Strengthening Expertise Among Experts:

A Cricothyrotomy Simulation to Improve Anesthesia Provider Confidence

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Author Note

There is no known conflict of interest.

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

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Abstract

A cricothyrotomy is usually performed during a “cannot intubate, cannot oxygenate” (CICO) scenario when all other interventions have failed to successfully secure a patent airway. Anesthesia providers are among the select few specialties that are qualified to perform this lifesaving procedure. However, the need for a cricothyrotomy is rare, which leaves anesthesia providers to feel unconfident in their ability to establish an emergency surgical airway simply from the lack of practice opportunities. A hesitant provider can delay intervention which has been associated with poor patient outcomes related to prolonged states of hypoxia, including death. Current literature reveals that cricothyrotomy simulation is a practical approach to improve provider’s self-perceived confidence levels. Therefore, a realistic and cost-effective cricothyrotomy simulation course was designed and implemented for anesthesia providers. An increased sense of realism was achieved through adaptation of the REAL Cric Trainer and the use of porcine tissue, simulated bleeding, and a flash of air once the cricothyroid membrane is punctured (Kei et al., 2018). A pretest/posttest design was utilized to measure the impact of simulation on the anesthesia provider's self-perceived confidence levels. Data analysis revealed significant increases in self-perceived confidence scores following participation within the cricothyrotomy simulation course. High-fidelity simulation allows anesthesia providers with an opportunity to practice and strengthen their skills, especially those that are necessary during an airway emergency and the patient’s life depends on it.

Keywords: cricothyrotomy, simulation, confidence, CRNA, anesthesia, emergent surgical airway, porcine tissue

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Chapter I: Introduction and Overview of the Problem of Interest

Cricothyrotomy is an emergent, lifesaving procedure utilized to establish a patent airway often within a "cannot intubate, cannot oxygenate" (CICO) scenario when all other routine methods have failed or are contraindicated. A cricothyrotomy is the final intervention of the American Society of Anesthesiologist's (ASA) difficult airway algorithm to reduce the likelihood of adverse outcomes related to hypoxia such as cardiopulmonary arrest, anoxic brain injury, and death (Apfelbaum et al., 2013). A cricothyrotomy technique is performed by perforating the cricothyroid membrane (CTM) and establishing an artificial airway into the trachea (Nagelhout & Elisha, 2018). Although this procedure is within the scope of practice for airway experts, including anesthesiologists and certified registered nurse anesthetists (CRNAs), its occurrence rate is rare. Therefore, cricothyrotomy is generally considered a "high risk, low frequency" procedure. Due to this procedure's infrequency, maintaining provider confidence and competence to perform cricothyrotomy is a challenge. Rehearsal of this critical airway procedure is warranted to ensure provider confidence and competence and reduce the morbidity and mortality associated with a CICO scenario.

Background and Significance

To maintain a patient's ventilation and oxygenation status during a general anesthetic for surgery or during an emergent situation, placement of an artificial airway (i.e., supraglottic airway, endotracheal tube) is necessary. However, there are situations when a difficult airway is present, and the anesthesia provider may not intubate or establish adequate oxygenation and ventilation successfully. When intubation and oxygenation efforts have failed, this is termed a

CICO scenario. According to the ASA difficult airway algorithm, invasive airway access such as cricothyrotomy is the final recommendation to establish a patent airway during a CICO scenario (Apfelbaum et al., 2013) (Appendix A). In addition to the failed airway, other indications for a cricothyrotomy include "traumatic injuries of maxillofacial, cervical spine, head, or neck structures that make intubation through the nose or mouth difficult to impossible or too time-consuming, immediate relief of an upper airway obstruction, and the need for a definitive airway for neck or facial surgery, assuming intubation is not possible" (Nagelhout & Elisha, 2018, p. 431). If a CICO scenario is not promptly treated and reversed, irreversible hypoxia will lead to adverse outcomes and potential death.

Fortunately, CICO incidence is rare, occurring in 1 in every 50,000 general anesthetics and 1 in every 600 emergency department intubations (Cook & MacDougall-Davis, 2012). Although rare, the occurrence of a CICO scenario that necessitates a cricothyrotomy accounts for up to 25% of anesthesia-related deaths according to the ASA Closed Claims Project (ASACCP) (Cook & MacDougall-Davis, 2012). A significant barrier to cricothyrotomy has been attributed to provider cognitive factors, which leads to an unacceptable delay in the decision to perform the emergent surgical airway (McKenna et al., 2021). In fact, the ASACCP reports that 2/3 of emergent surgical airways were completed too late to prevent adverse outcomes (Cook & MacDougall-Davis, 2012). A reluctance to perform an emergency surgical airway is likely the most common cause of delay (Hamaekers & Henderson, 2011).

According to reports from the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society (NAP4), when anesthesiologists attempted cricothyrotomies, a staggering 65% of them failed (Cook & MacDougall-Davis, 2012). Of further concern, a Canadian national survey of 971 anesthesiologists found that only 57% of respondents stated they felt comfortable performing a cricothyrotomy (Wong et al., 2005). Due to the rarity of cricothyrotomies, anesthesia providers have minimal opportunities to practice this lifesaving procedure to become proficient, thus reducing their confidence levels.

Although the need to perform a cricothyrotomy is rare, regular training and practice in emergent front-of-neck access and subglottic techniques are essential. A cricothyrotomy may be performed by either a needle or surgical method. A needle cricothyrotomy is performed by puncturing the CTM with a needle followed by placing a large-bore angiocatheter for temporary percutaneous transtracheal jet ventilation (PTJV) (Nagelhout & Elisha, 2018). The Seldinger method is a surgical technique that requires a manufactured kit, such as the Melker Universal Emergency Cricothyrotomy Catheter Set (Nagelhout & Elsiha, 2018). The Seldinger method incorporates an initial needle puncture of the CTM followed by the insertion of an airway dilator/catheter placed over guidewire for a more definitive airway (Nagelhout & Elisha, 2018). An alternative surgical cricothyrotomy method, also known as the scalpel-finger-bougie technique, uses equipment that is commonly found in most operating rooms, including a scalpel, bougie catheter, and a 6.0-6.5-millimeter endotracheal tube (Nagelhout & Elisha, 2018). The scalpel-finger-bougie technique involves a vertical incision of the skin, finger palpation of the CTM, a transverse incision of the CTM, bougie insertion, and placement of the endotracheal tube over the bougie into the trachea (Nagelhout & Elisha, 2018).

Wong et al. (2014) surveyed 997 anesthesiologists about their preferences, experience, and comfort regarding airway equipment in difficult intubation and CICO situations in adult patients. Results revealed that 39% of respondents preferred the wire-guided cricothyrotomy as their first choice (i.e., Seldinger method), 28% preferred the intravenous catheter cricothyrotomy, and 23% would defer to tracheostomy performed by a surgeon (Wong et al., 2014). Despite the presence of multiple choices and alternatives to perform a cricothyrotomy, a metanalysis of prehospital airway management revealed success rates of 90.5% for surgical cricothyrotomy and only 65% for needle cricothyrotomy (Hubble et al., 2010). In fact, the most extensive single reported series of scalpel-finger-bougie cricothyrotomies came from the London Air Ambulance Service with a reported 98 scalpel-finger-bougie cricothyrotomies performed by anesthetists and emergency medicine doctors with a 100% success rate (Lockey et al., 2014). The high success rate was attributed to several factors, including a positive mental attitude, immediate availability of equipment, and a simple, well-practiced technique (Lockey et al., 2014).

At extreme stress levels, practitioners are susceptible to increasingly elevated heart rates, cognitive deterioration, decreased reaction times, perceptual narrowing, hypervigilance, and fine/complex motor skill deterioration (Baker et al., 2016). The fine motor skills requiring accuracy and cognition, such as threading a guidewire during the Seldinger method, may deteriorate during an airway catastrophe due to significantly elevated heart rates (Baker et al., 2016). The physiological response to a stressful event can negatively impact provider performance, thus affecting patient outcomes. Therefore, cricothyrotomy training should be designed to inspire confidence and emphasize simplicity (Baker et al., 2016). The simple scalpel-finger-bougie technique minimizes the need for fine motor control, requires minimal equipment easily accessible in operating rooms, and is associated with increased success rates compared to needle cricothyrotomy (Baker et al., 2016; Hubble et al., 2010). Although anesthesia providers may prefer the wire-guided approach, the current literature supports the alternative scalpel-finger-bougie technique as it is most likely to achieve the primary goal of establishing oxygenation and preventing death.

PICO Question Guiding Inquiry

Given the rarity of cricothyrotomies and minimal practice opportunity, the DNP project authors developed the following PICO question: "Among anesthesia providers, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competence in performing emergent cricothyrotomy?" The purpose of this project was to evaluate the impact of a realistic cricothyrotomy simulation on anesthesia provider's perceived confidence and competence levels to perform a cricothyrotomy. The cricothyrotomy simulation method included the scalpel-finger-bougie technique, as it is associated with the most successful outcomes compared to other alternatives.

System and Population Impact

Not only is difficult airway management a significant challenge, but it is also the most critical patient safety concern in the practice of anesthesiology. The challenges associated with difficult airway management are the leading cause of death and legal ramifications within anesthesiology (Cook & MacDougall-Davis, 2012). Therefore, it is fundamental that anesthesia providers receive the best available training in airway management skills. While anesthesia providers rarely practice cricothyrotomy in real life, every practitioner should be proficient in performing this lifesaving procedure. Simulation training is the most optimal method to teach anesthetists the hands-on skill of cricothyrotomy, which can be done on a high-fidelity simulator with the replaceable/consumable trachea and skin or cadavers (Green et al., 2016). Findings from a study by Boet et al. (2011) demonstrated that a single high-fidelity simulation training session improves and increases the retention of cricothyrotomy skills for at least one year.

Upon implementation of the cricothyrotomy simulation, anesthesia providers initially viewed an educational module on cricothyrotomy before performing the cricothyrotomy simulation on the intended task trainer. After completion of the cricothyrotomy simulation, participants then viewed an instructional video module on the cricothyrotomy task trainer assembly. The anticipated system and population impact will result from improved provider self-perceived confidence and competence to perform an emergent surgical airway within a real-life scenario. In addition, the instructional video was developed to encourage and increase provider confidence to recreate the realistic cricothyrotomy simulation model for future simulation-based training sessions at their respective institutions. Implementation of simulation-based anesthesia training within the workplace is recommended to improve high-quality, safe patient care (Higham & Baxendale, 2017). Routine hands-on cricothyrotomy skills training and improved provider confidence will significantly impact patient outcomes within a CICO scenario. Overall, improved confidence and reduced reluctance to perform a lifesaving cricothyrotomy will potentially prevent detrimental hypoxia-related injuries, including death.

Purpose

The lack of opportunities to practice cricothyrotomy and low confidence among anesthesia providers is a critical concern for patient safety and patient outcomes. Anesthesia providers cannot develop and maintain their cricothyrotomy skill proficiency due to limited exposure, which significantly increases the risk of adverse patient outcomes in a CICO scenario. Given this patient safety issue, strategies to provide practice opportunities and improve anesthesia provider confidence levels are obligatory.

Simulation-based education has become an integral component of anesthesia training to increase confidence in clinical decision-making while also expanding clinical knowledge (Green et al., 2016). More specifically, anesthesia providers are encouraged to routinely utilize simulation training to manage clinical crises, such as CICO events (Green et al., 2016). Thus, the purpose of this evidence-based project was to determine whether a cricothyrotomy simulation will increase anesthesia provider's self-perceived confidence and competence to perform an emergent surgical airway during a CICO scenario.

The cricothyrotomy simulation model that was recreated for this DNP project was a model that was intended to be highly realistic, cost-effective, and simple to replicate. The REAL Cric Trainer is a model that consists of simulated bleeding, a flash of air, and porcine tissue to mimic human flesh (Kei et al., 2018). These are elements that are generally missing from traditional simulation models. Cricothyrotomy experts compared the REAL Cric Trainer to commercial dry simulation models and found the REAL Cric Trainer superior in terms of external appearance, realism, tactile fidelity, and usefulness within a simulation scenario (Calvo et al., 2021).

Objectives

This evidence-based project aimed to improve provider confidence to perform cricothyrotomy in a CICO scenario by implementing a realistic and cost-effective cricothyrotomy simulation. The desired results of this project were formulated into the following objectives:

1. Anesthesia provider's self-perceived confidence to perform an 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 students.
2. Anesthesia provider's self-perceived confidence to recreate a realistic and cost-effective cricothyrotomy simulation model for adoption at their institution for the purpose of additional practice opportunity 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 students.

Following DNP project implementation, the expected outcomes included improved provider perceived confidence to perform an emergent cricothyrotomy within the clinical setting and improved provider perceived confidence to recreate and adapt the cricothyrotomy model at their institutions.

Chapter II: Review of Evidence/Literature

Search Methodology

A literature review began with an online search of Google Scholar, PubMED, and CINAHL databases. The key terms used for the literature search were "cricothyrotomy," "anesthesiologist," "nurse anesthetist," "CRNA," "cricothyroidotomy," "simulation," "self-efficacy," and "confidence." Results were limited to a time frame of 2015 to 2021 to find the most current literature. The literature search yielded 531 articles total between all three databases. The results were further limited to research from peer-reviewed journals, and all non-research publications were excluded. The primary inclusion criteria consisted of a population of healthcare specialties licensed to perform cricothyrotomy within their scope of practice. The publications included a cricothyrotomy simulation as the intervention to evaluate the provider's pre-and post-simulation confidence levels. All publications that did not assess the impact of cricothyrotomy simulation on a provider's confidence levels were excluded. A total of six research publications were chosen for review to address the specific clinical question.

Evidence Synthesis of Findings

Following a thorough literature search, the evidence from selected publications were reviewed and synthesized to evaluate the effect of cricothyrotomy simulation on provider's perceived confidence levels (See Appendix B). The purpose of this literature review was to gather evidence from recent studies of high levels of strength and quality to formulate a project design to address the clinical problem.

The study populations included a vast array of specialties, including anesthesiology residents, otolaryngology residents, medical students, certified registered nurse anesthetists (CRNAs), pulmonary critical care fellows, paramedics, and Air Force medics (Hall et al., 2014;

Kashat et al., 2020; Rajwani et al., 2019; Scott-Herring et al., 2020; Shaw & Hughes, 2020; Wray et al., 2019). Each study implemented some form of cricothyrotomy simulation and evaluated its impact on provider's confidence levels, measured by surveys administered pre-and post-simulation. Studies conducted by Hall et al. (2014) and Wray et al. (2019) randomly divided their study participants into two simulation groups to compare confidence levels following a realistic simulation model versus a traditional dry mannequin. Findings from Hall et al. (2014) demonstrated a statistically significant increase in self-efficacy scores for both models ($p < 0.0001$) with a preference for live animal training ($p < 0.0001$). Results from Wray et al. (2019) were similar, with a statistically significant increase in comfort levels post-intervention for the realistic trainer ($p = 0.021$) and traditional simulation model ($p = 0.014$).

The remaining studies conducted by Kashat et al. (2020), Rajwani et al. (2019), Scott-Herring et al. (2020), and Shaw and Hughes (2020) consisted of a quasi-experimental design with results that demonstrated a statistically significant increase in provider's self-perceived confidence levels to perform cricothyrotomy after simulation training ($p < 0.001$, $p <0.005$, $p \leq .001$, and $p < 0.001$ respectively). The cricothyrotomy models varied between studies with the incorporation of either a porcine model trachea, three-dimensional printed bleeding cricothyrotomy trainer, or standard dry mannequin (Kashat et al., 2020; Rajwani et al., 2019; Scott-Herring et al., 2020). The central theme noted within the existing literature is the support of simulation as a practical approach to improve provider confidence and reduce reluctance to perform a cricothyrotomy within a real-life clinical scenario.

Limitations

Several limitations were noted among the various studies. The first limitation is the lack of a consistent cricothyrotomy simulation model utilized across all studies with varying degree of costs. Although all studies employed different forms of cricothyrotomy training models, findings still demonstrated increased provider self-perceived confidence with each model. These findings suggest that providing any practice opportunity to perform a rare, lifesaving skill, through simulation-based training is an effective tool to improve provider confidence. Another limitation noted is the wide variation of healthcare specialties beyond anesthesiology included within the study population. However, the results of each study apply to the research question because each healthcare specialty is qualified and licensed to perform an emergent cricothyrotomy. Lastly, all studies had small sample sizes, which hinders the generalizability of results. Despite small sample sizes, these findings demonstrate clinical significance to the problem of limited practice opportunities to become proficient and confident in performing an emergent surgical airway.

Chapter III: Organizational Framework of Theory

A framework served as a guide to translate the current evidence into practice through implementation of a cricothyrotomy simulation course for anesthesia providers. The Ottawa Model of Research Use (OMRU) was the chosen theoretical framework to guide this quality improvement project (See Appendix C). The OMRU framework consists of three phases: 1) assessment of barriers and supports, 2) monitoring of intervention and extent of use, and 3) evaluation of outcomes (Graham & Logan, 2004). The OMRU framework was chosen because it was specifically designed to guide healthcare providers during translation of evidence-based practice with special consideration of various factors that affect successful implementation (Graham & Logan, 2004). The OMRU framework has helped guide successful implementation of a nurse-led strategy for hypertension detection and management in an outpatient clinic in Uganda (Katende & Donnelly, 2016).

The first phase was an assessment of the evidence-based practice, potential adopters, and the practice environment (Katende & Donnelly, 2016). The initial phase allowed for an assessment of the feasibility and compatibility of the intervention within a specific context (Huybrechts et al., 2021). The first phase began with a literature search to identify the evidence-based innovation that addressed the clinical problem of reduced confidence among anesthesia providers to perform a cricothyrotomy. The current evidence demonstrated the use of simulation as an effective method to practice cricothyrotomy skills and improve anesthesia provider confidence. The potential adopters were identified as anesthesia providers including CRNAs and anesthesiologists which have demonstrated interest in participating within the simulation course. The ability to obtain buy-in from key stakeholders (i.e., anesthesia department nurse educator, staff anesthesia providers) demonstrated support for this DNP project. An assessment of the practice environment and current cricothyrotomy training methods was completed by an organizational gap analysis and needs assessment of the clinical site.

A meeting was held with the clinical site's nurse anesthesia department educator to discuss their current cricothyrotomy training methods for anesthesia providers. The anesthesia department educator indicated they have no preferred method for cricothyrotomy, nor does the institution have a simulation model available for skills training. To fill the gap between current and best practices supported by literature, the DNP project authors implemented a cricothyrotomy simulation for anesthesia providers at the Cedar Crest College (CCC) School of Nursing (SON). Potential barriers to successful implementation were also identified within the initial phase of the OMRU model (Graham & Logan, 2004). A major barrier for this project was recognized, such as insufficient time to participate in the entire simulation within a work shift break period. Following discussion with the project mentor and various CRNAs, the decision was made to modify the simulation location to the authors' academic institution to overcome this barrier.

The second phase of the OMRU comprised of implementation methods, monitoring, and degree of use (Graham & Logan, 2004). The primary implementation methods included an educational PowerPoint presentation on cricothyrotomy, a hands-on simulation using the cricothyrotomy simulation model, followed by an instructional video with demonstration on how to replicate the simulation model. Monitoring and data collection occurred by the distribution of self-efficacy surveys pre-and post-simulation. The electronic surveys were housed on a Wix website created by the project authors. The degree of use and plan for project sustainability was achieved by the development of an instructional video on the simulation model assembly for future reference and adoption at the participant's institutions. Participant confidence to adopt and re-create the simulation model for future training sessions were assessed within the self-efficacy survey. The project authors have intended to perform a follow-up with a local institution one year after the cricothyrotomy simulation course to assess their plan for continued simulation-based training sessions.

The final phase of the OMRU model evaluated the outcomes on the patient, practitioner, and system (Graham & Logan, 2004). The pre- and post-simulation surveys results were analyzed and compared through an online statistical software. Once the data was analyzed, the primary outcomes of the simulation were evaluated. During the final phase of the OMRU model, the project authors were able to determine whether the implementation of a realistic cricothyrotomy simulation was an effective method to improve anesthesia provider confidence to perform a cricothyrotomy within a real-life scenario.

Chapter IV: Project Design

Institutional Review Board (IRB) Approval

To ensure the protection of participant rights and safety, an application for limited review was submitted to the Cedar Crest College IRB and final approval was obtained on September 13, 2021. The project participants were voluntarily recruited, and full consent was obtained prior to the cricothyrotomy simulation course. Minor physical injury risk related to the use of sharp objects (i.e., scalpel) and possible cut injury was mentioned within the informed consent. A first-aid kit was readily available in the event of a cut injury. Participants were also informed on the handling of raw pork which will require the use of appropriate PPE (i.e., gloves, gown). The data collected did not contain any potential identifiers to ensure the privacy and anonymity of project participants. The survey responses were also submitted electronically and remained entirely anonymous.

Implementation Plan

Before participant recruitment began, availability of the CCC School of Nursing's Simulation Center needed approval by the simulation lab manager and Dean of Nursing. Once the simulation date was finalized for November 13, 2021, several recruitment methods were employed. These methods included face-to-face conversations with key stakeholders, mass e-mail invitation to local anesthesia providers, creation of an invitation flyer (See Appendix D), and advertisement of continuing education credits. The project authors obtained prior approval of 3.00 Class A continuing education credits (Code Number 1041306) through the American Association of Nurse Anesthesiology (AANA). The addition of approved continued education credits was an extra incentive for anesthesia providers to participate within this project. Invitation flyers were also posted at local anesthesia departments. Interested participants were then instructed to confirm their attendance on a Sign-Up Genius link as limited spots were available.

On the day of the simulation event, participants were asked to electronically sign an informed consent (See Appendix E), complete a demographic survey, and pre-simulation self-efficacy survey. Once surveys were completed, participants then viewed a slide presentation on cricothyrotomy including indications, complications, contraindications, and techniques. The participants then watched a video demonstration of a project author performing a simulated cricothyrotomy with the scalpel-finger-bougie technique. Following the slide presentation and video demonstration, two stations were available for participants to perform the hands-on cricothyrotomy simulation on the realistic, cricothyrotomy task trainer in the simulation center operating room. Once all participants completed the hands-on simulation, they viewed an additional slide presentation on the specific cricothyrotomy task trainer that was used within the simulation. Details such as task trainer fidelity, supplies, costs, and model assembly were discussed. An instructional video on task trainer assembly, filmed by the project authors, was shown for potential adoption of future cricothyrotomy simulation-based trainings. Lastly, the participants completed the post-simulation self-efficacy survey.

Data Collection Tools

Data was collected by distribution of electronic surveys. These surveys included a demographic survey (See Appendix F), pre-simulation survey (See Appendix G), and post-simulation survey (See Appendix H). Each survey was developed with Google Forms and embedded into a Wix website page specifically created for the implementation of this project. To maintain anonymity and link the pre- and post-simulation surveys, participants created a unique identifier consisting of the last two digits of their phone number, middle initial, and birth month (i.e., 26BApril).

The demographic survey was adapted with permission by Bartolomeo et al. (2019). Data such as provider role, anesthesia experience, prior simulation experiences, and number of actual cricothyrotomies performed was obtained. A pre-simulation self-efficacy survey was used to evaluate anesthesia provider baseline self-perceived confidence levels to perform an emergent cricothyrotomy. Following participation in the simulation workshop, a post-simulation self-efficacy survey was used to evaluate the impact of a cricothyrotomy simulation on their self-perceived confidence levels.

A validated measurement tool that measures self-perceived confidence to perform a cricothyrotomy does not currently exist. Therefore, the project authors adapted the self-efficacy scale developed by psychologist, Albert Bandura, famously known for introducing the socio-cognitive theory of perceived self-efficacy (Bandura, 1977). Within the social cognitive theory, Bandura defines self-efficacy as the judgement of one's ability to organize and execute given types of performances (Bandura, 1977). Thus, a survey was developed in accordance with Bandura's (2006) guide for constructing self-efficacy surveys and confidence levels were rated according to his 100-point self-efficacy scale. The 100-point scale structure for rating self-efficacy, ranged in 10-unit intervals from 0 ("Cannot do"); through intermediate degrees of confidence, 50 ("Moderately can do"); to complete self-confidence, 100 ("Highly certain can do") (Bandura, 2006).

Bandura's (2006) 100-point self-efficacy scale has been applied in many different contexts and studies as a method to measure self-efficacy. Numerous studies have confirmed the validity and reliability of questionnaires that have successfully adapted Bandura's self-efficacy scale structure. For example, Fueyo-Diaz et al. (2018) developed a valid, reliable, and feasible measurement tool to evaluate the self-efficacy of Celiac disease patients and their ability to adhere to a gluten-free diet. As a result of various successful adaptations of Bandura's self-efficacy scale, the project authors determined that Bandura's self-efficacy scale structure as an effective method to accurately measure anesthesia provider's self-perceived confidence to perform an emergent cricothyrotomy.

Resources Needed

There were numerous resources required to implement the cricothyrotomy simulation workshop. Most of the supplies required to build two realistic, cricothyrotomy task trainers (one per station) consisted of items that can be borrowed from the CCC Simulation Center or found in a standard operating room or anesthesia supply room. Supplies that were not found in the CCC Simulation Center were donated the project author's primary clinical site. Two 3-D printed tracheas were kindly donated by a member of the community. Additional non-operating room supplies were bought on Amazon (i.e., first aid kit, plastic storage containers, mannequin heads, red food coloring). Pork belly with skin still attached was the key component of this cricothyrotomy task trainer and was bought at a local butcher shop. The CCC Simulation Center was used to film the cricothyrotomy simulation video and instructional video on cricothyrotomy task trainer assembly. Additional technological and software resources included personal cellphones to record videos, iMovie for editing purposes, Macbook laptops, Microsoft Office, Wix, Google Forms, and an overhead projector screen to display presentations. A volunteer DNP student was recruited for their assistance with cricothyrotomy task trainer turnover between simulations.

Budget Justification

A primary goal of this simulation was to utilize a task trainer that was realistic and cost-effective to increase overall sustainability and adoption of this trainer at future simulation-based training sessions. The cost to assemble two task trainers was approximately $100 while a single commercial dry simulation mannequin may cost up to thousands of dollars (See Appendix I). The adaptation of the REAL Cric Trainer was evidently more cost-effective than the traditional simulation mannequins. The most expensive component of the model was the pork belly as pricing per pound fluctuated between sellers with an average range of ~$3.50-$5.00 per pound and the overall cost increased during the COVID-19 pandemic.

Despite the financial cost of this project, the budget was justified by the benefit of increased provider confidence to perform an emergent cricothyrotomy and the possibility of reduced morbidity/mortality associated with a CICO event. By providing an opportunity for anesthesia providers to practice their cricothyrotomy skills and build confidence, the project authors hoped to lessen the risk of a future failed airway within a CICO scenario and minimize the burden of care-related and litigation costs. According to Cook et al. (2010), the cost of anesthesia-related litigation claims involving airway and respiratory events between 1995 to 2007 was millions of dollars, accounting for 27% of all costs. Further, the average cost of claims in cases of hypoxia and/or death is an estimated $39,748 (Cook et al., 2010). Following review of these figures and configuration of a cost-benefit analysis (See Appendix I), the project authors determined that the small expense of this project was greatly supported and justified.

Chapter V: Implementation Procedures and Processes

Population

The primary inclusion criterion for selected participants was based upon their role in anesthesia including CRNAs and physician anesthesiologists. Student registered nurse anesthetists (SRNAs) were excluded to reduce response bias as their confidence levels to perform an emergent cricothyrotomy would be expected to be low due to their limited experience in anesthesia. Participants were voluntarily recruited through a mass e-mail invitation, and 14 individuals registered for the event on a Sign-Up Genius link. The participants included only CRNAs and no physician anesthesiologists. On the simulation day, three participants withdrew due to unforeseen circumstances resulting in a total of 11 participants.

Setting

The simulation event took place at the CCC School of Nursing Simulation Center. Within the Simulation Center was a realistic operating room and was the location where the hands-on cricothyrotomy simulation portion took place. The Simulation Center operating room mimics a traditional operating room environment as it contains similar machines, monitors, carts, and supplies. The educational presentation portion of the event took place in an adjacent classroom which included an overhead projector for PowerPoint presentation display.

Procedures

Upon arrival to the Cedar Crest College School of Nursing, participants were directed to the classroom area of the Simulation Center and were asked to electronically complete the informed consent, demographic survey, and pre-simulation survey. The electronic surveys were housed on a Wix website and available to participants via QR codes that were conveniently located on each desk for scanning. Participants accessed and completed the electronic surveys on their personal cellphones. The surveys were created and stored on Google Forms, a password-protected software only accessible to the DNP project authors. Once completed, the participants viewed an educational PowerPoint presentation on cricothyrotomy including incidence, indications, complications, techniques, case studies, anatomy, and outcomes. The clinical problem of low anesthesia provider confidence was discussed due to the rarity of a cricothyrotomy and lack of practice opportunities. A literature review of evidence comparing the needle, Seldinger, and scalpel-finger-bougie technique was presented. In addition, the step-by-step process of the scalpel-finger-bougie technique was discussed in detail along with a video demonstration performed by one of the project authors on the realistic cricothyrotomy task trainer.

Following the educational presentation, participants were asked to complete the hands-on cricothyrotomy simulation in the Simulation Center operating room. Two cricothyrotomy task trainer stations were previously set-up and participants were divided into groups of two. Individuals donned the appropriate personal protective equipment (PPE) including a mask with a facial shield, impermeable isolation gown, and gloves prior to the cricothyrotomy simulation. The two DNP project authors managed the task trainers while the participants performed the simulated cricothyrotomy on the realistic task trainer utilizing the scalpel-finger-bougie technique. When each group finished, the DNP project authors disposed of the non-reusable supplies and the model was turned over for the next group within an average time frame of five minutes. Once all participants completed the hands-on portion of the cricothyrotomy simulation, a second PowerPoint presentation was reviewed. The second portion of the PowerPoint presentation focused on the realistic and cost-effective cricothyrotomy task trainer including a step-by-step video demonstration of its assembly for future replication. The simulation event came to an end once participants electronically completed the post-simulation survey.

Simulation Model

The simulation model utilized was an adaptation of the REAL Cric Trainer developed by Kei et al. (2018). The primary components of the model included a 3D-printed trachea and slab of pork belly with the skin still attached (See Appendix J for complete supply list). To build the model, the dry components were first placed together on a storage bin lid, which consisted of a 3-liter reservoir bag, trach extender, 3D-printed trachea, and mannequin head (See Figure 1).

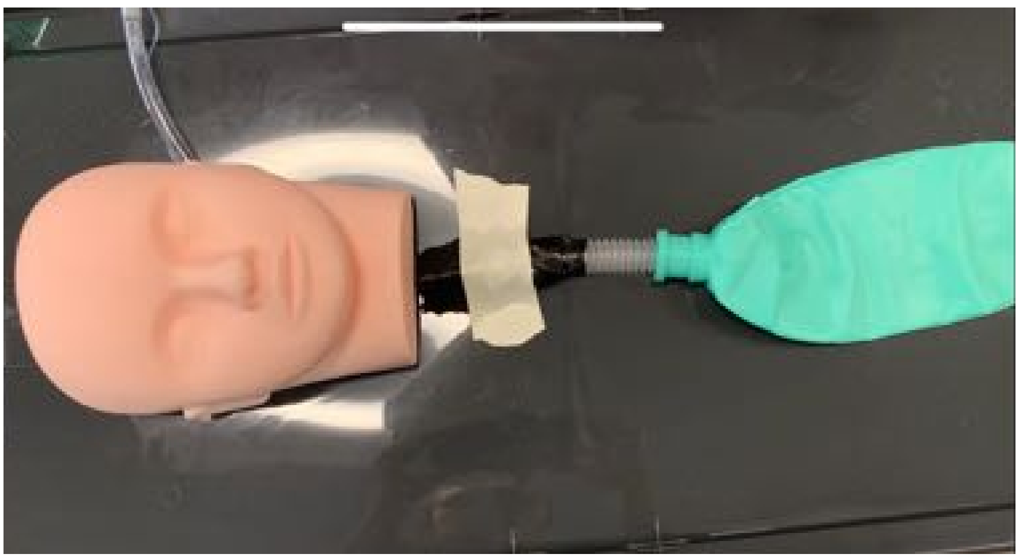

Figure 1. Dry supplies of task trainer placed together and secured to storage bin lid.

A piece of 3M Microfoam tape was used to mimic the cricothyroid membrane. A piece of Seran wrap was used to occlude the distal portion of the 3D-printed trachea so that the realistic flash of air escapes through the cricothyroid membrane to create a bubbling effect once punctured. A trach extender and 3-liter reservoir bag were then attached to the 3D-printed trachea with duct tape. The 3-liter reservoir bag was adapted to this model to recreate inflation of a “lung.” An 8.0 endotracheal tube is then placed into the proximal end of the 3D-printed trachea and connected to a bag-valve-mask. The mannequin head placed on top of the 8.0 endotracheal tube and secured to the storage bin lid with Velcro strips.

Next a slab of pork belly, approximately 4.5 x 6 inches in size, was prepared by injecting a 10-milliliter skin wheel of red-dyed saline just beneath the epidermal layer. The skin wheel is necessary to simulate bleeding once the skin is incised by a scalpel. A liter bag of red-dyed saline with attached intravenous tubing was then tunneled into the piece of pork belly from the posterior side and laid over top of the 3D-pinted trachea. This step is necessary to create continuous "bleeding" as the user was performing the simulated cricothyrotomy. Lastly, three blue surgical towels were placed along the model leaving only the head and neck portion exposed (See Figure 2).

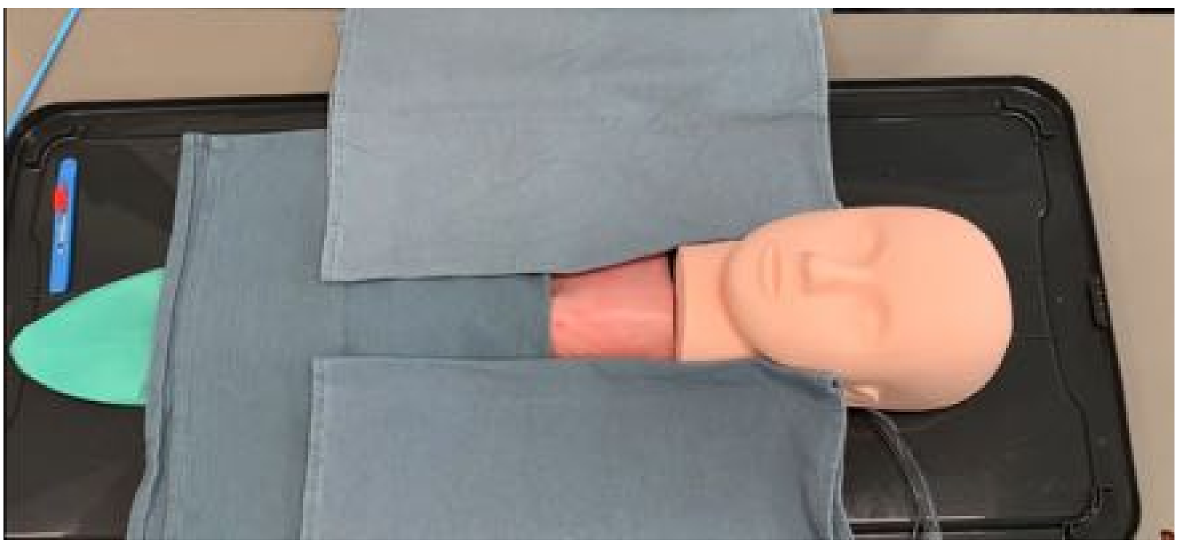

Figure 2. Complete assembly of cricothyrotomy task trainer.

For the actual simulation, the user palpates the neck and locates the cricothyroid membrane through a vertical incision made with a No. 10 scalpel. At this point, the project author managing the model began to compress the bag-valve-mask attached to the 8.0 endotracheal tube and opens the roller clamp on the intravenous tubing. These steps are critical to replicate the realistic features of this model such as bleeding and a flash of air once the cricothyroid membrane is punctured. Once the cricothyroid membrane is located through finger palpation, a horizontal stab incision is made and a gum elastic bougie is then inserted into the trachea of the model. A pre-lubricated 6.0 endotracheal tube is then inserted over the bougie catheter and into the model. A 10-milliliter syringe is used to inflate the endotracheal cuff, a bag-valve-mask is attached, and ventilation is confirmed via inflation of the reservoir bag. Once the simulation was complete, each work surface was cleaned for the next group and non-reusable items (i.e., pork belly, Seran wrap, etc.) were discarded.

Chapter VI: Evaluation and Outcomes

Demographics

A total of 14 participants pre-registered for the simulation event. On implementation day, three participants withdrew due to unforeseen circumstances. The final sample size consisted of 11 CRNAs. Most participants had not received cricothyrotomy training in the past year (81%; n=9), 72.7% had less than 6 years of experience (n=8), 72.7% had not performed a simulated cricothyrotomy in the last 10 years (n=8), and 100% of participants had never performed an actual cricothyrotomy (n=11).

Data Analysis

The statistical analysis software, IBM SPSS, was utilized to conduct the data analysis for this project. As mentioned in chapter four, the pre-simulation and post-simulation survey (See Appendix G & H) consisted of five identical questions and each participant created a unique identifier to link their pre- and post-simulation surveys. For the purposes of this project, a paired *t*-test was selected as the most appropriate statistical test to analyze the effect of a cricothyrotomy simulation on anesthesia provider self-perceived confidence to perform an actual cricothyrotomy within a CICO scenario. According to Polit & Beck (2016), a paired *t*-test is used to compare two measures (i.e., interval or continuous) that is obtained from the same set of subjects. Statistical significance was determined by an alpha level of 0.05.

Use of the ASA difficult airway algorithm

The first survey question assessed the participants' self-perceived confidence with navigating the ASA difficult airway algorithm during an airway emergency. On a confidence scale ranging from 0-100, the mean score on the pre-simulation survey was 62 and the mean post-simulation score was 91 ($p = 0.001$).

Ability to identify the cricothyroid membrane

The second survey question assessed the participants' self-perceived confidence in their ability to identify the cricothyroid membrane rapidly and correctly. The pre-simulation survey mean score was 57 and the post-simulation survey mean score was 90 ($p < 0.001$).

Ability to identify cricothyrotomy supplies

The third survey question assessed the participants' self-perceived confidence in their ability to rapidly and correctly identify the supplies needed to perform a cricothyrotomy with the scalpel-finger-bougie technique. The pre-simulation survey mean score was 35 and the post-simulation survey mean score was 97 ($p < 0.001$).

Ability to perform a cricothyrotomy

The fourth survey question assessed the participants' self-perceived confidence in their ability to perform an emergent cricothyrotomy. The pre-simulation survey mean score was 16 and the post-simulation survey mean score was 90 ($p < 0.001$).

Ability to assemble a cricothyrotomy simulation model

The fifth survey question assessed the participants' self-perceived confidence in their ability to correctly assemble a realistic cricothyrotomy simulation model for adoption at their clinical institutions. The pre-simulation survey mean score was 13 and the post-simulation survey mean score was 89 ($p < 0.001$).

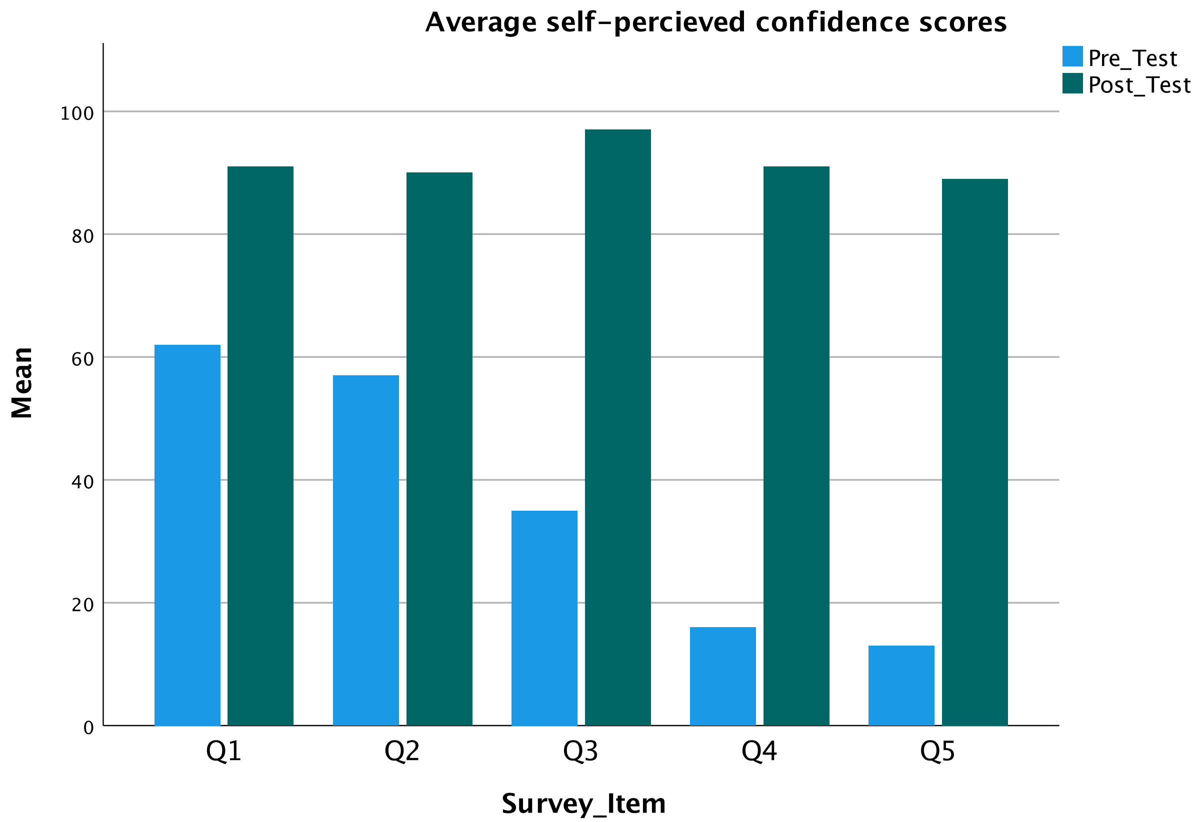

Figure 1: Average self-perceived confidence scores before and after cricothyrotomy simulation

Statistical significance was determined by a *p* value of < 0.05, of which was demonstrated with each comparison between all pre- and post-simulation survey question scores regarding anesthesia provider self-perceived confidence levels related to cricothyrotomy. Although statistical significance was achieved with each survey question, the sample size of this project is small, and the findings are not generalizable to the entire population of anesthesia providers. However, the findings of this project demonstrate clinical significance regarding the use of simulation-based training as an effective method to improve provider self-perceived confidence levels to perform an emergent surgical airway. A realistic and cost-effective cricothyrotomy simulation can significantly improve anesthesia provider confidence to manage an airway emergency. Increased anesthesia provider confidence to perform this life-saving procedure could hypothetically improve patient outcomes in the event of a CICO scenario and may even prevent adverse outcomes related to hypoxia, including death.

Outcomes

The PICO question that guided this project was "Among anesthesia providers, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competence in performing an emergent cricothyrotomy?" Provided the results of this project, the answer to the PICO question is that a cricothyrotomy simulation does indeed improve anesthesia provider self-perceived confidence and competence to perform an emergent cricothyrotomy. The desired results of this project were formulated into the following two objectives: 1) Improved provider self-perceived confidence to perform an emergent cricothyrotomy and, 2) Improved self-perceived confidence to recreate a realistic and cost-effective cricothyrotomy simulation model for future adoption at their institution. Both objectives were successfully met as the implemented cricothyrotomy simulation significantly increased anesthesia provider self-perceived confidence levels in all areas related to cricothyrotomy including simulation model assembly. In addition, the initial needs assessment demonstrated a lack of practice opportunities for anesthesia providers to become proficient at this life-saving skill simply due to the rarity of having to perform this procedure within clinical practice. The needs assessment was successfully addressed as this project demonstrated support of cricothyrotomy simulation-based training to practice and maintain this skill and overall, improve provider self-perceived confidence.

Discussion

A cricothyrotomy is the last intervention on the ASA difficult airway algorithm to secure a failed airway and some of the major factors associated with an airway emergency is attributed to a lack of provider confidence and delayed decision-making. Anesthesia providers must be confident with their difficult airway algorithm knowledge and must also be proficient with identifying when a cricothyrotomy is necessary and know how to perform one should the event present itself because the patient's life depends on it. A cricothyrotomy has been identified as a high risk, low frequency event with detrimental adverse outcomes if performed too late or incorrectly. Simulation-based training for cricothyrotomy is strongly supported by the literature and even further by the outcomes of this project. A common limitation noted throughout previous research findings was the lack of tactile realism and costs associated with commercial, silicone-based cricothyrotomy training models. This project was able address these limitations by utilizing the REAL Cric Trainer, a model specifically designed with an increased sense of realism and a significantly lower cost compared to its commercial competitors.

While this project was able to address the previously stated limitations, this project had several key limitations of its own. The first limitation is the small sample size of 11 participants including all CRNAs and no physician anesthesiologists. In addition, the sample size did not include a diverse level of experience and largely consisted of participants with less than 6 years of experience (72%). Another limitation is the use of convenience sampling for participant recruitment through email invitation distribution at the project authors clinical site where resources are abundant including advanced airway equipment, anesthesia technical partners, physician anesthesiologist support, and in-house access to trauma and neck surgeons. With that said, the results of this project are not generalizable to rural settings where resources and support are likely limited in the event of a CICO scenario. To strengthen the outcomes of this project, a repeated attempt should include a larger, more diverse population of anesthesia providers from various practice settings.

Lastly, the project authors decided to only measure anesthesia provider self-perceived confidence levels related to cricothyrotomy and did not measure technical skill accuracy or speed. The purpose of this project was to provide a hands-on practice opportunity for anesthesia providers to identify the cricothyroid membrane, make incision, and intubate the trachea. Due to limited portions of pre-prepared pork belly, each participant had only one opportunity to practice this skill. As a result, the project authors made a collective decision to allow the participant an unlimited time to perform this skill on their only simulated cricothyrotomy attempt. A cricothyrotomy is a skill that must be performed rapidly and correctly; Therefore, a future opportunity for this project should incorporate the evaluation of speed and technical skill accuracy to further strengthen the outcomes of this project.

Chapter VII: Implications for Nursing Practice

Implications for Practice

The purpose of this DNP project was to improve anesthesia provider confidence to perform an emergent cricothyrotomy by the implementation of a realistic and cost-effective cricothyrotomy simulation. Successful project implementation led to significantly increased anesthesia provider confidence in their ability to perform an emergent cricothyrotomy and assemble a realistic cricothyrotomy simulation model for future training purposes. The outcome of this project supports the use of simulation-based training for infrequent perioperative crisis events, such as the need to perform a cricothyrotomy during a CICO scenario. Simulation is already highly integrated within anesthesia and medical training as it facilitates skill acquisition, improves skill retention, and reduces the loss of skills (Murray, 2011). Further, cricothyrotomy simulation provides anesthesia providers with the practice opportunity to become more confident and proficient in this rare, lifesaving procedure. Cricothyrotomy simulation training can also be both cost-effective and of high-fidelity with the use of this simply adapted version of the REAL Cric Trainer. Higher self-perceived confidence levels, skill proficiency, and rapid intervention can significantly reduce the risks and adverse outcomes during airway catastrophes like the CICO scenario. Future practice opportunities are necessary to increase anesthesia provider confidence which can be successfully accomplished with adoption of this simulation-based training course.

Strengths of the Project

There were several key aspects that added significant strength and value to this project. The first strength was the realism of the cricothyrotomy simulation model with the use of porcine tissue, “bleeding,” and a flash of air. The key components of the simulation model provided a much more realistic experience for participants in comparison to commercial dry simulation models. In addition to increased realism, the model was also much more cost-effective alternative when compared to commercial training models as most supplies required to build the model can be found in most operating rooms or anesthesia supply rooms. Although the components of the model had to be manually placed together, the process was quick, simple, and easily adoptable. The project authors promoted the future adoption of this cricothyrotomy simulation model by creating and providing a step-by-step instructional YouTube video on model assembly. The instructional YouTube video (https://youtu.be/3gz4IUTEeaA) is a reference that can be accessed at any point in time for participants or other medical professionals interested in re-creating this simulation training course. The authors have also created an instructional video of the scalpel-finger-bougie technique being performed on the specific cricothyrotomy task trainer used within this simulation (https://www.youtube.com/watch?v=EQKqZ3mCKKo).

Another identified strength was the authors inclusion of the scalpel-finger-bougie technique. As previously mentioned, the scalpel-finger-bougie method is associated with the highest success rate (Lockey et al., 2014). In fact, it is the preferred cricothyrotomy technique recommended by the Difficult Airway Society and Advanced Trauma Life Support (Mazza et al., 2021). This method is preferred because of the immediate availability of minimal supplies required to perform a cricothyrotomy and most importantly, its simplicity. Other widely known cricothyrotomy techniques require greater fine motor control and include numerous steps that may easily be forgotten if not routinely practiced. As a result, the scalpel-finger-bougie technique is most likely to be remembered and retained by providers with confidence due to its simplistic approach.

The final identified strength of this project was the use of technology and development of a project website. The website allowed the project authors to organize the informed consent, data collection surveys, and project videos within a secure location. The website was accessed individually by each participant with ease by placing QR codes on each desk, making data collection an efficient and paperless process. The strength of these aspects played a significant role in the successful implementation of this project.

Limitations of the Project

Despite the evident strengths, there were several limitations identified as previously mentioned in Chapter VI. First, the sample size was small and lacked experience and background diversity as the only participants were CRNAs which then limits the generalizability of results on a larger scale. However, the project authors intentionally sought out a small sample size due to COVID-19 restrictions, simulation center event space, and the limited amount of pre-purchased pork products. Sample bias can also be considered a limitation because a convenience sampling method (i.e., email invitation) was employed during participant recruitment. Finally, technical skill proficiency and the amount of time to perform a cricothyrotomy were not measurable outcomes within this project but are also equally important indicators of a successful cricothyrotomy. The presence of these limitations provides future opportunities for similar cricothyrotomy simulation projects.

Linkage to DNP Essentials

The American Association of Colleges of Nursing (2006) define eight DNP essentials as the foundational competencies of DNP education and advanced practice nursing. The completion of this DNP project exhibits direct linkage to each DNP essential which will be further discussed in detail.

Essential I: scientific underpinnings for practice, was achieved by first conducting a thorough literature review to identify the problem of minimal to no practice opportunities to perform a cricothyrotomy which has ultimately led to insufficient anesthesia provider confidence. Following the creation of a PICO question and final approval by DNP faculty, the current body of literature was synthesized to identify the best evidence-based practice approach towards improving anesthesia provider confidence regarding cricothyrotomy.

Essential II: organizational and systems leadership for quality improvement and systems thinking, was fulfilled by various actions. The first action was identifying key stakeholders, such as CRNAs and physician anesthesiologists. Once stakeholders were identified, a meeting was held, and discussions took place with anesthesia providers to review current cricothyrotomy training methods. From there, a formal needs assessment was conducted at the project authors clinical site and numerous providers described the need for more cricothyrotomy practice opportunities and clearly stated their support of this project.

Essential III: clinical scholarship and analytical methods for evidence-based practice, was achieved through development of the DNP project proposal, followed by the construct and submission of an IRB proposal at Cedar Crest College. Once IRB approval was obtained, project authors developed various tools necessary for successful implementation. For example, project authors created data collection tools including the demographic survey, pre-simulation survey, and post-simulation survey, which they then statistically analyzed via SPSS after project implementation. Further, a professional e-portfolio was built from the very start of DNP curriculum to demonstrate how the coursework was used to achieve each DNP essential and provided a means to document and store DNP project progress.

Essential IV: information systems technology and patient care technology for the improvement and transformation of healthcare, was also demonstrated by the design of an online website. The website housed the informed consent, data collection tools, and educational/instructional videos developed by project authors. This technological component allowed for easy access to web-based training materials for the simulation event and for future implementation opportunities.

Essential V: healthcare policy and advocacy in healthcare, was met through the advocacy of simulation-based training for perioperative high-risk, low frequency events with primary focus on the CICO scenario. By advocating for cricothyrotomy stimulation-based training, the project authors also demonstrate strong advocacy for the perioperative patient population undergoing general anesthesia. Advocacy for improved anesthesia provider self-perceived confidence to perform a cricothyrotomy will only improve the level of quality care the perioperative patient receives while reducing possible negative outcomes associated with a failed airway.

This project fulfilled essential VI: interprofessional collaboration for improving patient and population outcomes, by utilizing a team approach throughout the entire project development and implementation process. Meetings were established with preceptors, mentors, key stakeholders, and simulation-based training experts to discuss the many different variables surrounding the implementation of a cricothyrotomy simulation course. Input and feedback were gladly received to facilitate successful implementation. Interprofessional collaboration and consultation played a fundamental role in the development of this simulation-based training course.

The dissemination of DNP project results demonstrates the fulfillment of essential VII: clinical prevention and population health for improving the nation's health. The project demonstrates that simulation-based training is an effective method to improve anesthesia provider self-perceived confidence to perform an emergent cricothyrotomy. The knowledge gained from this project was shared with other healthcare providers via video conference presentation at Drexel University hosted by the Philadelphia Advisory Group of Nurse Anesthesia Programs. The project authors have an additional dissemination plan scheduled for the Department of Anesthesiology Annual Winter Retreat Conference hosted by Lehigh Valley Health Network, a large regional and academic healthcare institution.

Lastly, essential VIII, advanced nursing practice, was met by completion of program specific clinical hours at various clinical sites located throughout Eastern Pennsylvania. The project author functioned as a member of the anesthesia team to provide direct, evidence-based patient care. Interdisciplinary collaborative efforts were developed and sustained to facilitate care and positive patient outcomes. Further, the project authors designed, implemented, and evaluated the impact of a cricothyrotomy simulation on anesthesia provider self-perceived confidence with the goal of promoting clinical excellence amongst their anesthesia colleagues.

Chapter VIII: Summary of Project

Summary and Conclusions

In conclusion, anesthesia providers demonstrate low self-perceived confidence levels to perform a cricothyrotomy simply due to the lack of practice opportunities within the clinical area. The need to perform a cricothyrotomy in a CICO scenario is considered a true airway emergency and anesthesia providers must feel confident in their decision-making and procedural skill to secure the airway when all other routine measures have failed. The rarity of this life-saving procedure contributes to low anesthesia provider confidence levels and reluctance to perform an emergent surgical airway. Decreased confidence levels coupled with provider reluctance can lead to a detrimental delay of intervention when each second matters during a prolonged state of hypoxia.

High-fidelity simulation has been supported by the literature as an effective method to improve anesthesia provider's self-perceived confidence levels to perform an emergent surgical airway. Therefore, a realistic and cost-effective simulation was designed and implemented using pork belly with the skin attached to mimic human flesh, simulated "bleeding," and a 3D-printed trachea. In addition, focus was maintained on the most simplistic and rapid cricothyrotomy method, the scalpel-finger-bougie technique. The simplicity of the scalpel-finger-bougie technique is the most desirable method especially during rapid patient deterioration. The implementation of this realistic and cost-effective simulation project can significantly increase anesthesia provider confidence levels to perform a cricothyrotomy within a CICO scenario. A confident and competent anesthesia provider is necessary for quality and safe patient care to reduce the likelihood of adverse events, including death, during true airway emergencies.

Dissemination Plans

The dissemination of this project occurred at several different events. On March 5, 2022 initial virtual dissemination was carried out at a conference hosted by the Philadelphia Advisory Group of Nurse Anesthesia Programs. The target audience consisted of various nurse anesthesia program faculty members, CRNAs, and SRNAs. The subsequent dissemination plan took place at Cedar Crest College on April 11, 2022 for the School of Nursing's DNP project dissemination event. A PowerPoint presentation was shared with a live audience consisting of graduate nursing faculty, students, and other members of the CCC community. Lastly, the project authors have agreed to present this project in the future at the Department of Anesthesiology Annual Winter Retreat Conference hosted by Lehigh Valley Health Network in January of 2023. The conference is hosted by a large, regional academic institution with a target audience of anesthesiologists, CRNAs, SRNAs, surgeons, and post-anesthesia care unit (PACU) registered nurses.

Future Ideas

This project may act as a foundation for future DNP projects that involve the implementation of a realistic and cost-effective cricothyrotomy simulation. While the focus of this project was aimed towards improving anesthesia provider self-perceived confidence to perform a cricothyrotomy, there are other outcomes surrounding a successful cricothyrotomy that can be expanded upon in future projects. Outcomes such as technical skill proficiency and time to perform the procedure may be included to increase the overall strength and value of this simulation project. Further, a detailed instructional video on model assembly was created by project authors with project sustainability in mind. The model assembly video serves as a resource for future project opportunities as well as health care institutions interested in model adoption for anesthesia procedural training purposes.

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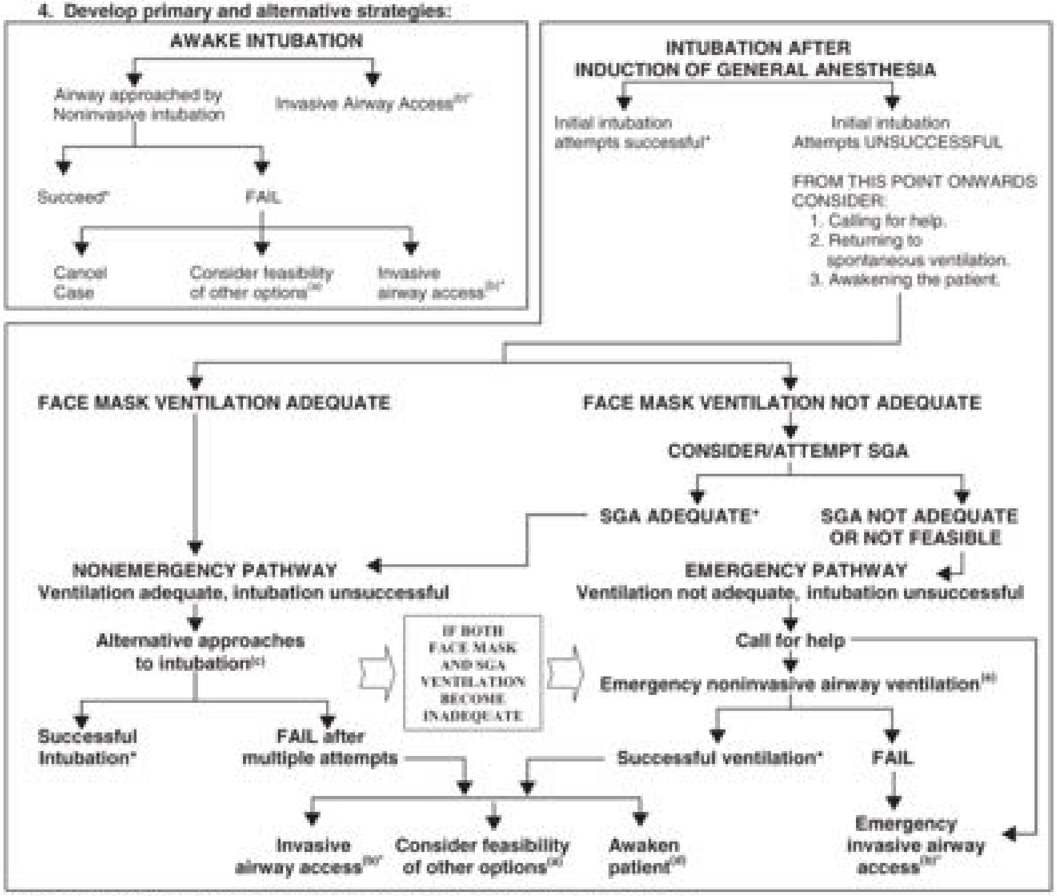
Wray, A., Khan, F., Ray, J., Rowe, R., Boysen-Osborn, M., Wiechmann, W., & Toohey, S. (2019). Comparison of the bleeding cricothyrotomy model to SimMan for training students and residents emergency cricothyrotomy. *Journal of Advances in Medical Education & Professionalism*, *7*(3), 144–148. https://doi.org/10.30476/JAMP.2019.74895

Appendix A

American Society of Anesthesiologists®

DIFFICULT AIRWAY ALGORITHM

1. **Assess the likelihood and clinical impact of basic management problems:**
   - **Difficulty with patient cooperation or consent**
   - **Difficult mask ventilation**
   - **Difficult supraglottic airway placement**
   - **Difficult laryngoscopy**
   - **Difficult intubation**
   - **Difficult surgical airway access**
2. **Actively pursue opportunities to deliver supplemental oxygen throughout the process of difficult airway management.**
3. **Consider the relative merits and feasibility of basic management choices:**
   - **Awake intubation vs. intubation after induction of general anesthesia**
   - **Non-invasive technique vs. invasive techniques for the initial approach to intubation**
   - **Video-assisted laryngoscopy as an initial approach to intubation**
   - **Preservation vs. ablation of spontaneous ventilation**
4. **Develop primary and alternative strategies:**



***Confirm ventilation, tracheal intubation, or SGA placement with exhaled CO_2.**

a. Other options include (but are not limited to): surgery utilizing face mask or supraglottic airway (SGA) anesthesia (e.g., LMA, ILMA, laryngeal tube), local anesthesia infiltration or regional nerve blockade. Pursuit of these options usually implies that mask ventilation will not be problematic. Therefore, these options may be of limited value if this step in the algorithm has been reached via the Emergency Pathway.

b. Invasive airway access includes surgical or percutaneous airway, jet ventilation, and retrograde intubation.

c. Alternative difficult intubation approaches include (but are not limited to): video-assisted laryngoscopy, alternative laryngoscope blades, SGA (e.g., LMA or ILMA) as an intubation conduit (with or without fiberoptic guidance), fiberoptic intubation, intubating stylet or tube changer, light wand, and blind oral or nasal intubation.

d. Consider re-preparation of the patient for awake intubation or canceling surgery.

e. Emergency non-invasive airway ventilation consists of a SGA.

Appendix B

PICO Question: Among anesthesia providers, 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
Hall, A. B., Riojas, R., & Sharon, D. (2014).	Compare post-training self-efficacy between artificial simulators and live animal training for the performance of emergency medical procedures. RCT	111 volunteer airman of the 81st Medical Group Keesler Air Force Base, Biloxi, MS, USA	Didactic lecture followed by skills training of diagnostic peritoneal lavage, thoracostomy (chest tube, and cricothyroidotomy on either the Trauma Man artificial simulator or a live pig model.	**Measures:** Self-efficacy questionnaire utilizing a 10-point scale **Outcomes:** Self-efficacy scores	Post-training self-efficacy scores were significantly higher than post-lecture scores for either training model and for all procedures ($p < 0.0001$) with a preference for live animal training ($p < 0.0001$).	Number of trainees in each group were unequal and included a small sample size. Study took place within a single institution. Self-efficacy questionnaire lacks previous validation.	I	B
Kashat, L., Carter, B., Archambault, M., Wang, Z., &	Examine whether an immersive, multidisciplinary boot camp style	62 PGY-2 residents (50 anesthesiology residents, 12 otolaryngology residents)	Boot camp simulation course for residents from 2013 – 2018. Course included	**Measures:** Pre- and post-course self-assessment tool utilizing a 5-	The greatest decrease in levels of discomfort was among the most complex	Small sample size within a single institution. Resident self-assessment tool	II	B

PICO Question: Among anesthesia providers, 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**
Kavanagh, K. (2020).	simulation course leads to an improvement in novice airway provider confidence. Quasi-experimental design	Connecticut Children's Hospital, Hartford, CT, USA	short didactic and targeted simulation activities of airway maneuvers included along the ASA difficulty airway algorithm such as cricothyroidotomy.	point Likert Scale **Outcomes:** Self-reported comfort and familiarity scores	airway situations and topics including cricothyroidotomy ($p < 0.001$).	is subjective in nature.		
Rajwani K., Mauer, E., & Clapper, T. (2019).	Evaluate whether a cricothyrotomy simulation course would increase the perceived knowledge, confidence, and competence	11 pulmonary - critical care fellows Weill Cornell Medical College, NY, USA	Implementation of a four-phase cricothyrotomy simulation course utilizing a 3D model and porcine model trachea.	**Measures:** Pre- and postintervention survey utilizing a visual analog rating scale, 10 question knowledge exam, procedural technique checklist	Survey results demonstrated an improvement in perceived confidence ($p<0.005$) and competence ($p<0.002$) following this educational intervention.	Small sample size within one site location.	II	B`

PICO Question: Among anesthesia providers, 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**
	to perform cricothyrotomy for pulmonary and critical care fellows. Quasi-experimental design			**Outcomes:** Self-perceived confidence, self-perceived competence, provider knowledge, skill proficiency				
Scott-Herring, M., Morosanu, I., Bates, J., & Batoon, B. (2020).	The goal of this study was to increase CRNA ability to successfully perform cricothyrotomy in less than 2 minutes and levels of confidence	43 CRNAs Large academic medical center, Mid-Atlantic Region, USA	Over 2-month period, CRNAs were randomly selected based on availability to simulate cricothyrotomy on a mannikin. Baseline attempts were recorded and sequential attempts were recorded until	**Measures:** Cell phone stopwatch to record time Confidence levels rated on a 10-point numeric scale **Outcomes:** Ability to successfully perform cricothyrotomy	All but 1 CRNA met the goal of successfully performing a surgical airway on the manikin in less than 2 minutes. The confidence of CRNAs in performing a successful cricothyrotomy	Small sample size within a single institution.	II	B

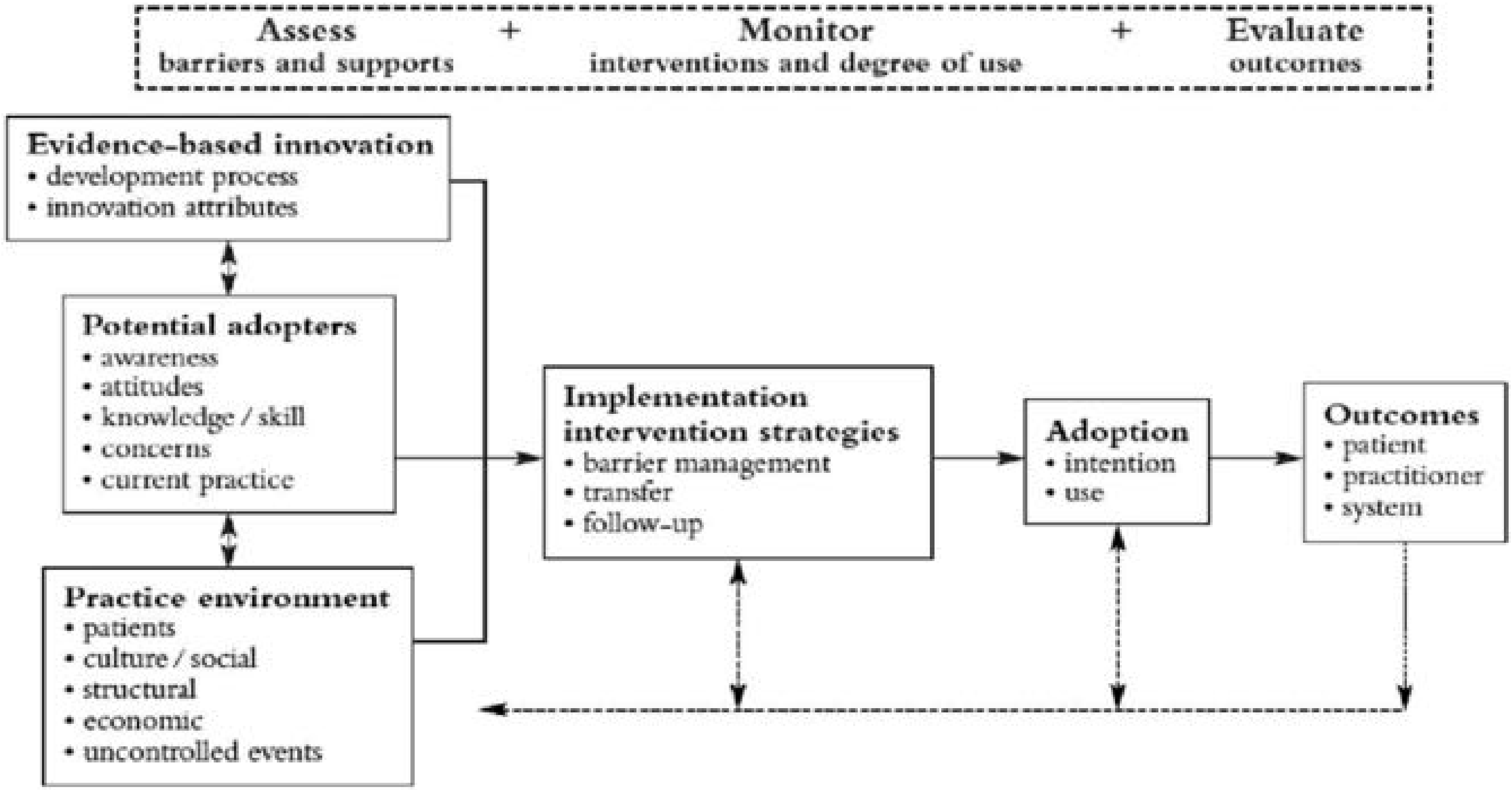
PICO Question: Among anesthesia providers, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?

Author & Date	Aim & Research Design	Sample Size, Population & Setting	Methods	Measures & Outcomes	Study Findings that Answer the PICO	Limitations	Evidence Rating	
							Level	Quality
	through implementation of a "cannot intubate, cannot ventilate" simulation scenario. Quasi-experimental design		time for successful confirmation of placement of less than 2 minutes was achieved. Pre- and post-simulation confidence levels were assessed.	in less than 2 minutes Confidence level	in less than 2 minutes was significantly increased (p ≤ .001).			
Shaw, M., R., & Hughes, K. E. (2020).	Evaluate a 3D-printed bleeding cricothyrotomy trainer in increasing paramedic confidence level and procedural competence	44 paramedics Hospital based in Northern Arizona, USA	Cricothyrotomy model simulation took placed during a mandatory biannual difficult airway training course for paramedics.	**Measures:** Pre- and post-intervention survey utilizing a 10-point visual analog scale **Outcomes:** Procedure comfort level	Procedural comfort levels improved following cricothyrotomy simulation training ($p < 0.001$).	Small voluntary sample from a single institution may increase the risk of result bias.	II	B

PICO Question: Among anesthesia providers, 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**
	as defined by completing cricothyrotomy without error. Quasi-experimental design							
Wray, A., Khan, F., Ray, J., Rowe, R., Boysen-Osborn, M., Wiechmann, W., & Toohey, S. (2019).	Determine whether a realistic and cost-effective cricothyroidotomy training model improves user's comfort and success in performing cricothyroidotomies while being non-	17 residents and medical students University of California, Irvine School of Medicine Simulation Center, Irvine, CA, USA	Participants were randomized to simulate cricothyroidotomy on either the new task trainer (Bleeding CRIC) or the current standard task trainer (SimMan) and then were asked to perform the procedure on a	**Measures:** Objective Structured Assessment of Technical Skills (OSATS) Pre- and post-simulation surveys utilizing a visual analog scale **Outcomes:**	Both simulation groups demonstrated a statistically significant increase in comfort levels from baseline post-intervention (Bleeding CRIC: $p = 0.021$;	This study included a small convenience sample, within a single institution which may increase the risk of bias and can limit the generalizability of findings.	I	B

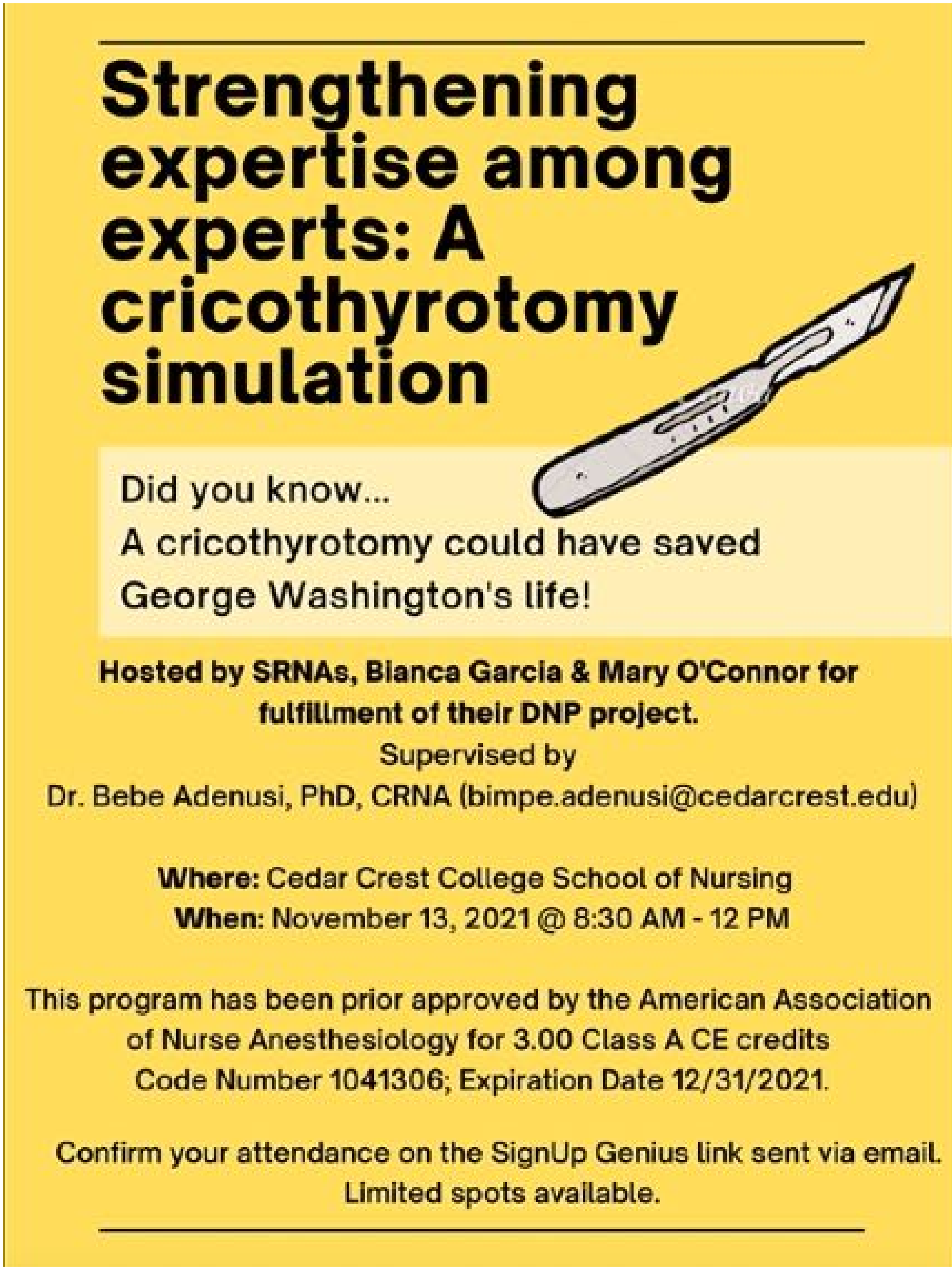
PICO Question: Among anesthesia providers, does the implementation of a cricothyrotomy simulation improve self-perceived confidence and competency in performing emergent cricothyrotomy?								
Author & Date	**Aim & Research Design**	**Sample Size, Population & Setting**	**Methods**	**Measures & Outcomes**	**Study Findings that Answer the PICO**	**Limitations**	**Evidence Rating**	
							Level	**Quality**
	inferior to an existing standard task trainer. Randomized control non-inferiority study		pig trachea model.	Technical skill proficiency, comfort levels, task trainer realism scores	SimMan: *p* = 0.014).			

Appendix C



Note. Ottowa Model of Research Use (OMRU) (Graham & Logan, 2004)

Appendix D



Note. Invitation flyer attached to email and posted throughout the clinical site.

Appendix E

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 F

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

Prior to the start of the simulation, please fill out the following self-efficacy 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**

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

Following your participation in the cricothyrotomy simulation, please complete the self-efficacy survey below. 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

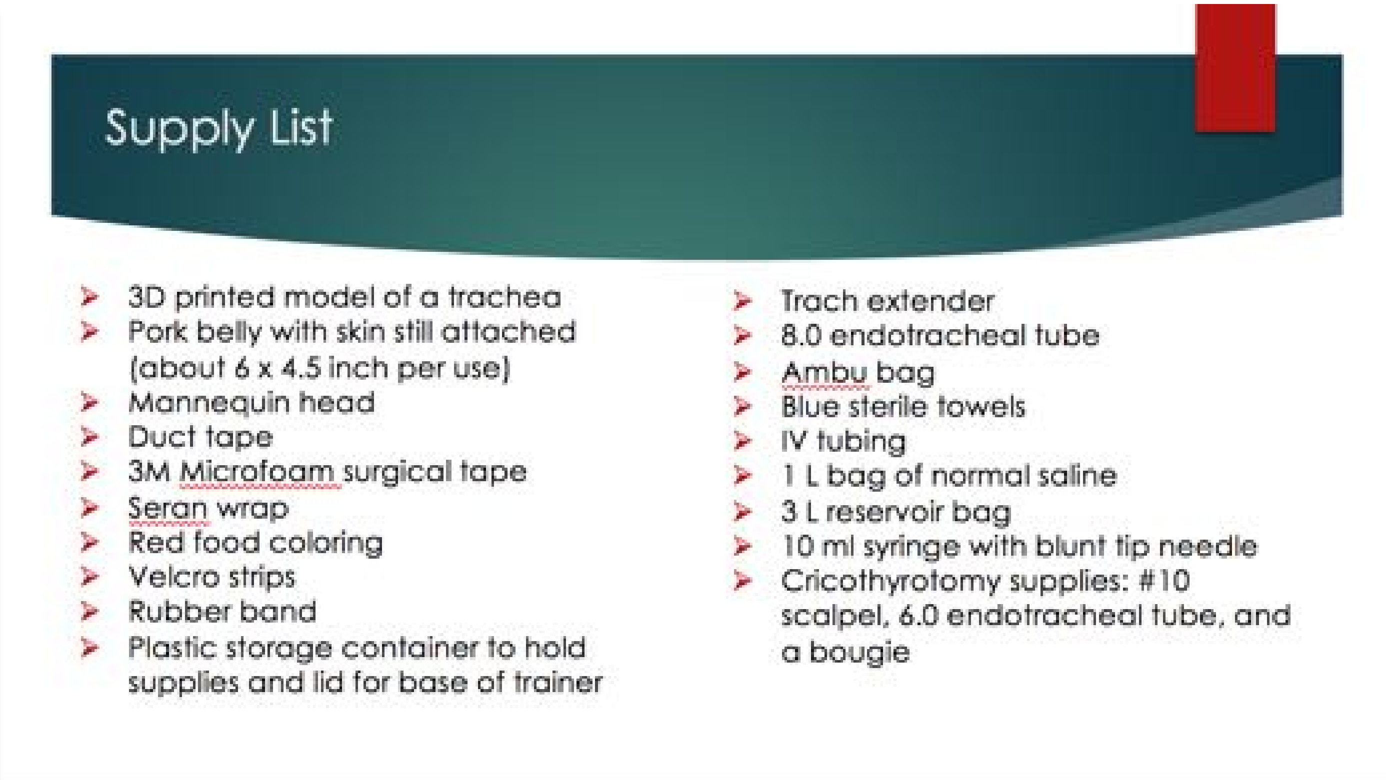
Note. Cost considerations for the realistic cricothyrotomy trainer compared to a commercial cricothyrotomy simulation model.

[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



Note. Complete supply list to assemble cricothyrotomy task trainer.