context of this project, the "assess phase" of the OMRU framework consisted of the identification of the problem, the literature search, the gap analysis/needs assessment of the clinical site, and the identification of stakeholders and their concerns. In addition, plans for knowledge transfer were put in place. The project authors' clinical site is part of a large regional health network and is a level-1 trauma center as well as large surgical center employing over 180 anesthesia providers. To assess the needs of the organization, a meeting was held with the educator of the anesthesia department, who stated that they currently have no standard method for cricothyrotomy in place nor do they have a simulation or training model to allow their anesthesia providers to practice the skill. The implementation of a cricothyrotomy simulation will seek to close the gap between the current practice within the organization and what has been demonstrated as effective in current literature related to cricothyrotomy simulation. As previously discussed, due to the infrequency of cricothyrotomy, there is limited opportunity for practice of this skill outside of a simulation setting. However, concerns exist among stakeholders regarding the cost and resources required for simulation. This concern was addressed by using an inexpensive and easily replicable model for implementation of the simulation.

The "monitoring phase" of the OMRU model in the context of this project took place at the time of implementation during the live simulation workshop held at Cedar Crest College simulation lab. During this phase, knowledge transfer occurred through power-point presentation and video demonstration, and the participants hands-on performance of the simulated cricothyrotomy was monitored by the project authors. An additional element of the monitoring phase at the time of implementation was the data collection via administration of the pre- and post-intervention surveys. Also addressed in this phase of the OMRU model is implementation barriers. The primary barrier that was foreseen in the implementation of the simulation was time. Initially, the project authors intended to host the simulation during meal breaks at the clinical site. However, this was determined to be unfeasible and excessively time-limiting; therefore, the decision was made to host a scheduled simulation event at Cedar Crest College and invite participants to attend outside of their scheduled work hours. As the implementation phase occurred within a window of just a few hours, plans for “follow up” denoted in the OMRU model was transferred to the “evaluation phase.”

Finally, in the “evaluation phase”, the data collected during the simulation performance was analyzed, and the outcomes of the intervention were evaluated. The adoption component of the evaluation phase also addressed the long-term sustainability of the project and was accomplished by the creation of an instructional video on the assembly of a realistic cricothyrotomy training model which can be recreated for adoption within the participants’ organizations. The participants confidence in their ability to recreate the simulation model was assessed in the pre- and post- intervention surveys and served as an indicator of likelihood of adoption. At approximately one year after the implementation of the simulation, follow up will occur with the clinical site’s department of anesthesia educator to assess adoption and use of the cricothyrotomy simulation model. By the utilization of the OMRU model, this evidenced based practice project was carried out systematically and thoroughly from its beginning to its successful completion.

Chapter IV: Project Design

After the initial conception of the cricothyrotomy simulation, the authors sought the input and guidance of several key stakeholders. As previously discussed in Chapter III, a meeting was held with the department of anesthesia educator at the authors' clinical site. After obtaining the support and enthusiasm of the clinical site, the authors consulted with their Cedar Crest College Doctor of Nursing Practice (DNP) and Nurse Anesthesia Program faculty and obtained their support and guidance. In light of several factors including the DNP program timeline, the current COVID-19 pandemic, as well as time and setting constraints at the clinical site, a collaborative decision was made to implement the project at the Cedar Crest College School of Nursing Simulation Center, rather than at the clinical site. This decision also enabled the project authors' the ability to solely obtain Institutional Review Board (IRB) approval from their academic institution, Cedar Crest College, without also having to obtain approval form the IRB at the clinical site.

Institutional Review Board (IRB) Approval

In order to ensure that the rights and safety of the participants have been considered and are protected, an application was submitted to the Cedar Crest College IRB for a limited review. It was determined that a limited review was appropriate as opposed to a full review, since the project does not include any vulnerable populations, and poses no more than minimal risk to participants. Included in the application was the project objectives, methods, qualifications of researchers, recruitment procedures, requirements of participation, possible risks and benefits, assurance of anonymity and confidentiality, and security of data and data destruction. In addition, the informed consent (Appendix D) for participants was submitted. Potential safety considerations surrounding this project include risk of injury from the handling of a sharp instrument (a scalpel) to perform the cricothyrotomy simulation. This risk was explained in the consent, instruction on the procedure was provided prior to the simulation, and a first aid kit was kept available for the event of a cut injury. The initial application to the IRB was submitted on May 13th, 2021, with notice of approval on May 17th, 2021, with no required revisions. Because there was a change in the project's DNP faculty chair, a second IRB application was submitted as a matter of formality on August 29th, 2021 and approved on September 13th, 2021. As the protection of the participants' rights and safety is of the utmost importance to the project authors and Cedar Crest College, the project authors additionally obtained certification from the Collaborative Institutional Training Initiative (CITI) program for training in the protection of human subjects.

Implementation Plan

Implementation of this live simulation workshop has required careful preparation and planning. First, cooperation with the School of Nursing Simulation Coordinator was needed to ensure the availability of the Simulation Center and adjacent classroom for the event. Once the date and time of Saturday, November 13th from 0900 to 1200 was finalized with the School of Nursing, recruitment of participants was initiated. Recruitment was accomplished via the creation of an invitation letter sent via email to the entire anesthesia department at the clinical site. Included in the invitation was the informed consent, a flyer (Appendix E), and link to a Sign-up Genius for participants to register. The event flyer was also printed and placed in high traffic areas at the clinical site. Finally, additional recruitment was achieved via word-of-mouth within the clinical site. The project authors also obtained prior approval from the American Association of Nurse Anesthesiologists (AANA) for three class A continuing education (CE) credits for the attendants of the simulation.

The implementation consisted of the participants' signing of the informed consent and completion of demographic and pre-test surveys prior to viewing a classroom slide presentation embedded with video demonstrations created by the project authors. Microsoft PowerPoint was used for the creation of the slide presentation, and the projects authors' personal iPhones were used to film the videos. Video editing and voice-over was accomplished using the iMovie application on the project authors' personal MacBooks. Following a presentation on cricothyrotomy, participants performed a cricothyrotomy simulation on a realistic model assembled by the project authors in the Simulation Center OR. After all participants completed the simulation, a slide presentation and video demonstration were presented on the replication of the cricothyrotomy model for future adoption. Finally, participants were asked to complete a post-test survey.

Data Collection

The data collection was accomplished through the administration of three electronic surveys: the demographic survey (Appendix F), the pre-test survey (Appendix G) and the post-test survey (Appendix H). A Wix website was created for the implementation project to house the informed consent form with digital signature capability, the surveys, and videos. The three surveys were created using Google Forms and were embedded into the Wix webpage. The Google Forms application automatically populated data into a spreadsheet for later data analysis. Anonymity was maintained throughout the data collection process by the use of a unique identifier with which to link the surveys, consisting of the last two digits of the participants phone number, their middle initial, and their birth month, i.e., 02CJanuary.

Measurement Tools

The demographic survey was adapted with written permission from Sarah Bartolomeo, of Bartolomeo et al. (2019). This survey was used to ascertain such data points as years of anesthesia experience, prior simulated or real cricothyrotomy experiences, etc. The pre-test survey consisted of questions to evaluate the participants baseline self-perceived confidence level in their ability to perform an emergent cricothyrotomy, and conversely, the post-test survey consisting of identical questions evaluated self-perceived confidence level after completing the simulation. Because a validated measurement tool specific to this application does not currently exist, the authors adapted a self-efficacy scale from that of psychologist Albert Bandura (2006). This consists of a numeric scale in increments of 10 from 0-100, which correlate to confidence level with “0” representing “very unconfident”, “50” representing “moderately confident”, and “100” representing “very confident.”

Bandura (2006) defines self-efficacy as the belief in one's capabilities to organize and execute the course of action required to produce given attainments. Further, he postulates that the greater one’s self-confidence is in their own ability, the more likely they are to succeed at that given task (Bandura, 2006). As the measurement of one’s perceived self-efficacy can be applied to countless subjects and applications, Bandura (2006) published a guide for constructing self-efficacy scales. Numerous examples of self-efficacy scales derived from Bandura (2006) can be found in the literature, and many authors have conducted validation studies confirming the validity and reliability of their self-efficacy scales. Examples of this include a tool to assess the self-efficacy of patients with Celiac Disease to adhere to a gluten free diet, a tool to assess the self-efficacy of healthcare providers in their clinical communication, and a tool to measure the self-efficacy of survivors of sudden cardiac death who received implantable cardioverter defibrillators (ICDs) (Fueyo-Diaz, et al., 2018; Axboe, et al., 2016; Dougherty, et al., 2007).

While it was not feasible for the project authors to pilot their measurement tool prior to its use for their implementation, the many examples of the successful adaptation of Bandura's self-efficacy scale leave the project authors confident in the adaptation of this scale for the assessment of self-perceived confidence in performing emergency cricothyrotomy.

Resources Needed

Many human, material, and technological resources were needed for the implementation of this project. Human resources included Cedar Crest College faculty mentors, and clinical mentors from the authors' clinical site. Material resources included all of the items necessary for the assembly of the cricothyrotomy model, which will be discussed in complete detail in the following chapter. These materials included items owned by the Cedar Crest College School of Nursing Simulation Center (used with permission from the School of Nursing), materials donated to the project from the authors' clinical site, and materials purchased by the authors. Two unique materials needed for the model included skin-on porcine tissue purchased from a local butcher, and a 3D-printed trachea which was fabricated and donated by a contact of the School of Nursing. Additionally, the project authors purchased personal protective equipment (PPE), and a first aid kit to have on-hand in the event of a cut injury. Technological resources included the authors personal electronic devices, the School of Nursing's projector, and the aforementioned programs and software applications: Microsoft PowerPoint, Google Forms, iMovie, and Wix.

Budget Justification

The affordability of the realistic simulation model utilized for this implementation is one of the model's strengths and lends itself well to its adoption and sustainability. With the supplies that are commonly found in the OR donated to the project by the School of Nursing and the clinical site, the cost of the materials and assembly of 2 models was approximately $100. In comparison to many of the commercially sold cricothyrotomy simulation models on the market which sell for thousands of dollars, this model is a fraction of the cost.

While the resources required for the successful implementation did come at a financial cost to the project authors, the expense is justified by the potential benefit of the project. When assessing the cost benefit of the simulation compared to no simulation at all, it is difficult to quantify the exact cost that could ensue as a result of an anesthesia provider being unprepared to perform a successful cricothyrotomy. The poor outcomes related to failed airway management in CICO events no doubt result in increased treatment cost, hospitalization, and litigation. According to Cook, et al. (2010), litigation against anesthesia providers from 1995-2007 related to airway events accounted for 27% of cost and amounted to millions of dollars. In light of these considerations, we have determined the proposed simulation to be well worth the expense. A cost benefit analysis can be found in Appendix I.

Chapter V: Implementation Procedures and Processes

Setting

The setting of the implementation was the Cedar Crest College School of Nursing simulation center. The college simulation lab consists of a realistic operating room (OR) environment complete with anesthesia machine, monitors, OR table, multiple emergency carts including malignant hyperthermia cart, airway cart, and code cart, as well as supply cabinets, IV poles and pumps, etc. This environment lends itself to achieving the most accurate and true-to-life experience in which to simulate a real airway emergency. In addition, the adjacent classroom with desks and overhead projector was utilized for the presentation and data collection components of the implementation.

Population

The inclusion criterion for participation was the title of anesthesia provider including Certified Registered Nurse Anesthetists (CRNAs) and physician anesthesiologists. The exclusion criterion was Student Registered Nurse Anesthetists (SRNAs), as their baseline confidence level with cricothyrotomy is expected to be low without years of anesthesia practice experience. After a recruitment email was sent to the Department of Anesthesia at the authors' clinical site, 14 CRNAs registered via a SignUp Genius Link. Three CRNAs withdrew, resulting in 11 total participants on the day of implementation. No physician anesthesiologists registered.

Procedure

Upon arrival to the Cedar Crest College School of Nursing, participants were asked to sign in and take a seat in the classroom. A PowerPoint slideshow was projected on the screen with instructions to read and sign the informed consent and fill out the demographic and pre-simulation surveys. The informed consent and surveys were located on a Wix webpage created by the authors, accessed by scanning a QR code located on each desk. The participants were then able to fill out the forms on their personal cell phones. The informed consents and completed surveys were automatically stored within password protected Google Forms, accessible only to the project authors.

After the informed consent, demographic, and pre-simulation surveys were complete, the authors presented an educational slideshow on cricothyrotomy. This included the incidence, indications, contraindications, complications, relevant anatomy, techniques, and outcomes related to the procedure. The authors presented the evidence from literature related to anesthesia provider confidence, as well as comparison of the needle, Seldinger, and surgical cricothyrotomy techniques. The “scalpel-finger-bougie” technique was presented in detail, including required supplies and step-by-step instruction on the technique. A video demonstration was presented that had been previously filmed by the project authors on a realistic cricothyrotomy model. This video can be accessed on YouTube with the following link: https://youtu.be/EQKqZ3mCKKo.

The next portion of the implementation consisted of the hands-on cricothyrotomy simulation. In the simulation center operating room, two stations were set up with the cricothyrotomy model in place. Participants completed the simulation two-by-two, with each station manned by one of the project authors. Personal protective equipment (PPE) including isolation gowns, gloves, masks, and face-shields were provided. Participants completed the “scalpel-finger-bougie” cricothyrotomy technique that they had received instruction on during the slide presentation. Between uses, the disposable elements of the model were turned over and the model reset for the next group of participants.

After all participants had completed the simulation, a second PowerPoint presentation was presented in the classroom on the cricothyrotomy model and steps required for its replication. In addition, an instructional video on model assembly created by the project authors was shown. This video can be accessed on YouTube with the following link: https://www.youtube.com/watch?v=3gz4IUTEeaA. Finally, participants completed the post-simulation survey.

Simulation Model

The model used for this simulation was an adaptation of the REAL CRIC Trainer, which was chosen for its affordability and realism (Kei, et al., 2019). 3D printed tracheas were fabricated and donated to the project authors, with the STL file provided by Kei, et al. (2019). 3M Microfoam tape was placed over the trachea as the simulated cricothyroid membrane. A slab of skin-on pork belly, approximately 4.5 x 6" in size, overlayed the 3D printed trachea to simulate human flesh. The pork belly was injected with approximately 10 ml of red-dyed saline to create a realistic bleeding effect when incised. In addition, a liter bag of saline with red-food coloring connected to IV tubing was tunneled into the pork belly to create a continuous flow of "blood." An 8.0 endotracheal tube was tunneled into the trachea and connected to an ambu bag, that the operator squeezed to mimic a flash of air through the neck incision when the cricothyroid membrane was penetrated. In order to ensure that the air escaped through the cricothyroid membrane, the distal end of the 3D printed trachea was occluded with saran wrap and a rubber band. A 3-liter reservoir bag was connected to the trachea with duct tape, to serve as the "lung." Additional elements of the model include a mannequin head for effect, which was secured with Velcro to a plastic storage container lid. The container lid served as a stable base for the model and collected any "blood" spilled from the model.

To perform the simulation, the participant located the cricothyroid membrane by palpation, made incision with a #10 scalpel into the subcutaneous tissue, and again through the cricothyroid membrane. Then, a gum elastic bougie was introduced into the trachea (puncturing the saran wrap) and a lubricated 6.0 endotracheal tube was advanced over the bougie into the trachea. The endotracheal tube cuff was then inflated, and ventilation delivered via an ambu bag. Confirmation of ventilation was achieved by noting inflation of the reservoir bag.

During the simulation, the model operator performed two actions. First, when the participant made incision, the operator opened the roller clamp on the IV tubing containing the simulated blood to allow for continuous “bleeding.” Second, the ambu bag connected to the trachea was squeezed when incision was made through the cricothyroid membrane to simulate the flash of air that would be seen. Between each participant, the operators performed a brief reset of the model. The work surface was cleaned, and the single use items (pork belly, saran wrap, and microfoam tape) were discarded and replaced. For the assembled model and necessary supplies, see Appendix J.

Chapter VI: Evaluation and Outcomes

Demographics

Participants in the implementation consisted of 11 Certified Registered Nurse Anesthetists (CRNAs). Originally, 14 CRNAs enrolled; however, three dropped out due to personal emergencies on the day of implementation. As previously discussed, a demographic survey was administered to participants prior to the simulation. From the demographic survey, metrics such as years of anesthesia experience, number of prior cricothyrotomy experiences, and number of prior of cricothyrotomy trainings were obtained. In relation to years of anesthesia experience, 72% (n=8) of participants had less than 6 years, while 9% (n=1) had 11-15 years, 9% (n=1) had 21-25 years, and 9% (n=1) had greater than 25 years of experience. None of the participants had performed an actual cricothyrotomy in the past, and 72% (n=8) had not performed a simulated cricothyrotomy in the last 10 years.

Data Evaluation

The pre-simulation survey consisted of five questions related to self-perceived confidence with cricothyrotomy related skills, while the post-simulation survey consisted of the identical five questions prefaced by “After performing the cricothyrotomy simulation. . .” Survey responses were linked by the use of a unique identifier created by the participant. Data analysis was completed using IBM SPSS, in which the paired t-test was used to assess the difference between the pre- and post-simulation scores for each question. The paired t-test was chosen as the appropriate statistical test, as it is used for comparing scores between dependent groups, i.e., two sets of data from the same participant (Polit & Beck, 2016). The alpha value was set at $p < 0.05$ to test for statistical significance.

Use of the difficult airway algorithm

The first question of the surveys assessed the participants' self-perceived confidence in utilizing the ASA difficult airway algorithm in an airway emergency. The mean score on the pre-simulation survey was 62, while on the post-simulation survey the mean score was 91, with $p = .001$.

Ability to identify the cricothyroid membrane

The second question of the surveys assessed the participants' self-perceived confidence in their ability to quickly and correctly identify the cricothyroid membrane. The mean score of the pre-simulation survey was 57, while on the post-simulation survey the mean score was 90, with $p < .001$

Ability to identify cricothyrotomy supplies

The third question of the surveys assessed the participants' self-perceived confidence in their ability to quickly and correctly identify the supplies needed to perform a cricothyrotomy. The mean score of the pre-simulation survey was 35, while on the post-simulation survey the mean score was 97, with $p <.001$.

Ability to perform a cricothyrotomy

The fourth question of the surveys assessed the participants' self-perceived confidence in their ability to perform an emergent cricothyrotomy. The mean score of the pre-simulation survey was 16, while on the post-simulation survey the mean score was 90, with $p <.001$.

Ability to assemble a cricothyrotomy model

The fifth and final question of the surveys assessed the participants' self-perceived confidence in their ability to assemble a realistic cricothyrotomy model for adoption and use at their clinical institutions. The mean score of the pre-simulation survey was 13, while on the post-simulation survey the mean score was 89, with $p <.001$.

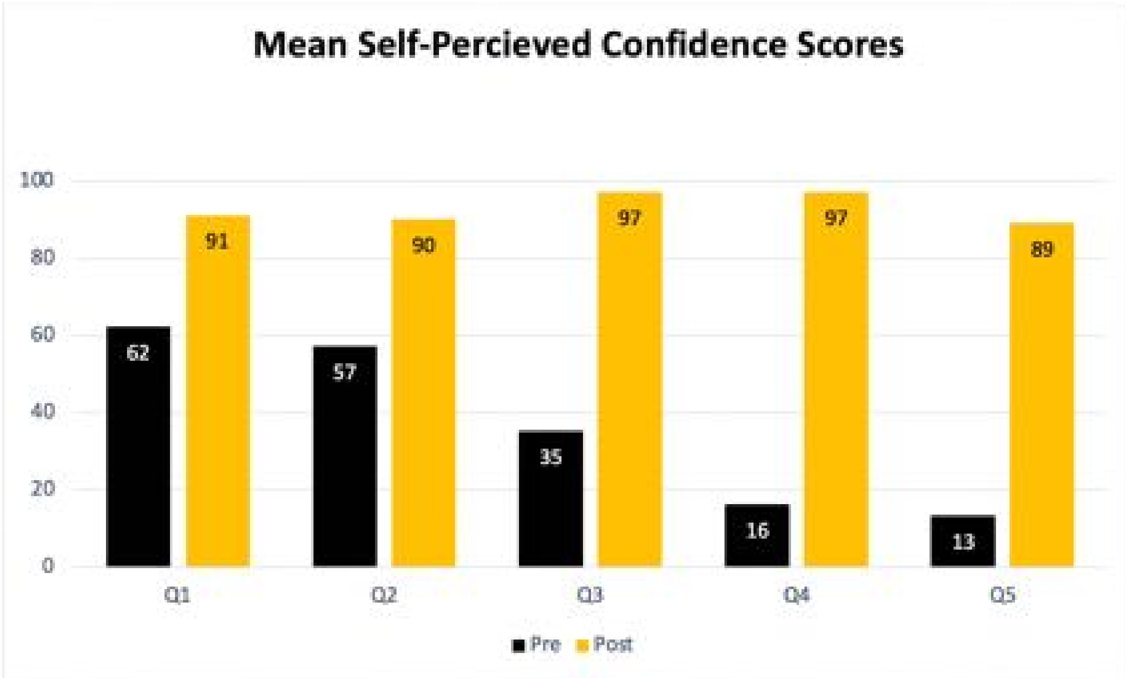

Figure 1: Mean self-perceived confidence scores before and after cricothyrotomy simulation

Statistical Significance Versus Clinical Significance

As previously stated, statistical significance was determined to be present with a p value of <0.05. By running the paired t-test, statistical significance between pre-simulation and post-simulation scores was established in all measured areas of self-perceived confidence related to cricothyrotomy. Perhaps more important than statistical significance in this case is clinical significance. Within the scope of this project, we are unable to collect data related to actual airway emergencies in the clinical setting. However, the increase in self-perceived confidence scores by anesthesia providers can be seen as a reflection of the clinical impact this project will have in future airway emergencies encountered by these participants.

Outcomes

To determine the success of the project, the PICO question, objectives, and needs assessment must be revisited. To reiterate as stated in chapter I, the PICO question guiding the inquiry was: among anesthesia providers, does the implementation of a cricothyrotomy simulation improve self-perceived confidence in performing emergent cricothyrotomy? By using an adaptation of Bandura's (2006) self-efficacy scale, the project authors were able to measure the self-perceived confidence of anesthesia providers on specific items related to cricothyrotomy before and after the simulation, and found that, indeed, the implementation significantly improved anesthesia provider self-perceived confidence with this life-saving skill. This outcome achieved the primary objective of the implementation, and the secondary objective of improved self-perceived confidence in recreating a realistic cricothyrotomy simulation model was also met, as evidenced by responses to the fifth survey question. Finally, the needs assessment of the clinical site was met in developing and implementing a realistic, cost effective, and replicable cricothyrotomy training program.

Discussion

The danger of high-risk, low frequency events in anesthesia, and in any healthcare setting, is the inopportunity for clinicians to practice and become proficient in the skills needed to navigate the crisis event. However, the severity of the event demands that the clinician act quickly and correctly to save the life of the patient. This poses a unique problem which requires a unique solution – one that simulation is increasingly shown to successfully address. The literature search performed at the outset of the project yielded numerous examples of simulation being used to increase provider confidence with airway emergencies, and even more examples can be found of the successful application of simulation for other emergency scenarios. The findings of this implementation are consistent with the literature in the efficacy of simulation training. In addition, the tactile realism of the chosen model provides a high-fidelity experience to prepare clinicians for the event of a real cricothyrotomy in a cannot intubate, cannot oxygenate

(CICO) scenario. As previously discussed in chapter I, a major factor in failed airway emergencies is attributed to lack of provider confidence. By providing a means of realistic practice for anesthesia providers, confidence with emergency surgical airway access was improved, and clinicians are better prepared to safely perform a cricothyrotomy if and when the CICO scenario presents itself.

Chapter VII: Implications for Nursing Practice

Implications for Practice

After having identified the problem of lack of provider confidence in performing emergency surgical airway, the goal of this implementation was to improve provider confidence to perform cricothyrotomy in real “cannot intubate-cannot oxygenate” scenarios through participation in a realistic cricothyrotomy simulation. This goal was achieved as demonstrated by our data collection and analysis discussed in the previous chapter. The broader implication of this implementation in the field of nurse anesthesia practice is that hands-on practice of a rarely used skill is crucial in developing provider confidence and therefore improving the likelihood of a positive patient outcome in a cannot-intubate cannot oxygenate emergency. Our data collection demonstrated low self-perceived confidence levels in several areas related to cricothyrotomy among our participants, which were significantly improved after implementation. If this cricothyrotomy model and simulation were to be adopted by anesthesia departments on a broad scale, it is plausible that anesthesia providers would become more confident and better equipped to perform a cricothyrotomy, thereby reducing risk for patients undergoing anesthesia.

Strengths of the Project

This project had many strengths which contributed to its success. The authors had long-term adoption and sustainability in mind when developing this project. For this reason, the cost-effectiveness of the chosen cricothyrotomy model compared to commercially available models is a tremendous strength and an attractive feature to potential adopters. Furthermore, the project authors intended that the education provided to participants on the assembly of the model could be distributed and understood by anyone, not just participants on the day of implementation. To achieve this, the authors filmed a step-by-step educational video which was uploaded to the project website, as well as to YouTube for later access and distribution.

Another significant strength of the implementation was its realism. The porcine tissue with “bleeding” and flash of air created a realistic tactile experience for participants. In addition, the setting of the Cedar Crest College School of Nursing Simulation Center operating room provided participants with a milieu which added to the realistic experience. Yet another strength of the implementation was the simplicity of the chosen cricothyrotomy technique, the scalpel-finger-bougie technique. As the technique preferred and recommended the Difficult Airway Society and Advanced Trauma Life Support, the scalpel-finger-bougie surgical cricothyrotomy technique requires minimal equipment and steps in establishing a surgical airway as compared to other techniques (Mazza, et al., 2021). By maintaining simplicity of technique, participants are more likely to be able to obtain the necessary supplies as well as remember and perform the necessary steps of an emergent cricothyrotomy with more confidence.

Finally, the use of technology in this implementation was a noteworthy strength. By creating a project website, embedded with the informed consent, demographic survey, pre-simulation survey, and post-simulation survey all neatly contained in one place and easily accessible by QR code from each participants’ personal device, the data collection process was efficient and secure. All of these elements combined to achieve a strong and successful implementation.

Limitations & Future Opportunities

While this implementation possessed many strengths, it contained several key limitations. Firstly, the small sample of 11 CRNAs was certainly a limitation. Due to the nature of the in-person, hands-on experience, the project authors were constrained in how many participants could realistically be included in the simulation event. However, this small sample limits the power of the statistical analysis and significance.

Secondly, the sample lacked diversity in several areas: job title, level of experience, and practice setting. The sample consisted solely of CRNAs with no physician anesthesiologists in attendance. In relation to level of anesthesia experience, the sample was heavily weighted towards new CRNAs, with 72% having less than 6 years of anesthesia work experience. Perhaps most significant to the purposes of this study was that all participants came from the same institution—a level one trauma center with significant resources available including advanced airway equipment, physician anesthesiologist support, and availability of trauma surgeons for establishing surgical airway access. Therefore, our results cannot necessarily be generalized to anesthesia providers practicing in rural and community settings with less resources at their disposal who may be more likely to encounter a CICO scenario. Repeating this project with a more diverse group of anesthesia clinicians would be useful in obtaining more generalizable results.

Thirdly, while the project authors chose to measure anesthesia provider self-perceived confidence with cricothyrotomy, they did not measure speed and technical accuracy with the simulated cricothyrotomy. This was a calculated decision as the purpose of the simulation was to allow hands on experience with unlimited time to perform the steps of identifying the cricothyroid membrane, making incision, and intubating the trachea. As resources allowed for each participant to perform the simulation only once, it was decided not to measure speed and technical accuracy on the participants first and only attempt. This precluded the ability to definitively state that our implementation did indeed improve cricothyrotomy technical skill. These limitations leave the door open for future opportunities and improvements with cricothyrotomy simulation projects in which speed and technical accuracy could be graded as opposed to self-perceived confidence alone.

Linkage to DNP Essentials

The Doctor of Nursing Practice (DNP) Essentials are the foundational elements of all advanced nursing practice roles, according to the American Association of the Colleges of Nursing (AACN) (2006). These eight essential elements must be incorporated into the curriculum of DNP programs in order for them to meet accreditation requirements. As such, the culmination of the DNP student's doctoral work should bear linkage to each of the DNP essentials. The connection of the DNP essentials to this cricothyrotomy simulation project will now be explored.

First, DNP Essential I: scientific underpinnings for practice, refers to the DNP graduate's ability to evaluate and incorporate science-based theory with individual, population, and organizational needs for the advancement of nursing practice and healthcare as a whole (AACN, 2006). This DNP essential was employed from the very beginning of this project, particularly through the literature search and review of evidence for application of evidenced based practice, as well as the anatomical and physiological aspects of the cricothyrotomy education.

DNP Essential II: organizational and systems leadership for quality improvement and systems thinking, refers to the DNP graduate's ability to assess the needs of an organization, collaborate and communicate professionally to bring about quality improvement, and to utilize principles of finance, economics, cost-analysis, budgeting and risk analysis (AACN, 2006). This essential was met in this project through the needs assessment of the clinical site, and collaboration with the anesthesia department educator, the DNP project chair, and project mentors. In addition, principles of finance were continuously employed through the process of the cost-benefit analysis, risk assessment, and project budget.

Essential III: clinical scholarship and analytical methods for evidenced based practice, refers to scholarly activities including appraising evidence, designing and carrying out an implementation, collecting and analyzing data, and dissemination of findings (AACN, 2006). This essential was met in this project throughout the entire process from developing and refining the project proposal to carrying out the implementation. The data collection and analysis were performed by the project authors using SPSS and the paired t-test as well as descriptive statistics. Finally, dissemination of the project took the form of developing a poster and presenting at the Drexel University CNRA/SRNA Virtual Professionalism Lecture, as well as at Cedar Crest College Dissemination Day.

Essential IV: information systems/technology and patient care technology for the improvement and transformation of health care was met in this project through the use of multiple technological platforms, such as in the development of the educational videos, development of the project webpage, the electronic data collection, and data analysis using SPSS statistical software. Information systems and technological literacy is vital for the DNP graduate to be effective in the translation of evidence and improve practices and outcomes (AACN, 2006).

DNP Essential V: healthcare policy for advocacy in healthcare, refers to the DNP graduate’s ability to analyze, influence and develop healthcare policy. In addition, the essential refers to the demonstration of leadership, advocacy and education (AACN, 2006). While this project did not directly have to do with healthcare policy or legislation, it did require the ability to effectively educate others on a subject of a health care intervention to improve patient safety and outcomes. The skills utilized for that aspect of the project will no doubt transfer to future efforts of education and advocacy for healthcare policy by the project authors.

This project incorporated DNP Essential VI, interprofessional collaboration for improving patient and population health outcomes, from its conception to its completion. As a group implementation, the project authors worked together continuously throughout every step of the process while also collaborating closely with the DNP chair, mentor, and stakeholders at the clinical site in order to develop and execute an implementation to improve provider confidence and patient outcomes.

Essential VII: Clinical prevention and population health for improving the nation's health, refers the analysis of epidemiological and biostatistical data to evaluate individual, community, and population health (AACN, 2006). In addition, it encompasses the synthesis of psychological and socioeconomical factors on health promotion and disease prevention (AACN 2006). While this project does not directly address population health, it did analyze the psychological effect that a lack of confidence has on cricothyrotomy outcomes. In addition, the authors analyzed the statistics related to anesthesia related death and airway emergencies as discussed in chapter II. In this way, essential VII was incorporated into the DNP project and the skills utilized can be applied in future practice related to population health.

Finally, essential VIII: advanced nursing practice, refers to the elements that comprise the foundation of all advanced nursing practice roles, which is the application of biophysical, psychosocial, behavioral, sociopolitical, cultural, economic, and nursing science into practice (AACN, 2006). This last essential can be thought of as the synthesis of all the others and it was fulfilled through the culmination of the authors doctorate education in the implementation of the cricothyrotomy simulation and education to improve anesthesia providers self-perceived confidence in performing emergent cricothyrotomy.

Chapter VIII: Conclusion and Future Ideas

Summary and Conclusions

A lack of confidence exists among anesthesia providers in their ability to perform an emergency surgical airway in a cannot intubate, cannot oxygenate (CICO) event. Less than 60% of anesthesia providers report they feel confident in their ability to perform an emergency surgical airway (Wong, et al., 2005). The rarity of these high-risk, low-frequency events provides insufficient opportunity for anesthesia providers to become proficient and confident in the life-saving skill of emergency cricothyrotomy. Nevertheless, the emergency surgical airway is the final step of the American Society of Anesthesiologists (ASA) difficult airway algorithm, and is a skill that anesthesia providers, as the "airway experts," are expected to be able to perform to save the life of a patient (Apfelbaum, 2013). Further highlighting the clinical problem at hand, outcomes related to CICO events are poor, and despite their infrequency, they account for up to 25% of anesthesia related deaths (Cook & McDougal-Davis, 2012). This presents a problem of patient safety and an opportunity for improvement among anesthesia providers.

Current evidence demonstrates that simulation is an effective strategy in improving provider confidence with high-risk, low-frequency events, and specifically with cricothyrotomy (Rajwani, et al., 2019; Scott-Herring, et al., 2020; Shaw & Hughes, 2020; Hall, et al., 2014; Wray, et al. 2019; Kashat, et al., 2020; Berwick et al., 2019). With the ultimate goal of improving patient outcomes in CICO events by improving anesthesia provider confidence to perform emergency cricothyrotomy, a realistic and cost effective cricothyrotomy simulation was implemented. Eleven CRNAs in total participated in an educational module followed by a hands-on simulation on a realistic model. Through the analysis of the data collected from pre-simulation and post-stimulation self-efficacy surveys, it was demonstrated that anesthesia provider self-perceived confidence in key areas related to the process of cricothyrotomy was significantly improved after participation in the cricothyrotomy simulation. These findings are consistent with the published evidence supporting the use of simulation to improve provider confidence with cricothyrotomy.

Dissemination Plans

Dissemination efforts will be crucial to ensure that the greatest possible impact may be obtained in improving anesthesia provider confidence with cricothyrotomy. This will be accomplished in multiple stages and across various platforms. Initial dissemination has already taken place at the Philadelphia Advisory Group of Nurse Anesthesia Programs CRNA/SRNA Virtual Professionalism Lecture on March 3rd, 2022. Next, the project was disseminated on April 11th, 2022 at Cedar Crest College before the graduate faculty and students. Finally, the project authors have been invited to disseminate at the Lehigh Valley Health Network Department of Anesthesiology Winter Retreat Conference in January of 2023.

Future Ideas

While this project thoroughly addressed the problem of lack of provider confidence with cricothyrotomy, it leaves the door open for future opportunities with cricothyrotomy simulation. A future project to be pursued is the utilization of the realistic and cost effective cricothyrotomy model to measure speed and technical proficiency with cricothyrotomy. CICO events are rare, but when they occur, they require providers with confidence, proficiency, and expertise to intervene. Through the utilization of cricothyrotomy simulation, the expertise of the airway experts can be strengthened.

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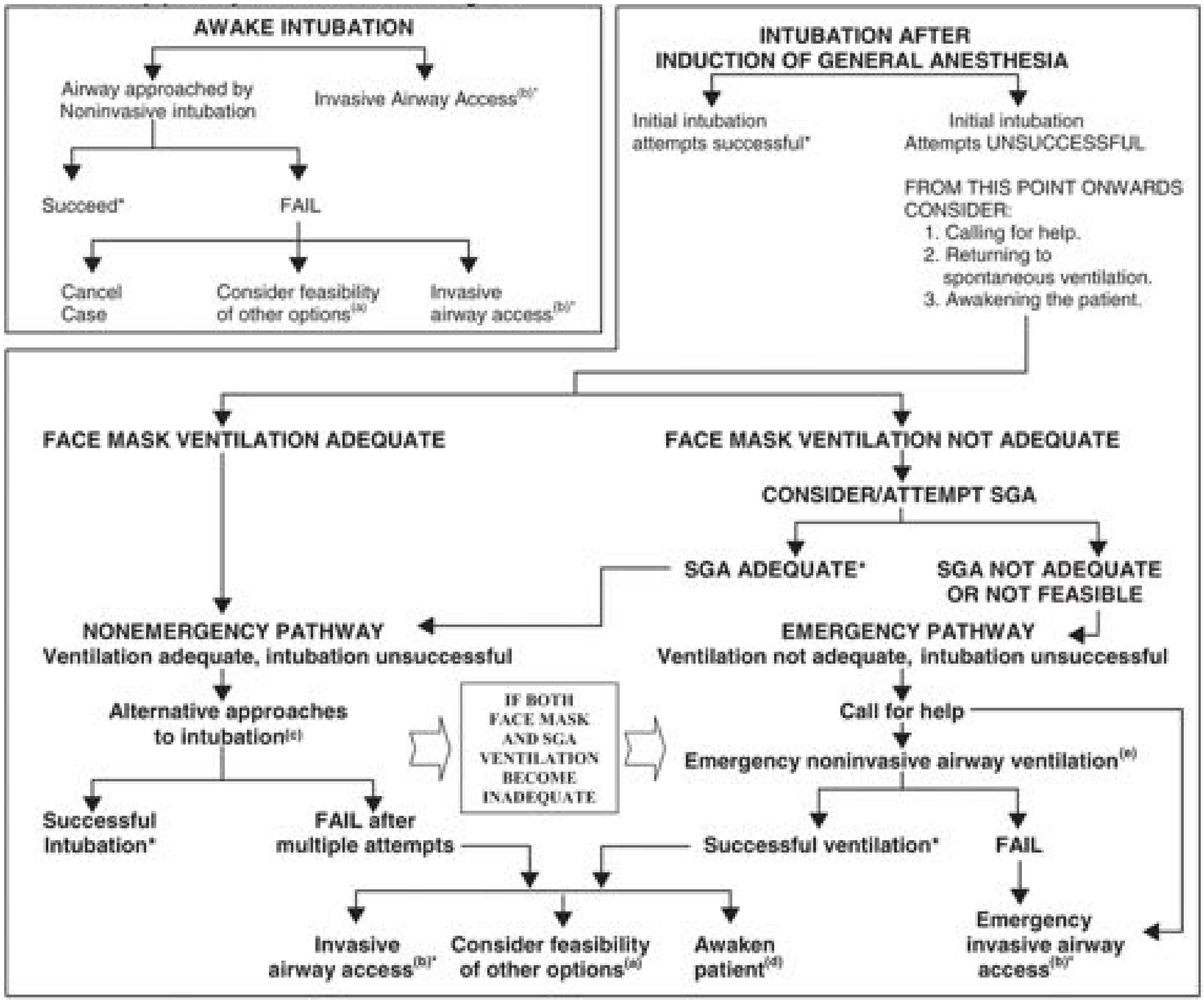
Appendix A: ASA Difficult Airway Algorithm



(Apfelbaum, et al., 2013)

Appendix B: Evidence Table

PICO Question: Among CRNAs, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?

Author & Date	**Aim & Research Design**	**Sample Size, Population & Setting**	**Methods**	**Measures & Outcomes**	**Study Findings that Answer the PICO**	**Limitations**	**Evidence Rating**	
							Level	**Quality**
Berwick, Gauntlett, Silverio, Wallace, Mercer, Brown, Sandars, Morton, & Groom, 2019	To implement a collaborative surgical and anaesthetic training package to address perceived anaesthetic reluctance to perform surgical cricothyroidotomy Mixed methods pilot study	10 anesthetic specialist trainees Aintree University Hospital	The package consisted of theory teaching, surgical experience and repeated high-fidelity simulation. A standardized, high-fidelity in situ 'can't intubate, can't oxygenate' simulation was used to assess performance at baseline and at two weeks and six months after training	Self-efficacy was scored by participant self-assessment. Qualitative interviews identified themes related to participants perceptions and feelings regarding performing cricothythyrotomy before and after training. Performance was quantitatively assessed to	Self-efficacy scores improved from 50% to 87% after 2 simulations. Themes that were identified before training included reluctance to initiate cricothyrotomy and concern about performing it. Themes identified after training included feeling confident about performing	Small sample size	III	B

PICO Question: Among CRNAs, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?

Author & Date	**Aim & Research Design**	**Sample Size, Population & Setting**	**Methods**	**Measures & Outcomes**	**Study Findings that Answer the PICO**	**Limitations**	**Evidence Rating**	
							Level	**Quality**
				evaluate the training package	cricothyrotomy and less reluctance to initiate it.			
Hall, A. B., Riojas, R., & Sharon, D., 2014	The objective of this study is to compare post-training self-efficacy between artificial simulators and live animal training for the performance of emergency medical procedures	111 air force airmen Training center of the 81st Medical Group	Volunteers were randomized into a pig trachea group and a SimMan group and performed emergency medical procedures including cricothyrotomy. Volunteers were given a postlecture and postskills training assessment of self-efficacy.	Post skills training self-efficacy scores were significantly higher than post lecture scores for either training mode and for all procedures ($p < 0.0001$).	Cricothyrotomy simulation significantly increases participant perceived self-efficacy in performing the skill.		II	B

PICO Question: Among CRNAs, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?								
Author & Date	**Aim & Research Design**	**Sample Size, Population & Setting**	**Methods**	**Measures & Outcomes**	**Study Findings that Answer the PICO**	**Limitations**	**Evidence Rating**	
							Level	**Quality**
	Qausi-experimental study							
Kashat, Carter, Archambault ,Wang, & Kavanagh, 2020	To examine whether an airway simulation boot camp leads to an improvement in novice airway provider familiarity with the step-by-step approach to airway management described in the American Society of Anesthesiologi	60 anesthesia and otolaryngology residents	Participants took a pre and post intervention survey to assess their comfort level with airway procedures before and after participating in an airway bootcamp simulation course that included cricothyrotomy among other airway procedures	Level of familiarity and comfort level with the airway procedures was measured before and after simulation.	Significant improvement ($p<.001$) in familiarity was reported and the number of residents reported lack of comfort with cricothyrotomy went from 90% pre-simulation to 42% post simulation	Small sample	II	B

PICO Question: Among CRNAs, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?								
Author & Date	**Aim & Research Design**	**Sample Size, Population & Setting**	**Methods**	**Measures & Outcomes**	**Study Findings that Answer the PICO**	**Limitations**	**Evidence Rating**	
							Level	**Quality**
	sts (ASA) difficult airway algorithm and with surgical airway techniques and modifications Quasi-experimental Study							
Rajwani, Mauer, & Clapper, 2019	To improve the confidence and confidence of critical care fellows in performing cricothyrotom y using simulation	11 pulmonary critical care fellows	Participants received a pre-intervention survey, instruction and practice on cricothyrotomy, simulation of cricothyrotomy, and a post intervention survey	Knowledge was assessed using a 10-question test pre and post intervention. Self-perceived confidence and confidence were assessed using a Likert scale questionnaire. Procedural skill	Participants demonstrated significant improvement in self perceived confidence and competence	Small sample size	II	B

PICO Question: Among CRNAs, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?								
Author & Date	**Aim & Research Design**	**Sample Size, Population & Setting**	**Methods**	**Measures & Outcomes**	**Study Findings that Answer the PICO**	**Limitations**	**Evidence Rating**	
							Level	**Quality**
	Quasi-experimental study			was assessed before and after instruction by assigning one point to each step of the procedure				
Scott-Herring, Morosanu, Bates, & Batoon, 2020	Evaluate whether a simulated "cannot intubate, cannot ventilate" scenario with cricothyrotomy would increase the likelihood of successful completion in less than 2 minutes and increase	44 CRNAs A large academic medical center in the mid-Atlantic region	Participants performed emergency cricothyrotomies on a simulation manikin using one of three techniques available. Participants were timed with a cell phone timer. Confidence levels assessed with data collection sheet.	Technique selection and performance were recorded until successful confirmation of placement was achieved in less than 2 minutes. Confidence levels performing cricothyrotomy were also measured before and after simulation.	The confidence of CRNAs in performing a successful cricothyrotomy in less than 2 minutes was significantly increased after simulation	Small sample size	III	B

PICO Question: Among CRNAs, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?								
Author & Date	**Aim & Research Design**	**Sample Size, Population & Setting**	**Methods**	**Measures & Outcomes**	**Study Findings that Answer the PICO**	**Limitations**	**Evidence Rating**	
							Level	**Quality**
	CRNA confidence levels Prospective cohort study							
Shaw & Hughes, 2020	To evaluate a 3-dimensional printed bleeding cricothyrotomy trainer in increasing paramedic comfort level and procedural competence Quasi-experimental study	44 paramedics Hospital based ambulance service, Northern Arizona	Participants completed cricothyrotomy training using a reusable, bleeding trainer and took a pre and post-intervention survey	Procedural skill comfort level was measured using a a 10-point visual analog scale anchored at 1 (extremely unconfident), 5 (neutral), and 10 (extremely confident)	Significant improvement in procedural skill comfort level after cricothyrotomy training	Small sample size	II	B

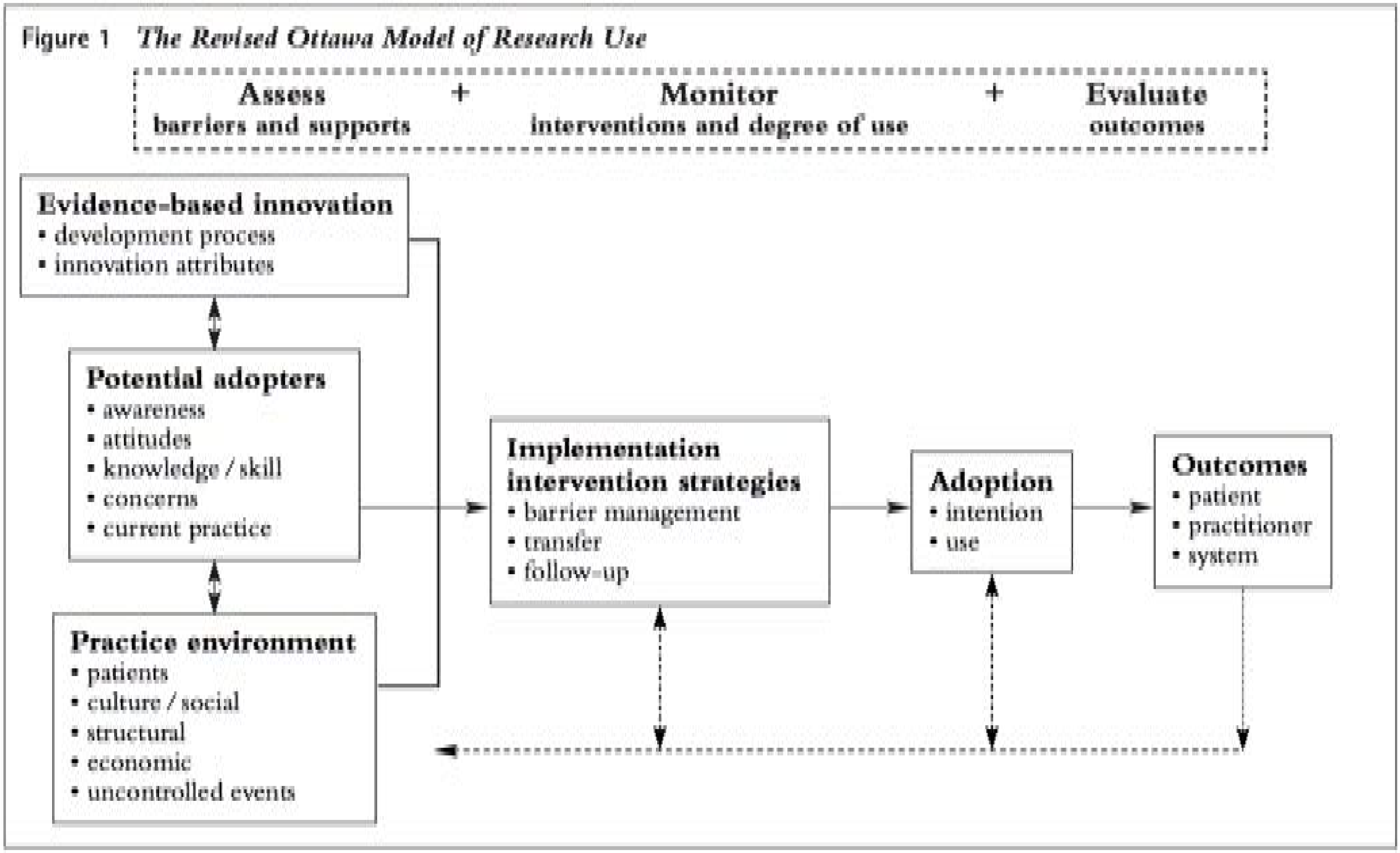
PICO Question: Among CRNAs, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?

Author & Date	**Aim & Research Design**	**Sample Size, Population & Setting**	**Methods**	**Measures & Outcomes**	**Study Findings that Answer the PICO**	**Limitations**	**Evidence Rating**	
							Level	**Quality**
Wray, Khan, Ray, Rowe, Boysen-Osborn, Wiechmann, & Toohey, 2019	To compare a bleeding cric trainer to the standard simulation model Randomized control non-inferiority study	17 UC Irvine fourth year medical students and emergency medicine residents. UC Irvine School of Medicine Simulation Center	Participants were randomized into the standard SimMan group or the bleeding cric trainer group, received a pre-intervention survey, and an instructional session on cricothyrotomy using the model they were randomized to. All participants then performed cricothyrotomy on a pig trachea. The participants then performed the simulation on the model that they were not	Primary outcome: Completion of a cricothyroidotomy on the pig model evaluated by a previously validated Objective Structured Assessment of Technical Skills (OSATS) Secondary outcome: Participants' comfort levels measured by the visual analog scale before and after training and evaluation and realism rating on each model	Participants in both groups reported significantly improved comfort levels with performing cricothyrotomy after simulation	Small sample size	I	B

PICO Question: Among CRNAs, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?

Author & Date	Aim & Research Design	Sample Size, Population & Setting	Methods	Measures & Outcomes	Study Findings that Answer the PICO	Limitations	Evidence Rating	
							Level	Quality
			randomized to. A post intervention survey was administered					

Appendix C: Ottawa Model of Research Use



(Graham & Logan, 2004)

Appendix D: Informed Consent

Strengthening Expertise Among Experts: A Cricothyrotomy Simulation to Improve Confidence and Competence Among Anesthesia Providers
Informed Consent Form

You are invited to participate in a research study on a realistic cricothyrotomy simulation to increase anesthesia provider self-perceived confidence in their ability to perform emergent cricothyrotomy in a cannot intubate, cannot oxygenate scenario. You were selected as a possible participant based on your expertise within the field of anesthesia. We ask that you read this form prior to participating in the study. You must be 18 years of age or older in order to participate**.**

Due to the COVID-19 Pandemic, all research projects must follow the health and safety guidelines developed by Cedar Crest College. These guidelines are aligned with those of the CDC and state and local health authorities. https://www.cedarcrest.edu/healthservices/pdf/CCC_HealthandSafetyPlan.pdf

This study is being conducted by **Bianca Garcia, BSN, RN, SRNA** and **Mary O'Connor, BSN, RN, SRNA** of Cedar Crest College Nurse Anesthesia Program, Class of 2022.

Background Information The purpose of this evidence-based practice project is to improve provider confidence to perform emergent cricothyrotomy in real "cannot intubate-cannot oxygenate" scenarios by implementation of a realistic cricothyrotomy simulation. Objectives in achieving this goal include:

- Anesthesia provider self-perceived confidence and competence in performing emergent cricothyrotomy will be improved after participation in a realistic cricothyrotomy simulation, as evidenced by data collected from pre- and post- intervention surveys collected by the DNP student.
- Anesthesia provider self-perceived confidence to recreate a realistic and cost-effective cricothyrotomy simulation model for adoption at their institution will be improved following a video demonstration on model assembly, as evidenced by data collected from pre- and post-intervention surveys collected by the DNP student.

This information will be added to the existing body of evidence on the efficacy of simulation to improve provider confidence in performing high-risk, low volume procedures.

Procedures
If you agree to be in this study, we will ask you to attend a simulation held at Cedar Crest College Simulation Center. Participants will perform a cricothyrotomy simulation of the scalpel-finger-bougie surgical cricothyrotomy technique on a realistic model consisting of porcine tissue overlying a 3D-printed trachea. Participants will be asked to complete an anonymous pre- and post-simulation survey evaluating their perceived confidence in performing emergent cricothyrotomy. You will be asked to view two brief educational videos prior to the simulation. The entire simulation course should take no more than 90 minutes.

Risks and Benefits

It is anticipated that participants will be at no psychological or emotional risk, and minor physical risk. Potential physical risk included cut injury due to the use of a scalpel during the simulation of a surgical procedure. First aid supplies will be immediately available in the event of an injury.

Potential benefits of participation include an increased confidence in the ability to perform the clinical skill, as well as earning continuing education credits by the American Association of Nurse Anesthetists (AANA).

Confidentiality

Responses to all online questionnaire items will be anonymous through the participants use of a unique identifier. All electronic data will be stored in password protected computers and/or files where the passwords are known only to the researchers**.** Data will be stored for a period of one year, and shall be erased or otherwise destroyed by August, 2022.

I consent to participate in the research project entitled "Strengthening Expertise Among Experts: A Cricothyrotomy Simulation to Improve Confidence and Competence Among Anesthesia Providers" being conducted in the Department of Nursing by Bianca Garcia, BSN, RN, SRNA and Mary, O'Connor, BSN, RN, SRNA.

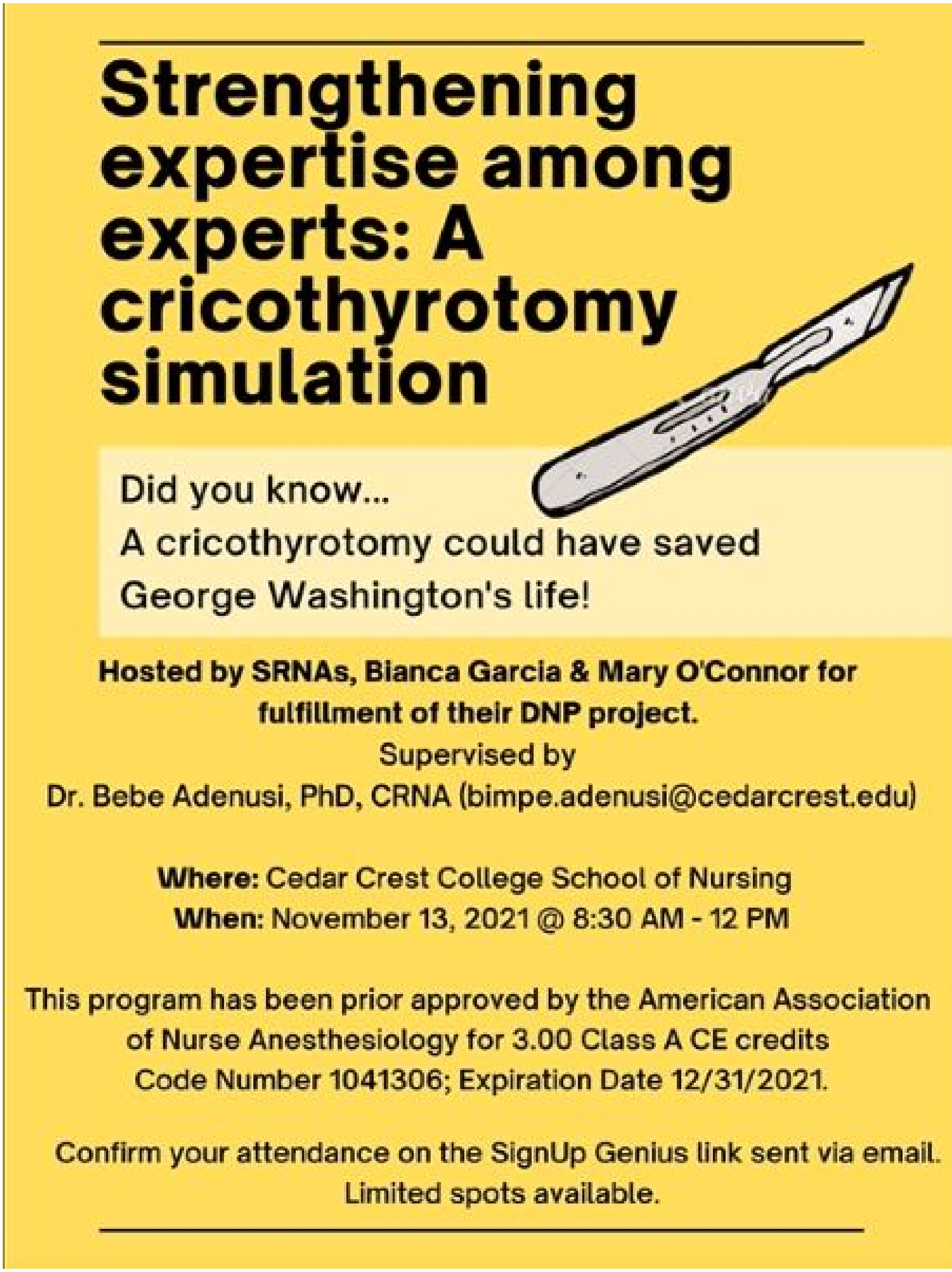
- I understand that my participation in this research is voluntary, and that I am free to withdraw my consent at any time and to discontinue participation in this project without penalty.
- I acknowledge that the general purpose of this study, the procedures to be followed, and the expected duration of my participation have been explained to me.
- I acknowledge that I have the opportunity to obtain information regarding this research project, and that any questions I have will be answered to my full satisfaction.
- I understand that no information will be presented which will identify me as the subject of this study unless I give my permission in writing.
- I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily.

Name (Print): ____

Date: __________________

Signature: ____

Appendix E: Invitation Flyer



Appendix F: Demographic Survey

Demographic survey

1. Have you received cricothyrotomy training in the last year?

   Yes No

2. Gender:

   Male Female Prefer Not to Say

3. Age in years:

   < 21 21-30 31-40 41-50 51-60 >60

4. Job title:

   CRNA Anesthesiologist

5. Years of anesthesia experience since completion of degree program or residency:

   < 6 6-10 11-15 16-20 21-25 >25

6. Number of scenario simulation experiences in the last 10 years (i.e., learning an induction sequence; case scenario; malignant hyperthermia or other crisis scenario):

   0 1-5 6-10 11-15 16-20 >20

7. Number of simulated cricothyrotomy placements in the last 10 years (task trainer, cadaver, or animal laboratory, etc.)

   0 1-5 6-10 11-15 16-20 >20

8. Total number of actual cricothyrotomy placements

   0 1 2 3 4 5 >5 (please specify number):_________

Appendix G: Pre-Simulation Survey

Pre-Simulation Survey

Please enter your unique identifier prior to answering these questions. The unique identifier must be the same as the demographic survey. The identifier should be the last two digits of your cell phone, followed by your middle initial (0, if you don't have one), followed by the month of your birth. Example: 220September

For each question, enter a numeric score correlating to your level of confidence:

0 10 20 30 40 50 60 70 80 90 100

Very unconfident Moderately confident Very confident

1. I feel confident in my decision making using the ASA difficult airway algorithm during airway emergencies ________

2. I can correctly and rapidly identify the cricothyroid membrane _________

3. I'm confident that I can successfully identify the supplies needed to perform a surgical cricothyrotomy via the scalpel-finger-bougie technique (i.e., scalpel size, tube size, etc.) ________

4. I can successfully perform a cricothyrotomy using scalpel-finger-bougie technique in an emergency cannot intubate, cannot oxygenate scenario ________

5. I can successfully assemble a realistic cricothyrotomy task trainer __________

Appendix H: Post-Simulation Survey

Post-Simulation Survey

For each question, enter a numeric score correlating to your level of confidence:

0 10 20 30 40 50 60 70 80 90 100

Very unconfident **Moderately confident** **Very confident**

After completing the cricothyrotomy simulation:

1. I feel confident in my decision making using the ASA difficult airway algorithm during airway emergencies ________

2. I can correctly and rapidly identify the cricothyroid membrane _________

3. I'm confident that I can successfully identify the supplies needed to perform a surgical cricothyrotomy via the scalpel-finger-bougie technique (i.e., scalpel size, tube size, etc.) ________

4. I can successfully perform a cricothyrotomy using scalpel-finger-bougie technique in an emergency cannot intubate, cannot oxygenate scenario ________

5. I can successfully assemble a realistic cricothyrotomy task trainer __________

Appendix I: Cost Benefit Analysis

	No intervention	**Commercial Cricothyrotomy Simulator**[b]	**Realistic cricothyrotomy trainer model**
One-time materials expenses	$0	$2,246	$50
Recurring expenses (For additional uses)	$0	$266 - Replacement Trachea $464 - Replacement skin flaps	~$2.60- Porcine tissue $0-$30 - 3D printed trachea (100 uses)
Other expenses	$39,748* – Median cost of litigation[a]	N/A	N/A

Note. Cost considerations for the realistic cricothyrotomy trainer compared to a commercial cricothyrotomy simulation model.
[a] Average cost of litigation against anesthesia related to airway claims in cases of hypoxia and/or death (Cook et al., 2010).
[b] Commercial cricothyrotomy simulator and associated products are from American 3B Scientific Supply (n.d.), a medical simulator supply company.
*Converted to dollars from pounds

Appendix J: Cricothyrotomy Model

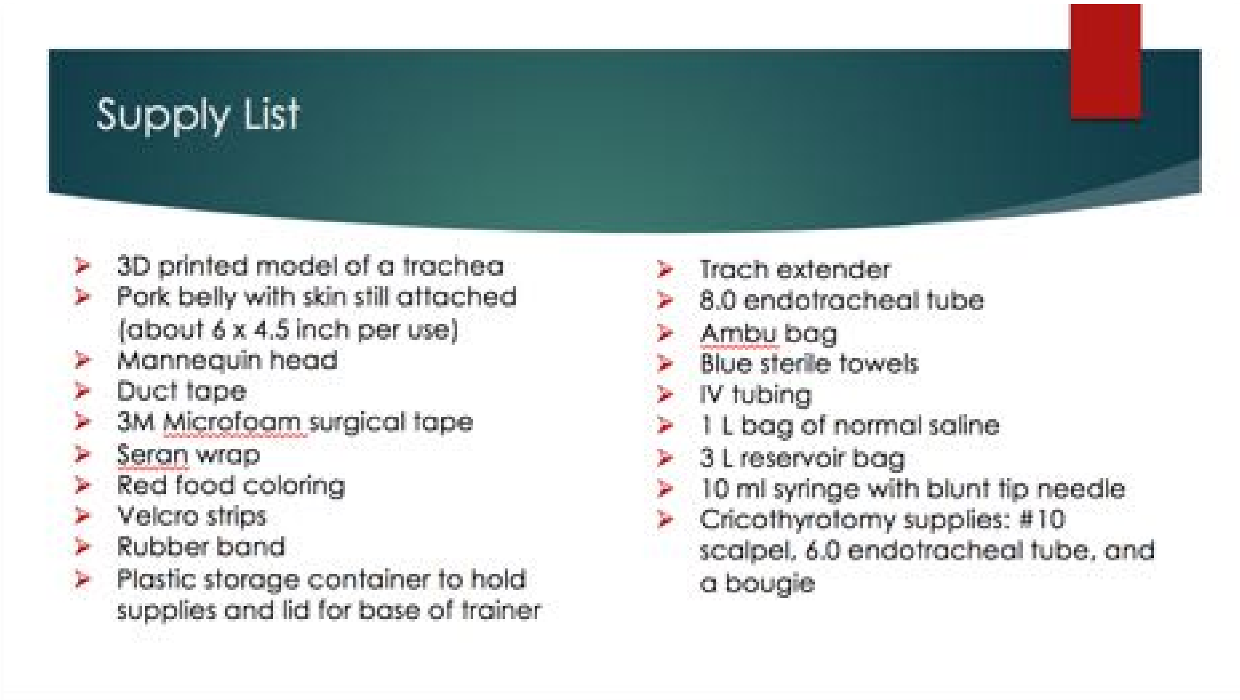


Figure 1. Supply list

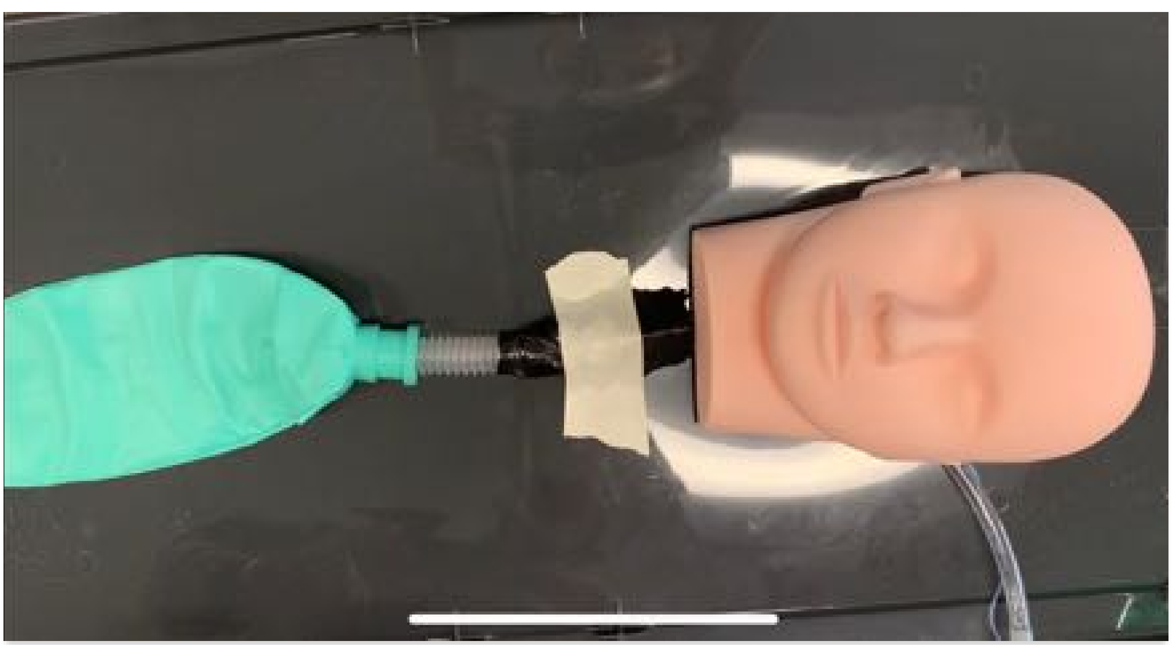


Figure 2. Cricothyrotomy model dry supplies

Figure 3. 3D printed trachea

Figure 4. Pork belly

Figure 6. Completed model