Marian University

Leighton School of Nursing

Doctor of Nursing Practice

Final Project Report for Students Graduating in May 2024

Cricothyrotomy: The Life-saving Airway Procedure

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Chair: Derrianne Monteiro, DNP, CRNA

Derrianne Monteiro, DNP, CRNA
Derrianne Monteiro, DNP, CRNA (Nov 30, 2023 14:53 EST)

Project Team Members: Merandah Tokarz, SRNA

Merandah Tokarz, SRNA
Merandah Tokarz, SRNA (Dec 4, 2023 08:58 EST)

Hannah Harris, SRNA

Hannah Harris

Committee Members: Mary Nguyen Reynolds, CRNA

Mary Nguyen Reynolds (Dec 4, 2023 10:25 EST)

Bradley Stelflug, DrAP, CRNA

Bradley Stelflug (Dec 4, 2023 06:51 PST)

Date of Submission:

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Abstract

Background: Anesthesia providers are trained to adapt and rapidly respond to cannot intubate cannot ventilate situations based on a difficult airway algorithm. In anesthesia education, simulated events allow for effective learning in a safe environment. Currently, at Marian University, there is no simulated education on the cricothyrotomy procedure.

Purpose: This DNP project was developed to assess the effectiveness of a cricothyrotomy simulation on student confidence level, knowledge base, procedural accuracy, and satisfaction in learning compared to the current didactic curriculum.

Methods: This project collected quantitative data through electronic pre- and post-simulation surveys. Information for the simulation was published through a Canvas page. The questions were derived from the curriculum textbooks and the Student Satisfaction and Self-Confidence in Learning instrument.

Implementation: A total of 12 SRNAs participated in this project. Students were given access to the Canvas course before the simulation date, which contained access to the pre-test. All students underwent the same simulation set-up and were asked to perform the procedure based on the information provided on Canvas. After completion of the simulation, students were asked to complete the post-test survey.

Conclusion: Simulation education increased the student's knowledge and self-confidence regarding the cricothyrotomy procedure ($p<0.05$; $p<0.05$). Overall, students revealed that they had increased satisfaction in learning with simulated events versus didactic learning ($p<0.05$). Similarly, the knowledge base of the students increased because of this simulation ($p=0.01$).

Keywords: Anesthesia, SRNA, Simulation, Cricothyrotomy, CICV, INACSL, Education

Cricothyrotomy: The Life-saving Airway Procedure

This project is submitted to the faculty of Marian University Leighton School of Nursing as partial fulfillment of degree requirements for the Doctor of Nursing Practice, Anesthesia track. Anesthesia providers are taught throughout their education how to manage an airway and the corresponding side effects of administering anesthetics. A prominent component of anesthesia education focuses on the assessment and management of airway complications. A student registered nurse anesthetist (SRNA) is expected to be able to respond to an emergency airway event through the guidance of a prefabricated airway algorithm. In the United States, the most common flowsheet is distributed by the American Society of Anesthesiologists (ASA) (Apfelbaum et al., 2022). This algorithm details how an anesthesia provider should differentially perform interventions in order to secure the airway. In the rare occurrence of a cannot intubate cannot ventilate (CICV) event, the algorithm requires the provider to insert an invasive airway after other interventions have been attempted (Appendix A).

Simulation incorporation within healthcare education is increasing in demand and popularity as it provides a safer route of hands-on demonstration for both the patient and the provider (Council of Accreditation, 2020). As such, the International Nursing Association for Clinical Simulation and Learning (INACS) has published guidelines that outline the best practice for simulations with references to standards, design, facilitation, and operations which should be included within an educational platform (Watts et al., 2021). Due to the invasive nature of cricothyrotomies, it is plausible that SRNA education may not fully meet the criteria outlined by the INACS guidelines. If simulation education improves knowledge, skill, and retention; then it is imperative that curriculum models follow this practice structure to acquire the best results for the students (Council of Accreditation, 2020).

Background

The cricothyrotomy procedure can be the intervention that determines life or death for critically injured and ill patients. A study completed by Kwon and colleagues (2019) concluded that 0.23% of tracheal intubations result in cricothyrotomy. Of these, the procedure success rate was 73.9% and the patient survival rate was 47.8% (Kwon et al., 2019). Based on these statistics, it can be assumed that the survival rate would have increased to 60.2% had the procedure been performed correctly every time. In a patient population of 1,000, this adjustment would have saved the life of an additional 124 patients. Interestingly, Kwon and colleagues (2019) found that residents had a higher success rate (100%) than practicing physicians (68.4%) in performing a cricothyrotomy. This could suggest that recent education and practice can increase the success rate of the procedure.

Fortunately, the cricothyrotomy procedure is not a frequently required procedure due to the advancements in the Difficult Airway Algorithm (Apfelbaum et al., 2022) However, this has left little opportunity to practice the skill during training (Chang et al., 1998; Cho et al., 2016). In fact, it is estimated that anesthesiologists and intensivists will experience a CICV situation an average of 2.6 times in their entire career (Cho et al., 2016). With cricothyrotomy being the final step in the difficult airway algorithm, this leaves little room for clinical experience and a high reliance on simulation training.

Hands-on simulation strategies have been used to teach a number of different medical skills, resulting in increased confidence in the provider, such as vascular access (Okano, 2021;

Blanie, 2022), airway management (Hansen, 2020), TEE performance and interpretation (Yang, 2021), regional techniques (Koh, 2021), and advanced life support (Massoth, 2019). Due to the technological advancements in simulation-based education, this method of teaching has become a staple in most medical-related professions.

Current literature states that anesthesia providers retain procedural skills for up to one year following a single session of a high-fidelity simulation (Boet et al., 2011). Providers who have less than 10 years of anesthesia experience are, at a minimum, 50% less likely to not know how to perform an emergency airway procedure (Fayed et al., 2022). Of those who are currently in practice, 87% of providers have never had hands-on experience in the cricothyrotomy procedure (Fayed et al., 2022). These statistics are alarming and demonstrate the education inadequacy surrounding the cricothyrotomy procedure.

Problem Statement

Anesthesia providers must be prepared to identify, a difficult airway, proceed to secure it, and provide the patient with ventilation. If initial attempts to secure an airway are futile, providers are taught to initiate a clinical algorithm to help guide the decision-making process. In the event of a CICV situation, the final step includes implementing a surgical airway (Apfelbaum et al., 2022). Students should enter the profession having firm confidence in their skills to perform this life-saving measure. This Doctor of Nursing Practice project focused on how SRNAs rank their confidence level in performing cricothyrotomies and their knowledge base founded on current educational practices in comparison to a hands-on simulation education curriculum.

Needs Assessment and Gap Analysis

Within the state of Indiana, there are currently two graduate programs that have a nurse anesthesia tract; both of which with varying degrees of incorporation and complete simulation of the ASA's difficult airway algorithm. Within Marian University, an Indianapolis-based campus, SRNAs are taught didactically the purpose, implications, and use of a cricothyrotomy. Simulation of the ASA difficult airway algorithm incorporates the hands-on experience of a CICV scenario, but students are requested only to act out the scenario until the decision point to place an invasive airway. A cricothyrotomy procedure is not physically performed in the simulation lab. The Council of Accreditation of Nurse Anesthesia Educational Programs states that simulation-based education produces higher learning outcomes, competency attainment, and skill retention (Council of Accreditation, 2020). By performing a needs assessment and literature review on how simulation improves cricothyrotomy skill confidence, this study hoped to prove that simulation could enhance student preparedness, performance, and retention of the cricothyrotomy procedure among Marian SRNAs.

Review of the Literature

A review of the literature was conducted to investigate the PICO question of "what is the effect of participation in a hands-on simulation experience in comparison to current curriculum methods on SRNA confidence level and knowledge basis concerning the performance of a cricothyrotomy?" The following electronic databases were utilized: PubMed, Academic Search Complete, Alt Health Watch, Biomedical Reference, CINAHL, ERIC, Health Business, Health Source: Nursing/Academic Edition, MEDLINE, and Professional Development. The search was conducted with the following combination of keywords: *CICV*; *simulat**; *difficult airway algorithm*; *skill*; a*nesthes**; *cricothyrotom**; *FONA*; and *nursing education*. Any articles that were not scholarly peer-reviewed, published within the last five years (2018-2022), and written in English were immediately disqualified (n= 15,382). For a journal article to be included within this literature review, the content must relate to the knowledge, confidence, and performance surrounding emergency surgical airway placement for anesthesia providers and/or the impact of simulation on nursing education. All articles that did not pertain to either of these categories were excluded from the review (n= 2,575).

These search criteria resulted in 4,174 articles populating, however, after a screening of inclusion and exclusion criteria, only 2, 598 were assessed. Based on those articles, 23 pertinent articles were included in the literature matrix found in Appendix B. The articles found in this literature review can be distributed within the following categories: difficult airway algorithm in simulation (n=11), confidence in procedural skill and knowledge (n=7), and nursing education in simulation (n=12). Reference the Prisma diagram in Appendix C.

Difficult Airway Algorithm in Simulation

Eleven articles pertained to the assessment of anesthesia providers' ability to work through the ASA's difficult airway algorithm and perform a surgical airway procedure (Alamrani, et al., 2018; Añez Simón et al., 2019; Clark et al., 2022; George et al., 2022; Issa et al., 2021; Johnson et al., 2022; Liu et al., 2022; Ott et al., 2018; Rajwani, Mauer & Clapper, 2019; Scott Hering et al., 2020; Zhang et al., 2022). The use of simulation has been shown to be effective in analyzing the knowledge base of providers for the cricothyrotomy procedure (Alamrani, et al., 2018; Añez Simón et al., 2019; Clark et al., 2022; Issa et al., 2021; Johnson et al., 2022; Scott Hering et al., 2020). Pre-education skill results show that providers range from successful completion of a cricothyrotomy by 2-86% (Añez Simón et al., 2019; Clark et al., 2022; Issa et al., 2021). However, when researchers placed a time restriction on the successful completion of a cricothyrotomy during testing, less than 10% could achieve this benchmark pre-education (Clark et al., 2022; Issa et al., 2021; Scott Hering et al., 2020). The articles varied on the equipment that providers could use to perform the procedure, but it was noted that the scalpel/bougie/endotracheal tube technique produced the fastest times (Clark et al., 2022; George et al., 2022; Scott Hering et al., 2020).

The project design for these articles incorporated demonstrations, traditional lectures, visual aids, and feedback as part of the educational component between pre-testing and post-testing (Alamrani, et al., 2018; Añez Simón et al., 2019; Clark et al., 2022; George et al., 2022; Issa et al., 2021; Johnson et al., 2022; Liu et al., 2022; Ott et al., 2018; Rajwani, Mauer & Clapper, 2019; Scott Hering et al., 2020; Zhang et al., 2022). Every study showed significant improvement in the first attempt post-education to perform a surgical cricothyrotomy regarding completion time and/or the number of safety breaches ($p<0.05$) (Alamrani, et al., 2018; Añez Simón et al., 2019; Clark et al., 2022; George et al., 2022; Issa et al., 2021; Johnson et al., 2022; Liu et al., 2022; Ott et al., 2018; Rajwani, Mauer & Clapper, 2019; Scott Hering et al., 2020; Zhang et al., 2022). In one study, it was noted that although results improved after educational interventions, some participants needed additional attempts to successfully complete the procedure (Issa et al., 2021).

Confidence in Procedural Skill and Knowledge

Seven articles pertained to student's evaluation of their self-reported confidence level regarding both their knowledge and ability to perform a surgical cricothyrotomy (Alamrani et al., 2018; Añez Simón et al., 2019; Bessman et al., 2020; Fayed et al., 2022; Issa et al., 2021;

Johnson et al., 2022; Rajwani, Mauer & Clapper, 2019). The most common tool utilized for the assessment of self-reported confidence was a Likert-type questionnaire (Alamrani et al., 2018; Añez Simón et al., 2019; Bessman et al., 2020; Fayed et al., 2022; Issa et al., 2021; Johnson et al., 2022; Rajwani, Mauer & Clapper, 2019). Knowledge assessments were generated with researcher-designed surveys that included multiple-choice questions and fill-in-the-blanks (Añez Simón et al., 2019; Bessman et al., 2020; Fayed et al., 2022; Issa et al., 2021; Johnson et al., 2022; Rajwani, Mauer & Clapper, 2019).

In general, the majority of participants rated their self-confidence in procedural confidence and technique low (Bessman et al., 2020). Furthermore, results disseminate that students struggle with preoperative planning of a difficult airway, optimization of basic airway techniques, and optimization of advanced airway techniques ($p<0.001$; $p=0.02$; $p<0.001$) (Bessman et al., 2020). For practicing providers, two studies reveal that actual clinical performance of the skill and years of practicing have a significant impact on knowledge and skill confidence ($p<0.05$) (Fayed et al., 2022). After educational intervention, 89% of participants ranked their confidence level as greatly improved (Issa et al., 2021).

Nursing Education in Simulation

Twelve articles focused on the impact that simulation had on nursing education, specifically with changes in confidence, communication, and critical thinking (Alamrani et al., 2018; Boostel et al., 2018; Chang et al., 2021; Fayed et al., 2022; Kim & Yoo, 2018; LaCerra et al., 2019; Leguox et al., 2020; Lei et al., 2022; Mulyadi et al., 2021; Oliveira Silva et al., 2022; Rajwani, Mauer & Clapper, 2019; Zasso et al., 2021). These studies focused on comparing hands-on simulation experience to traditional lecture-style education (Boostel et al., 2018; Chang et al., 2021; Lei et al., 2022; Mulyadi et al., 2021). Overall, the simulation shows improvement in the following categories: effective communication skills, problem-solving, confidence, feeling prepared, critical thinking, clinical judgment ability, and novel learning experience ($p<0.05$) (Change et al., 2021; Kim & Yoo, 2018; Lei et al., 2022; Oliveira Silva et al., 2022; Rajwani, Mauer & Clapper, 2019). Three of the twelve articles showed a significant improvement in participant's knowledge base in comparison to pre and post-test evaluation scores ($p<0.05$) (Fayed et al., 2022; Lei et al., 2022; Mulyadi et al., 2021). Regarding satisfaction with the educational intervention, participants preferred simulation-style learning over traditional lectures and suggested that simulation be introduced as part of annual competencies (Chang et al., 2021; Fayed et al., 2022; LaCerra et al., 2019; Mulyadi et al., 2021).

Literature Review Conclusion

Simulation training for anesthesia providers is effective and recommended. This style of education allows for content review, safe practicing, feedback, and self-evaluation while improving the speed of performance and confidence levels. For these reasons, simulation regarding the ASA difficult airway algorithm should be encouraged within SRNA curriculum in conjunction with the requirements set forth by the Council of Accreditation (Council of Accreditation, 2020).

Theoretical Framework

The foundational framework for this DNP project was based on the National League for Nursing (NLN) Jeffries Simulation Theory. This theory was originally developed in 2005 but has since been revamped three times. Appendix D represents the current conceptual illustration and representation of this theory. The basis of the NLN Jeffries Simulation Theory focuses on the interaction of six specific concepts that fit within an overarching theme of context. The six components that correspond to the context are background, design, simulation experience, facilitator and educational strategies, participant, and outcomes (Jeffries et al., 2015). Context is described as the circumstance or environment in which the learning will occur and can include the purpose for why this education must be implemented (Jeffries et al., 2015).

The background and design aspects of this theory filter into the simulation experience. The background takes into consideration the objectives and expectations of the educational intervention (Jeffries et al., 2015). This must build upon an existing curriculum and current resources in order to correspond to the educational benchmarks that are assigned to the students (Jeffries et al., 2015). This is fulfilled with the use of current clinical textbooks as references for the educational information and knowledge-based questions. The design of the simulation must further incorporate the educational objectives with a focus on developing a scenario that engages in curriculum content and the development of problem-solving (Jeffries et al., 2015). During this step, the participants' roles, the progression of the simulation, and the discussion must be established (Jeffries et al., 2015). This is pertinent to the SRNA education because it reinforces concepts and expectations set forth by the accreditation board (Council of Accreditation, 2020). The simulation portion of this project was structured as the same format students are accustomed to with their skill test-outs.

The simulation experience incorporates the facilitator, educational strategies, and the participant before converging into the simulation outcome (Jeffries et al., 2015). The simulation experience is meant to be a place of judge-free learning and collaboration where mistakes can be made. Educational strategies directly apply to the facilitator and can be tailored to the facilitator's preference. The facilitator brings their expertise, skill set, engagement, and preparation into the simulation (Jeffries et al., 2015). The relationship between the facilitator and the participant must be dynamic, with each one responding to the other (Jeffries et al., 2015). Participants bring forth various attributes to the simulation, such as preparation, confidence, anxiety, and personal experience (Jeffries et al., 2015).

The outcomes of the simulation can be categorized as participant, patient, and system outcomes (Jeffries et al., 2015). This project incorporated an analysis of both participant and system outcomes. A review of participant reactions and learning experiences has been reflected in the dissemination of the post-test information.

Project Aims and Objectives

The three aims of this project were to improve the knowledge foundation of the difficult airway algorithm regarding the purpose and utilization of cricothyrotomies, to teach the process of how to perform a cricothyrotomy, and to improve the participant's confidence level in performing a cricothyrotomy. The main objective of this DNP project was to give Marian SRNAs a hands-on cricothyrotomy simulation, which enhanced their knowledge and confidence level, in comparison to their pre-experience assessment, by the end of the workshop. The goal was that students would demonstrate a two-point increase in their post-workshop knowledge of anatomy and the cricothyrotomy procedure as well as perceived confidence levels based on the 'Student Satisfaction and Self-Confidence in Learning' assessment tool.

SWOT Analysis

Before the initiation of the workshop, a thorough assessment was completed to identify the positive and negative characteristics of the project. Positive contributions are sectioned as strengths and opportunities, while the negative aspects are labeled as weaknesses and threats, as demonstrated in Appendix E. The strengths of this project lie within having access to Marian University's simulation and cadaver lab as the physical environment to conduct the workshop, having numerous interested stakeholders (specifically the Marian SRNAs and faculty), and enlisting the help and resources of a community partner that is heavily connected within the Indiana CRNA community. This project has the potential to expand into something more including leg. This project has been set up in a way that it can be used as a legacy project for Marian DNP projects, be included in the future SRNA curriculum through yearly simulations, and can be replicated and offered to members of the CRNA community rather than students alone.

However, as important as it is to acknowledge the benefits of a project, it is equally important to identify and recognize the barriers that also are involved. Key weaknesses of this project included resource availability for both cricothyrotomy kits and organic tissue, potential discrepancies between student users as they will be asked to perform the procedure on artificial tissue that is not identical to human tissue, the need for volunteers to help during the workshop, and accuracy in timing the procedure length. Threats to this project included the weakness of insufficient resources for participants to utilize single-use items as intended. Secondly, the data collection for this project was dependent on the participant's effort in completing the questionnaires fully and being accurate in their responses.

Design and Methods

This DNP project utilized a quality improvement design in hopes to update the current cricothyrotomy teaching method at Marian University to a hands-on simulation experience. This quality improvement project collected quantitative data utilizing a variety of evaluation tools, such as a confidence scale, pre-test, post-test, and a skill observation and technique evaluation. The project was deemed as an *experimental quantitative* study using a *within-subjects* and *pre-test/post-test* design with the independent variable being the education method and the dependent variable being the participant's knowledge and confidence performing the skill. This design allowed for evaluation of pre-simulation compared to post-simulation knowledge basis, skill performance, and confidence levels. The goal of this project was to remodel the education at Marian University surrounding the cricothyrotomy procedure, and this quality improvement project design has adequately and numerically demonstrated the difference and the effectiveness in the current teaching and the purposed teaching method.

Project Site and Sample

This cricothyrotomy lab was held within the skills lab of the Marian University Anesthesia simulation lab. This location was ideal because, if implicated, the cricothyrotomy simulation mannequin would likely be housed in the anesthesia skills room. The Marian University Anesthesia Simulation Lab has recently been revamped to include two operating rooms, a skills lab, and a debriefing conference room. This revitalized simulation lab with high fidelity equipment has the chance to make Marian a front runner to prospective students. The program director and the simulation lab director are stakeholders in this project and have a vast interest in its results. In a broader since, this project could directly impact prospective students to

Marian University's medical programs and the patients that will come into their care. Ultimately, the company that creates the cricothyrotomy simulation mannequins, *Design and Business LLC,* are potential stakeholders because this project could provide efficacy of their product.

A sign-up sheet was presented to all CRNA students currently enrolled at Marian University. A total of 12 participants were included. Despite being a smaller population, this sample population will adequately represent the students within Marian University's Anesthesia program because of the comparably small class sizes. Inclusion criteria must have been met to be involved, this included being actively enrolled in the Marian Anesthesia program, ability to speak English, and a willingness to come to in-person training. Students that did not sign up before the deadline or were unable to be on campus for the cricothyrotomy simulation lab were excluded from the data collection. Additionally, students that have not completed the first two semesters of the program have yet to receive difficult airway algorithm training and therefore, were excluded from the study.

Methods

Before developing this project, an exemption was obtained from Marian University's Institutional Review Board (IRB) (Appendix F). Afterwards, the curriculum for this simulation was created based upon resources that are readily available to students who are enrolled in Marian University's nurse anesthesia program. Specifically, the resources included the textbooks, *Nurse Anesthesia*, 6th edition (Nagelhout & Elisha, 2018), and *Clinical Anesthesia*, 6th edition (Barash et al., 2017); as well as online material found on prominent organization's and equipment manufacturers' webpages, such as the American Society of Anesthesiologists, Cook Medical, and the Center for Disease Control and Prevention. Upon reviewing these resources, the authors developed a Canvas course that outlined this information in document, PowerPoint, and video format.

Students who enrolled into the project were given access to the Canvas course via email invitation. Before the students were able to view the media files within the course, they were asked to complete the measurement instrument pre-test, which was available and secured through Qualtrics. After completion of the pretest, the students were asked to view the media files found within the Canvas course before their requested time slot. Students were notified that they would have 30 minutes to conduct the cricothyrotomy procedure on the mannequin, with the possibility of a question-and-answer session, as well as personalized feedback after their performance. During the procedure, the authors would assess student performance based on the accuracy of the completion of the cricothyrotomy steps, as listed in the Cook Medical document, given to students within the Canvas course. After the completion of the simulation, students were asked to complete the measurement instrument post-test which was available and secured through Qualtrics.

Measurement Instrument

The measurement instruments, the pre- and post-test, were created based on the integration of a ‘Student Satisfaction and Self-Confidence in Learning’ assessment tool (Appendix G) and knowledge found within the required readings for Marian University curriculum in regards to current difficult airway simulation. During the pre-test, the authors included demographic based questions, such as years working as a registered nurse, learning preferences, and current experience with cricothyrotomies. Please review Appendix H for the questions contained within the pre- and post-test. The pre- and post-test questionnaires were administered through a Qualtrics link that was available through the Canvas course, as well as the student's Marian University email address. For the skill performance, the authors created a check-off that included the exact steps listed in the Cook Medical document, with each step being given a one point, for a total of seven points possible. While the Cook Medical has eight steps, the Melker Emergency Kit that was provided in the simulation does not have an inflatable cuff, therefore that step and subsequent point was deleted from the check off.

Satisfaction and Confidence Interval

The 'Student Satisfaction and Self-Confidence in Learning' assessment tool was developed by the National League for Nursing in 2005 (Appendix G). Since its publication, it has been validated for academic use, with a Cronbach alpha value range of 0.77-0.85 (Unver et al., 2017). It is a 13-question test that uses a Likert-like scale to gauge participants self-reported satisfaction and confidence regarding the learning outcomes. The participants were asked to rank their answers on a one to five scale, with one equating to strongly disagree and five equating to strongly agree. An analysis of the tool indicates that five of the questions relate to student satisfaction, while the other eight pertain to their perceived confidence level in the learning outcomes. As such, scores were tallied into two categories; the satisfaction questions contained a point range of 5-25, while the confidence questions contained a point range of 8-40.

Knowledge Assessment

In the pre- and post- test, there were seven questions that pertain to the clinical application of the cricothyrotomy procedure. Five questions were written with a multiple-choice structure, while one was a select all that apply, and the final question was order ranking format.

The order ranking question asked the participants to order the steps of the Seldinger technique (Appendix I). The topics included in the knowledge assessment focused on anatomy, contraindications, duration of use, proper cuff inflation, and procedural technique. The questions were derived from information found within the *Nurse Anesthesia*, 6th edition (Nagelhout & Elisha, 2018). The validity of the knowledge-based questions was confirmed by Marian University's simulation instructor, who is a Doctorly Prepared Nurse Anesthetist, and serves as a content expert on this project.

Data Collection

The authors utilized Qualtrics to collect data regarding the pre- and post-test. Students were given a one-week timeframe to complete the pre-test before the date of the simulation. The authors reminded the students of the post-test at the end of their timeslot and asked that it be completed within five days. The authors also sent a follow-up email after the simulation with a reminder message and a link to the Qualtrics survey. All responses were kept confidential.

Ethical Considerations

This project commenced after approval was granted from Marian University's IRB Committee on March 03, 2023 (Appendix F). Questionnaire results remained confidential and anonymous throughout the project as Qualtrics distributed the surveys to participants' academic email accounts. Qualtrics also acted as the secured storage location for survey results. Each participant chose a four-digit code and they placed it on each of their assessment tools. This allowed for correlation of the pre-evaluation assessments to the post-evaluation assessments with anonymity. No identifying information was required on the evaluation tools. The researchers had access to the list of 12 students who participated in the project. This access was required so that the appropriate students could be contacted regarding education material and lab sign up. However, no other stakeholders had access to which students participated in the study.

An educational video demonstrating the cricothyrotomy technique on a deceased donor was available for participants to see. Participants only had access to the video during the education portion of this project. Great care was taken to maintain the safety of the demonstrators and to uphold respect for the donors. Demonstrators received safety training and educational modules from the cadaver lab supervisor. After taping, the video was uploaded to a USB drive and securely stored at Marian University within the CRNA program director's locked office. It will stay there until the completion and dissemination of this project. After dissemination, it will be destroyed. University regulations pertaining to the use of deceased tissue for educational purpose were upheld throughout the entirety of this project. The researchers would like to acknowledge the generous people who donated their bodies to science as key contributors to this project.

Analysis

The data analysis for this project utilized descriptive and inferential statistics. Descriptive data was processed via central tendency, frequency, and variability measures. The calculations for central tendency including mean, median, and mode, along with frequency were performed on Microsoft Excel. Variability in the data was accounted for through standard deviations. Based on the knowledge survey and the demonstration of skills, the data fell into either ordinal or interval scales. After performing a Jarque-Bera test for normality, the resulting p value was 0.569, meaning that the null hypothesis is rejected, and the data is normally distributed. Since the data shows equal distribution, an independent samples t-test with equal variance was used to compare the pre- and post-tests. The quantitative data was analyzed using the program IBM SPSS Statistics v.27, a software provided by Marian University.

Results

A total of twelve Marian SRNAs were eligible and participated within this study. All students completed the pre-test prior to the simulation and completed the post-test immediately after the simulation. The participants were distributed between those in the junior and senior classes. The majority of participants were female (67%), healthcare providers who had 2-5 years of experience (42%) and never have had to perform a cricothyrotomy before either in simulation or life (83%; 92%).

Table 1: *Demographics and Characteristics of Study Participants*

	n=	%
Gender		
Females	8	66.7
Males	4	33.3
Years of Experience		
2-5	3	25
5-10	5	41.7
10+	4	33.3
Previous Demonstration		
Simulated	2	16.7
Actual	1	8.3

Satisfaction and Self Confidence with Current Learning

Based on the separation of questions found within the ‘Student Satisfaction and Self-Confidence in Learning’ assessment tool, the questions were analyzed in relation to their category. The first five questions targeted overall satisfaction with current learning, and the other eight questions related to the student's self confidence in skill performance. Students were made aware that in the pre-test, they should answer based on the previous didactic learning they have experienced through Marian University, and the post-test is based on the education from the Canvas course and simulation. Please refer to Tables 6-18 for a complete representation.

Overall Satisfaction with Current Learning (Pre- and Post-test)

The students were asked to answer five questions based on a Likert-like scale, ranking their responses from 1-5. An independent samples t-test with equal variance indicated that students were statistically more satisfied with their learning after completion of the simulation than with didactic only ($p < 0.05$). Furthermore, individual question analyzed showed that all five questions were statistically significant in improvement of learning outcomes ($p < 0.05$).

Table 2: *Results of 5-Items to Measure Satisfaction with Current Learning*

Item	Pre-test Mean	Post-test Mean	Mean Difference	p-value
Satisfaction 1	2.75	4.67	+1.92	4.91×10^{-6}
Satisfaction 2	2.75	4.75	+2.0	2.25×10^{-6}
Satisfaction 3	2.83	4.58	+1.75	1.39×10^{-5}
Satisfaction 4	2.83	4.67	+1.84	6.81×10^{-6}
Satisfaction 5	2.75	4.67	+1.92	5.31×10^{-7}
Summed Satisfaction	2.78	4.67	+1.79	7.58×10^{-26}

*Note: statistically significant change at $p<0.05$

Overall Self Confidence with Current Learning (Pre- and Post-test)

The students were asked to answer eight questions based on a Likert-like scale, ranking their responses from 1-5. An independent samples t-test with equal variance indicated that students were statistically more confident with their ability to perform the skill after completion of the simulation than with didactic only ($p < 0.05$). Individual question analysis showed statistically significant increases in self-confidence in seven out of the eight questions. The question "It is the instructor's responsibility to tell me what I need to learn of the simulation activity content during class time" did not have a significant change (p= 0.21).

Table 3: *Results of 8-Items to Measure Self-Confidence with Current Learning*

Item	Pre-test Mean	Post-test Mean	Mean Difference	p-value
Self-Confidence 6	2.67	4.50	+1.83	4.96×10^{-6}
Self-Confidence 7	2.75	4.58	+1.83	2.15×10^{-5}
Self-Confidence 8	2.75	4.58	+1.83	9.85×10^{-6}
Self-Confidence 9	2.92	4.58	+1.66	6.76×10^{-6}
Self-Confidence 10	3.83	4.58	+0.75	1.42×10^{-3}
Self-Confidence 11	4.00	4.67	+0.67	9.07×10^{-4}
Self-Confidence 12	3.83	4.58	+0.75	3.78×10^{-3}
Self-Confidence 13	3.33	3.67	+0.34	0.21
Summed Confidence	3.26	4.47	+1.21	7.58×10^{-26}

*Note: statistically significant change at $p<0.05$

Knowledge Assessment

Students were given a series of seven knowledge base questions as part of the pre- and post-test. These questions included the format of select one, select all that apply, and list in order. For the select all that apply and list in order questions, the scoring was all-or-nothing. Overall, the mean score for pre-test was 3 (range 1-7), while post-test was 5 (range 2-7). As a whole, this result is statistically significant (p=0.01). Between both pre- and post-test, the question concerning absolute contraindications was missed the most (8.3%; 33.3%). For the pre-test, the question concerning anatomy was answered correctly the most (91.7%), while for the post-test, the question of needle direction was answered correctly the most times (91.7%). The full breakdown of answer selection for the increased difficulty of placement and the order of the procedural steps can be found in Tables 19-21.

Procedural Checkoff Scores

The authors used the Cook Medical document that was provided to the students in the Canvas course to create a scoring basis for procedural step completion (Appendix I). Students were asked to perform seven steps, with each step earning a single point. The mean score from this simulation was 6, within a range of 0 to 7. The authors made notes as to why points were taken away. The results can be found in Table 4.

Table 4: *Results of Missed Points in the Performance of a Cricothyrotomy*

Deviations to Procedure	Occurrences
Did not stabilize the cricothyroid membrane	1
Did not insert needle/catheter into the cricothyroid membrane	1
Inserted the needle in the cephalad direction	1
Inserted the assembled airway in the cephalad direction	1
Did not attach syringe to needle/catheter for aspiration	1
Did not use the guidewire	2
Did not combine the dilator and tracheostomy device together	5
Did not take needle/catheter off guidewire before attempting to place airway device	1
Did not attach tracheostomy ties	2

Procedural Time to Completion

Before the start of the procedural demonstration, students were made aware that their efforts would be timed, but that the time would not be disclosed to them. The authors began the time after they said, “you may begin”, and ended the time after the student verbalized the final step. The mean time to completion was 288 seconds. The timed results may be found in Table 5.

Table 5: *Timed Results of Procedural Completion*

Time (seconds)			
273	349	474	243
265	493	126	131
159	212	194	535

Summary

A total of 12 Marian University SRNAs fully completed the components of this simulation project. Overall, there was a significant increase in satisfaction with learning, self-confidence in procedural skill, and knowledge base between pre- and post- simulation ($p<0.05$; $p<0.05$; $p=0.01$). During the simulation, participants averaged a check-off score of six out of seven, with the most missed step being putting the airway device and dilator together to make a single unit. The average time of completion during the simulation was 288 seconds.

Discussion

Although an anesthesia provider will only encounter a CICV scenario a few times in their career, having adequate knowledge and comfortability in invasive airway procedures are critical for patient survival (Cho et al., 2016). Creating a productive learning environment through simulation allows for students to learn new skills in a manner that promotes safety and self-confidence. The aim of this project was to determine the effect simulation had on students' knowledge base, self-confidence, and satisfaction in learning. The results indicate that simulation has a positive and significant effect on students. This further supports COA's recommendation that anesthesia education incorporates simulations.

Recommendations

The basis of this project is one that can create various other questions, aims, and goals. There are multiple techniques for how to perform a cricothyrotomy, however, we chose one for consistency. Studies have shown that when focusing on successful time of completion, certain techniques are faster than others (Clark et al., 2021; Geroge et al., 2022; Zang et al., 2022). Another aspect to consider would be to look at the retention rate for knowledge and procedural skill level for students after a specific timeframe has lapsed. Finally, we promote the use of larger sample sizes in order to create a more representative picture.

Strengths and Limitations

The study had five specific limitations. Primarily, single use Melker Emergency Cricothyrotomy kits were used multiple times due to the lack of equipment. The participants were able to complete the workshop prior to watching the educational material despite being prompted to do it firsthand. There should have been a definitive criterion that required full review of the required educational material prior to completion of the workshop. Although the mannequin and additional equipment simulated the procedure, it could not identically replicate human tissue. Additionally, the study was concluded at one location on one day, which limited participants to those who did not have other obligations such as class, clinical, or personal responsibilities. Also, the data retrieved could be disproportionate due to the smaller sample size.

Participant variability was noted regarding their previous cricothyrotomy training prior to Marian University. For instance, some participants had work-related education in various techniques with their previous healthcare occupations, such as respiratory therapists and EMTs. There was also variability in the amount of required educational material that the participants completed prior to the workshop and in what timeframe it was completed. For instance, some students arrived to the workshop after only completing the pretest while others had completed the pretest and the entire educational module.

Conclusion

This project provided insight into the benefits of a simulated cricothyrotomy workshop on student learning. Specifically, students showed an improvement in knowledge, satisfaction, and self-confidence with the simulation in comparison to didactic teaching alone. As simulation is a recommended resource for anesthesia learning, the hope is that an incorporation of simulated invasive airway procedures within anesthesia curriculum will produce SRNAs that are safe and competent care providers. Recommendations for future studies include focusing on different cricothyrotomy techniques and retention rate of knowledge and procedural skills.

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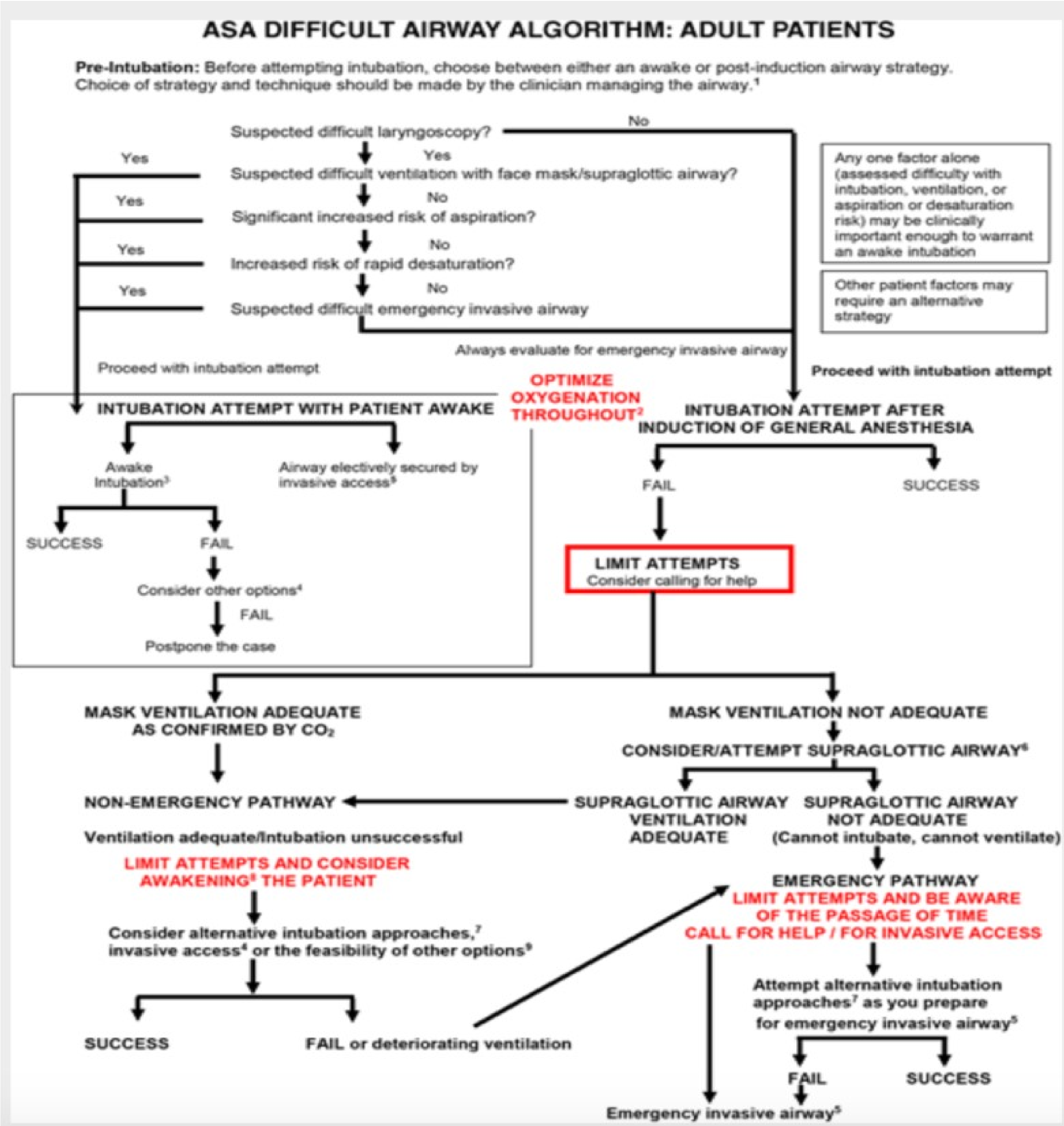
Appendix A: ASA Difficult Airway Algorithm



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Appendix B: Literature Review Matrix

Citation	Research Design & Level of Evidence	Population / Sample size n=x	Major Variables	Instruments / Data collection	Results
Alamrani et al., 2018	Randomized controlled trial; Level 1	n= 30 Participants were undergraduate nursing students enrolled within a specific program	Years of nursing education, previous exposure to simulation training, scenario the participant was assigned to, baseline mastery of nursing knowledge,	Data collection as based on a survey that incorporated components of C-scale. Data analysis includes paired samples t test, Wilcoxon signed-rank test, and Mann-Whitney U test on SPSS v. 22.	No significant differences in outcomes were identified between the simulator-based and traditional teaching methods, indicating that well-implemented educational programs that use either teaching method effectively promote critical thinking and self-confidence in nursing students.
Ambardekar et al., 2019	Randomized controlled trial; Level 1	n=67 Participants were anesthesia focused medical students at the University of Texas Southwestern Medical Center	Years of experience, previous exposure to the difficult airway algorithm, previous airway management experience	The pre- and post-tests included assessments from the State-Trait Anxiety Inventory Form Y and the National Aeronautics and Space Administration Task Load Index. Data statistics were measured with the Fisher's exact test and descriptive statistics.	Medical students perform better in a simulated airway crisis after training in the Vortex approach to guide decision-making. Students in the ASA group had task load scores indicative of high cognitive load. There was no difference in anxiety scores.
Añez Simón et al., 2019	Nonrandomized control trial; Level 3	n=91 Participants were students enrolled into anesthesiology specialty at an academic center	Years of education, previous exposure to cricothyrotomy education, time to perform the skill, number of attempts, pre- and post-test knowledge scores, self-reported performance confidence	Timing was based on stopwatches, and the pre- and post-knowledge tests were surveys. Data analysis was preformed via Wilcoxon signed rank test in IBM SPSS Statistics.	At first attempt, 86% of students performed a surgical cricothyrotomy with successful ventilation, and 92% at the sixth attempt ($P<.0001$). Time taken was 163 seconds at first attempt, and 70 seconds at the sixth ($P<.0001$). At the end of workshop, students had improved their theoretical knowledge ($P<.0001$) and perception of the ease of the technique.
Bessmann et al., 2020	Descriptive study; Level 6	n=191 Participants were anesthesiologists who have performed an airway management	Location of anesthesia services, years of experience, self-reported confidence scores, pre and post module test scores	The e-learning course and quizzes were given through Area9 Lyceum ApS coding. Data analysis was completed via frequency analysis	For preoperative planning, participants stated low confidence regarding predictors of difficult airway management. Subjective and objective assessments correlated, and lower confidence was associated with lower test

		procedure in the past 60 days		and Spearman's rho through IBM SPSS Statistics.	scores: preoperative planning [P < .001], optimization of basic techniques [P = .002], and advanced techniques [P < .001].
Boostel et al., 2018	Randomized controlled trial; Level 1	n=52 Participants were undergraduate nursing students in one program	Year in the program, previous experience in patient interaction, previous experience with simulation	The survey for data collection was based on the KEZKAK questionnaire. Data analysis was conducted through Bioestat and included descriptive statistics, Mann-Whitney and Wilcoxon test.	There was a significant increase in the perception of factors related to lack of competence, not controlling the relationship with the patient, emotional involvement, and contact with suffering as stressors for the students after the simulation (p< 0.05). Simulation promotes the students' awareness of their responsibility in patient care.
Chang et al., 2021	Randomized controlled trial; Level 1	n=107 Participants were students enrolled in a Fundamentals of Nursing class, found within the second year of a nursing program	Assignment and examination performance, number of times participants interacted with the animation simulation, score on the Confidence in Communication assessment	Simulation instructors created the knowledge-based questionnaires. Surveys used in this project include the Confidence in Communication self-assessment and another validated survey with 11 questions. Data was analyzed with paired or independent t-tests via IBM SPSS 22.	Both groups showed statistically significant improvement in Confidence in Communication; however, the experimental group performed better on the skillset (p < .001; p< 0.001). The experimental group demonstrated a positive response to the simulation. The following themes emerged: effective communication skills, problem solving, confidence, feeling prepared and novel learning experience.
Clark et al., 2021	Nonrandomized control trial; Level 3	n=60 Participants included board certified anesthesiologists	Performance without a safety breach, number of skill attempts, performance time, years away from residency	Data collection was gathered by the instructor and simulation engineer. Data analysis was run through a pairwise Wilcoxon signed-rank tests of medians and post-hoc power analysis.	Initial testing showed a success rate of less than 25% for each technique. After master-based practice, all anesthesiologists achieved successful invasive airway placement with TTJV, BC, and MC. Repeated performance of each skill improved in speed with zero safety breaches. BC was the fastest technique. 15 months later, retesting showed that 80% and 82.6% performed successful airway securement for TTJV and BC. ment for TTJV and BC.
Fayed et al., 2022	Descriptive study; Level 6	n=119 Collaboration of various anesthesia providers, including attendings, residents, and CRNAs.	Years of occupation, extent of prior training, self-reported competency, previous exposure to a CICV event	Data collection was gathered via surveys sent to provider's work email addresses with Microsoft Forms. The results of	87% of participants had not performed the surgical airway procedure before. The vast majority (96.7%) recommended simulation training compared to online

				the survey were analyzed through chi square and Fisher's exact test. Statistical analysis was gathered through SAS 9.4 programming.	training or lecture series, and just over 50% recommended annual training frequency. When looking at the differences in responses based on years of experience as an anesthesia provider, the longer the work experience, the more familiar with the procedure participants were.
George et al., 2022	Case control study-retrospective; Level 3	n=51 Charts included in this review occurred in a single hospital over a decade timeframe.	Pre-procedural Glasgow Coma Scale (GCS), Injury Severity Score (ISS), past medical history, vital signs, chief complaint, other injuries/symptoms, hospital course, hospital length of stay, disposition, clinical outcome, indication for cricothyrotomy, technique used, performing physician by subspecialty, location performed, and complications	Data collection occurred from the electronic health records. Data analysis included an independent t-test, descriptive statistics, Wilcoxon rank sums test and chi-square test on the SAS software.	Two techniques of cricothyrotomy were identified as preferred techniques (SFB and surgical). Both procedures were successful in securing an emergency airway. There was no significance difference in patient mortality rates (p=0.217).
Issa et al., 2018	Nonrandomized control trial; Level 3	n=37 Participants were doctoral students in years 2-5 of their medical education in the specialty of ENT or general surgery	Participation practice time with the simulation manikin, procedure performance time, participant base knowledge, and previous experience of performing a cricothyrotomy,	Pre and posttests, as well as the procedure checklist, were created in conjunction with the Mastery Angoff standard setting method and Likert scale. Data analysis includes paired Wilcoxon signed rank test, and unpaired t-tests on SPSS v26.	24% of participants indicated they were never trained on performing a cricothyrotomy and 32% had never done a cricothyrotomy. Only one participant reached the set goals at pretest. All 37 participants were able to reach the goals at posttest. 76% of learners passed the posttest on the first attempt. 14% required a second posttest, 3% required a third posttest, while 8% required a fourth posttest. The mean time of completing the procedure was 4:25 min for the pretest compared with 3:10 min for the posttest (p<0.001). Thirty-one participants (89%) indicated they felt more confident in their ability to perform cricothyrotomy on patients after the training.

Johnson et al., 2022	Nonrandomized control trial; Level 3	n=66 Participants were anesthesiologists and CRNAs who worked at a level 1 medical center	Years of experience, previous simulation exposure, previous experience with a task trainer, number of simulated cricothyrotomies, number of actual cricothyrotomies	Participants' skills were judged based on the Global Rating Scale (GRS) for Cricothyrotomies and a checklist. Time was measured via cell phone stopwatches. Data analysis was preformed via Wilcoxon signed-ranks test and IBM SPSS.	Only 3 participants (4.5%) reported performing a real-life cricothyrotomy. Thirty-seven (56.1%) had not performed a simulated cricothyrotomy in the previous 10 years. There was a significant increase in median total confidence scores from pre-simulation to post-simulation ($P < .001$). The median total GRS scores significantly improved from pre-education to post-education ($P < .001$). There was also a significant increase in overall checklist scores from pre-education to post-education ($P < .001$). The median procedure time in seconds decreased significantly from 151 in the pre-education assessment to 119 in the post-education assessment ($P = .007$).
Kim & Yoo, 2022	Systematic review and meta-analysis; Level 1	n=12 Articles included in this study were found on the following databases: CINAHL, Medline, Scopus, Embase, PsycINFO, ProQuest, KMbase, and RISS.	Previous clinical practice, variables of nursing students that were measured, mastery of nursing knowledge, publication bias	Data analysis included funnel plot, Egger's regression test, and the Begg and Mazumdar rank correlation test on the Comprehensive Meta-Analysis Software v.3.	Higher-fidelity manikins were more effective than lower-fidelity manikins in improving skill performance/clinical competence and perception of nursing students and nurses. In terms of learners' knowledge, satisfaction, and self-confidence, both higher- and lower-fidelity manikins were similarly effective for nursing students.
La Cerra et al., 2019	Systematic review and meta-analysis; Level 1	n=33 Articles included in this study were found on the following databases: PubMed, Scopus, CINAHL with Full Text, Wiley Online Library and Web of Science	Previous clinical practice, variables of nursing students that were measured, mastery of nursing knowledge, publication bias	Data was synthesized using meta-analytic procedures based on random-effect model and computing effect sizes by Cohen's d with a 95% CI, on ProMeta v.3 and IBM SPSS v.19.	Compared with other teaching methods, high-fidelity patient simulation revealed higher effects sizes on nursing students' knowledge and performance.
Legoux et al., 2020	Systematic review and meta-analysis; Level 1	n=10 Articles included in this study were found on the following databases: MEDLINE, Embase, and Central Trials	Previous simulation experience, previous difficult airway exposure, time elapsed after simulation training, skill measurements	Data analysis included qualitative and quantitative measures; however, the author only mentions standard deviation and	While there was some evidence of skill retention after simulation, overall, most studies demonstrated skill decline over time.

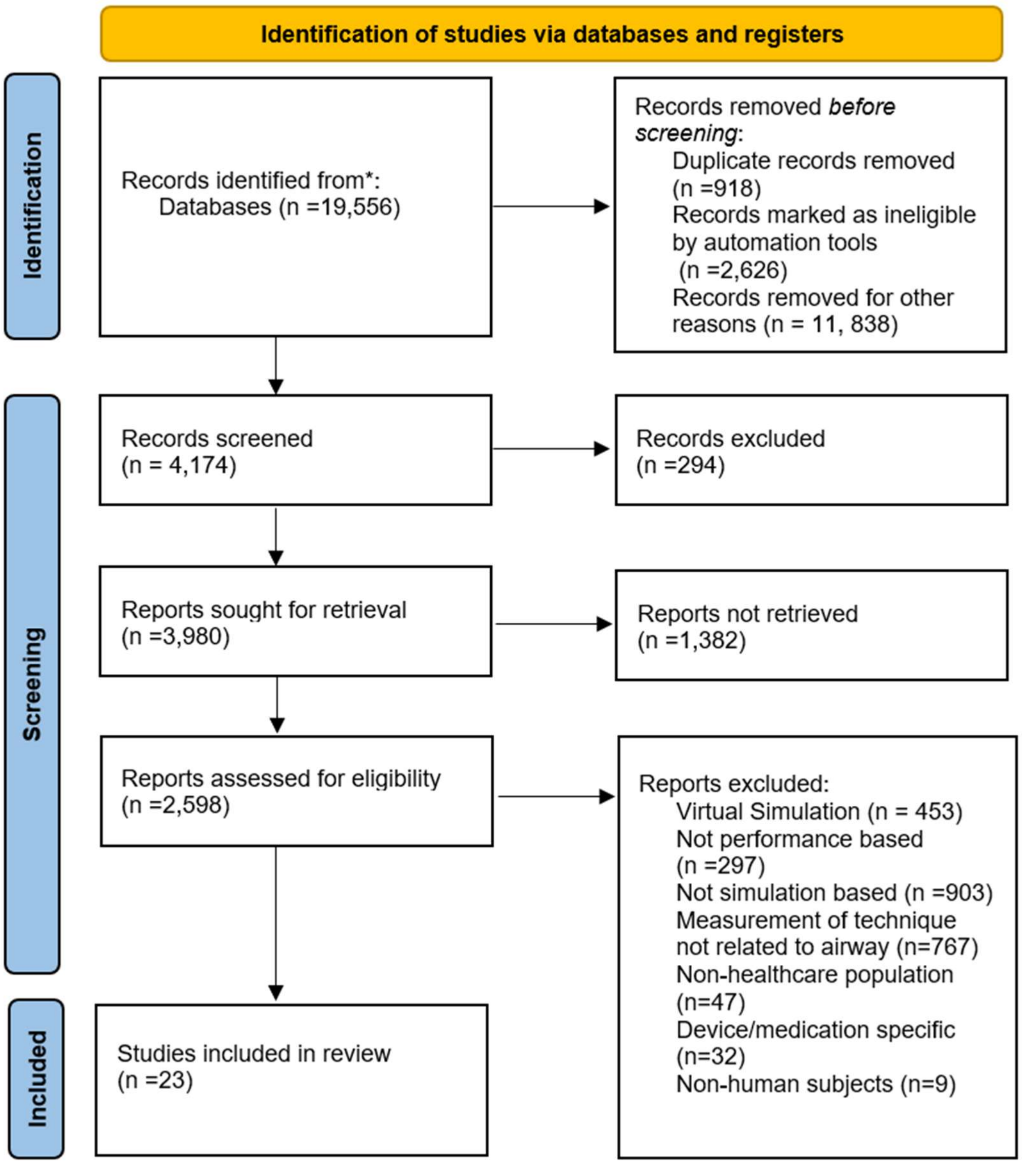
		Registry of the Cochrane Collaboration		I^2 test.	
Lei et al., 2022	Systematic review and meta-analysis; Level 1	n=15 Articles included in this study were found on the following databases: PubMed, Embase, Cochrane library, Web of Science, CNKI (China National Knowledge Infrastructure) and Wangfang	Previous clinical practice, variable of nursing students that were measured, measurement tools used, Cronbach's reliability score, risk of bias, baseline mastery of nursing knowledge	Data analysis program used RevMan 5 to run chi square tests and I^2 tests.	High-fidelity simulation significantly increased nursing students' knowledge acquisition ($P < 0.0001$), and enhanced nursing students' professional skills ($P = 0.0001$). In terms of clinical practice ability outcomes, high-fidelity simulation significantly improved the levels of critical thinking ability ($P < 0.00001$), clinical judgement ability ($P = 0.006$) and communication skills ($P < 0.001$).
Liu et al., 2021	Descriptive study; Level 6	n= 1935 Participants were anesthesia providers who were currently working in China	Working years in anesthesia, evaluation methods for difficult airway, approaches to difficult airways, participation in an airway training course	A questionnaire was submitted via survey. Data analysis includes Fishers exact test, descriptive statistics, and IBM SSPS v. 20.	When suffering from unanticipated difficult airway 63% less than 10 years anesthesiologists (LA) and 65% more than 10 years anesthesiologists (MA) would ask for help after trying 1 to 2 times ($P = .000$). More than 70% of LA and MA respondents reported preferring cannula cricothyrotomy to deal with emergency airway,
Mulyadi, et al., 2020	Systematic review and meta-analysis; Level 1	n= 17 Studies were found from the following sources: CINAHL, Embase, MEDLINE, PubMed, and Web of Science	Varying risk of bias, type of study design, study location, education platform (e-learning vs manikin vs traditional lectures), learning outcomes, data collection scales/ questionnaires/ assessments	The methodological quality of included studies was evaluated by the Cochrane risk-of-bias tool. Comprehensive Meta-Analysis Version 3.0 was used to conduct a meta-analysis using the random-effects model. Begg's and Egger's tests were performed to assess publication bias, and sensitivity analysis performed using a remove one study method.	Simulated technology–based learning significantly increased nursing student knowledge acquisition ($p = 0.043$), and increased student's satisfaction in learning ($p < 0.001$). Subgroup analyses showed that receiving simulation by manikins simulator had a greater effect on knowledge acquisition.
Oliveira Silva et al., 2022	Systematic review and meta-analysis; Level 1	n= 62 Studies were found on the following databases:	Previous clinical practice, variable of nursing students that were measured,	The methodological quality of included studies was evaluated by the Cochrane risk-	When comparing simulation with other teaching strategies, simulation showed small effect size for anxiety ($p = 0.051$) and

		CENTRAL, CINAHL, Embase, ERIC, LILACS, MEDLINE, PsycINFO, SCOPUS, Web of Science, PQDT Open (ProQuest), BDTD, and Google Scholar	measurement tools used, Cronbach's reliability score, risk of bias, baseline mastery of nursing knowledge, previous experience to simulation, self-assessment, simulation scenario, nursing program (ASN vs BSN)	of-bias tool. Critical appraisal of the studies was managed by means of the risk of bias tools RoB 2 and ROBINS-I, and quality of evidence by means of the GRADE tool. Data summarization was performed by qualitative synthesis with descriptive analysis and quantitative synthesis by meta-analytic methods and meta-regression.	medium effect size for self-confidence ($p < 0.001$); there was no difference in the effect-size for stress ($p = 0.90$). A positive relationship between self-confidence and learning was identified by meta-regression ($p = 0.018$).
Ott et al., 2018	Nonrandomized control trial; Level 3	n= 50 Participants were students enrolled in the simulation center	Previous experience with intubations, time spent in the simulation center, time to identify a CICV scenario, time spent on decision-making	Data was collected via pre- and post-test questionnaires, observational time, central tendency, and the Wilcoxon rank test.	In the CICV situation, 91% of the participants complied with the algorithm. A median of 63 s was required to perform the cricothyrotomy, with no difference being made between specialists and residents ($p = 0.46$). The cricothyrotomy could be performed surgically faster than the puncture cricothyrotomy using the Seldinger technique.
Rajwani, Mauer, & Clapper, 2019	Nonrandomized control trial; Level 3	n=11 Participants were pulmonary critical care fellows within the first 3 years of their medical education	Years in medical school, previous exposure to cricothyrotomy, practice time on the models	Data was collected via pre- and post-test questionnaires, checklist provided by Cook Medical, and the Wilcoxon signed rank test.	Survey results demonstrated an improvement in perceived confidence ($p<0.005$) and competence ($p<0.002$) following this educational intervention. Fellows also achieved significant improvement in knowledge ($p<0.003$) and performance in two cricothyrotomy techniques (Seldinger and MacIntyre) ($p<0.004$).
Scott-Herring et al., 2020	Cohort study; Level 4	n=43 Participants were CRNAs	Number of attempts, placement time, years of experience as a CRNA, previous airway course, performed live cricothyrotomy previously, preference in skill equipment	A professional development survey was distributed to participant's work emails. Cell phone timers were used for timing. Data analysis was preformed via Wilcoxon signed	All but 1 CRNA completed the cricothyrotomy in under 2 minutes. The scalpel/bougie/endotracheal tube combination was the fastest, with an average completion time of 86.6 seconds. The confidence of CRNAs in performing a successful cricothyrotomy in less than 2 minutes was significantly

				rank test in IBM SPSS Statistics.	increased (P ≤ .001). Simulating airway skills improved performance, speed, and confidence.
Zasso et al., 2021	Randomized controlled trial; Level 1	n= 40 Participants were divided into teams and employed at a tertiary hospital. Teams included an anesthesia resident, nurse, and respiratory therapist.	Job, years of experience, previous exposure to airway emergencies, previous education on difficult airway algorithm	Data was collected based on a checklist and assessment from the Mayo High-Performance Teamwork Scale. Cell phone timers were used for simulation timing. Data analysis includes two-sided two-sample equal-variance *t*-test, Shapiro-Wilk normality test and Wilcoxon rank sum test with SAS 9.4.	Prior exposure and teaching of a visual airway cognitive aid improved decision-making time to perform a FONA during a simulated airway emergency.
Zhang et al., 2022	Randomized controlled trial; Level 1	n= 65 Participants were anesthesiologists and senior residents working in a hospital	Years of experience, previous exposures to difficult airways, self-assessment, technique preference	Data collection included pre- and post-test survey and timing with cell phone timers. Data analysis included descriptive statistics, numerical equations (proportions), and Cox proportional hazards model with shared frailty on a STATA v.16.1 program.	SFC was associated with a shorter time to oxygen delivery (p<0.01). Higher first-attempt success was reported with SFC than SFB (p<0.01). Successful delivery of oxygen after the "can't intubate, can't oxygenate" declaration within 3 attempts and 180 seconds was higher (84.6% vs 63.1%) and more likely with SFC (p=0.06)

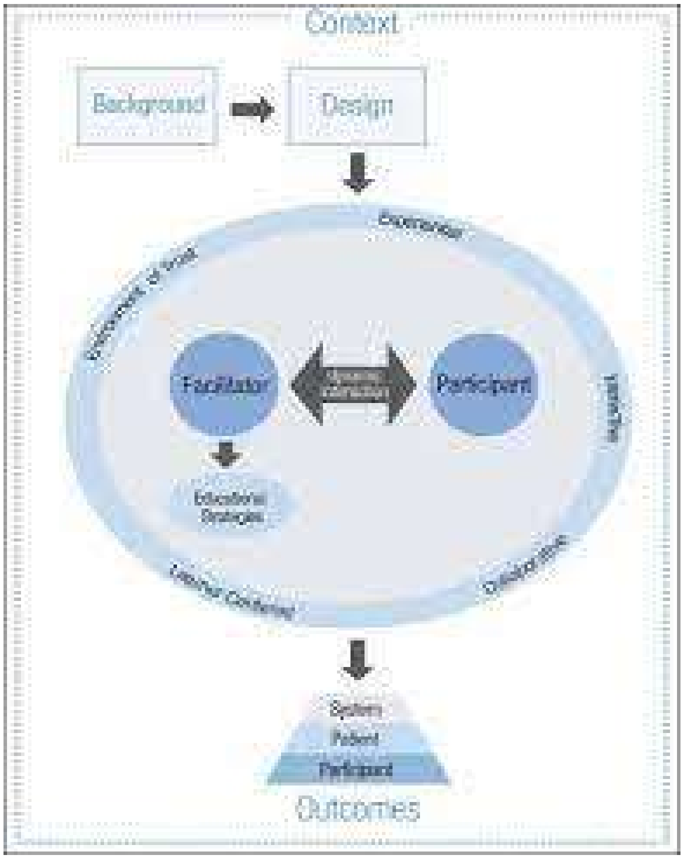
Footnotes: TTJV= transtracheal jet ventilation; BC= bougie cricothyrotomy; MC= Melker cricothyrotomy kit; SFC= scalpel-finger-cannula; SFB= scalpel-finger-bougie

Appendix C: Prisma Diagram



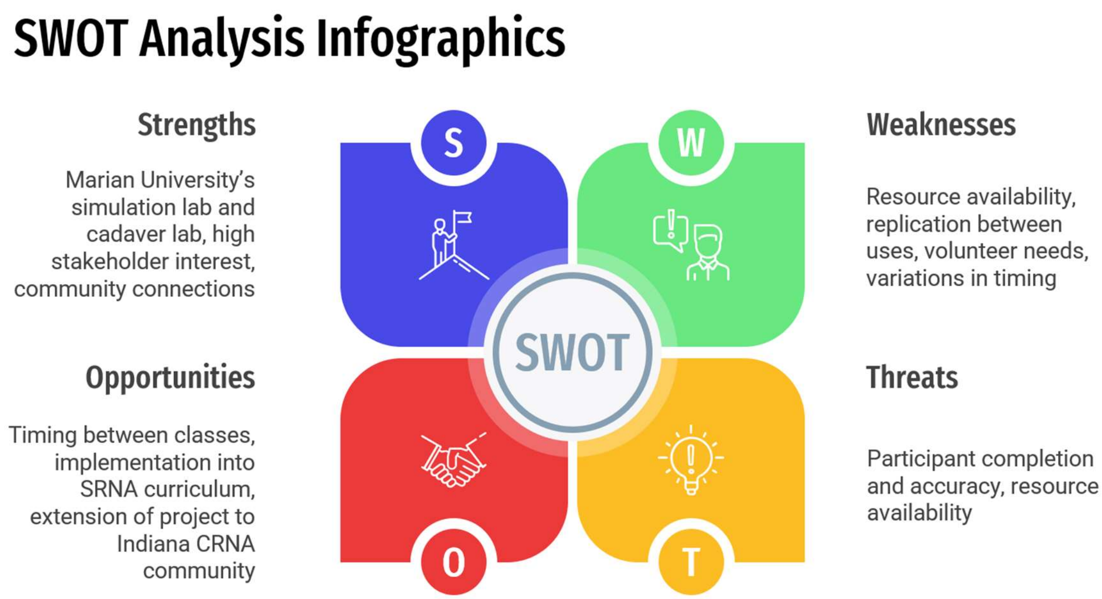
Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.113

Appendix D: Jefferies Simulation Theory Model



Jeffries, P. R., Rodgers, B., & Adamson, K. (2015). NLN Jeffries Simulation Theory: Brief Narrative Description. *Nursing Education Perspectives*, *36*(5), 292–293. https://doi.org/10.5480/1536-5026-36.5.292

Appendix E: SWOT Analysis Infographics



Appendix F: IRB Approval Letter

MARIAN UNIVERSITY
Indianapolis

Institutional Review Board

DATE:	03-03-2023
TO:	Merandah Tokarz, Hannah Harris, Dr. Monteiro, & Dr. Stelflug
FROM:	Institutional Review Board
RE:	S23.123
TITLE:	Cricothyrotomy: The Life-saving Airway Procedure
SUBMISSION TYPE:	New Project
ACTION:	Determination of EXEMPT Status
DECISION DATE:	03-03-2023

The Institutional Review Board at Marian University has reviewed your protocol and has determined the procedures proposed are appropriate for exemption under the federal regulation. As such, there will be no further review of your protocol and you are cleared to proceed with your project. The protocol will remain on file with the Marian University IRB as a matter of record.

Although researchers for exempt studies are not required to complete online CITI training for research involving human subjects, the IRB **recommends** that they do so, particularly as a learning exercise in the case of student researchers. Information on CITI training can be found on the IRB's website: http://www.marian.edu/academics/institutional-review-board.

It is the responsibility of the PI (and, if applicable, the faculty supervisor) to inform the IRB if the procedures presented in this protocol are to be modified of if problems related to human research participants arise in connection with this project. Any procedural modifications must be evaluated by the IRB before being implemented, as some modifications may change the review status of this project. Please contact me if you are unsure whether your proposed modification requires review. Proposed modifications should be addressed in writing to the IRB. **Please reference the above IRB protocol number in any communication to the IRB regarding this project.**

Amanda C. Egan, Ph.D.
Chair, Marian University Institutional Review Board

Appendix G: Student Satisfaction and Self-Confidence in Learning

Student Satisfaction and Self-Confidence in Learning

Instructions: This questionnaire is a series of statements about your personal attitudes about the instruction you receive during your simulation activity. Each item represents a statement about your attitude toward your satisfaction with learning and self-confidence in obtaining the instruction you need. There are no right or wrong answers. You will probably agree with some of the statements and disagree with others. Please indicate your own personal feelings about each statement below by marking the numbers that best describe your attitude or beliefs. Please be truthful and describe your attitude as it really is, not what you would like for it to be. This is anonymous with the results being compiled as a group, not individually.

Mark:
1 = STRONGLY DISAGREE with the statement
2 = DISAGREE with the statement
3 = UNDECIDED - you neither agree or disagree with the statement
4 = AGREE with the statement
5 = STRONGLY AGREE with the statement

Satisfaction with Current Learning	**SD**	**D**	**UN**	**A**	**SA**
1. The teaching methods used in this simulation were helpful and effective.	○ 1	○ 2	○ 3	○ 4	○ 5
2. The simulation provided me with a variety of learning materials and activities to promote my learning the medical surgical curriculum.	○ 1	○ 2	○ 3	○ 4	○ 5
3. I enjoyed how my instructor taught the simulation.	○ 1	○ 2	○ 3	○ 4	○ 5
4. The teaching materials used in this simulation were motivating and helped me to learn.	○ 1	○ 2	○ 3	○ 4	○ 5
5. The way my instructor(s) taught the simulation was suitable to the way I learn.	○ 1	○ 2	○ 3	○ 4	○ 5
Self-confidence in Learning	**SD**	**D**	**UN**	**A**	**SA**
6. I am confident that I am mastering the content of the simulation activity that my instructors presented to me.	○ 1	○ 2	○ 3	○ 4	○ 5
7. I am confident that this simulation covered critical content necessary for the mastery of medical surgical curriculum.	○ 1	○ 2	○ 3	○ 4	○ 5
8. I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting	○ 1	○ 2	○ 3	○ 4	○ 5
9. My instructors used helpful resources to teach the simulation.	○ 1	○ 2	○ 3	○ 4	○ 5
10. It is my responsibility as the student to learn what I need to know from this simulation activity.	○ 1	○ 2	○ 3	○ 4	○ 5
11. I know how to get help when I do not understand the concepts covered in the simulation.	○ 1	○ 2	○ 3	○ 4	○ 5
12. I know how to use simulation activities to learn critical aspects of these skills.	○ 1	○ 2	○ 3	○ 4	○ 5
13. It is the instructor's responsibility to tell me what I need to learn of the simulation activity content during class time..	○ 1	○ 2	○ 3	○ 4	○ 5

 Revised December 22, 2004

Appendix H: Pre-test and Post-test

Pre-test Survey

- What is your 4-digit identification code?
- Which category best fits your time as a licensed medical professional?
    - <2 years
    - 2-5 years
    - 5-10 years
    - >10 years
- What choice best fits your preferred education method when learning a new procedural skill?
    - I prefer to read about the procedure from a textbook.
    - I prefer to watch a video of the procedure.
    - I prefer to stimulate the procedure with hands-on experience.
    - I prefer to discuss the procedure and its steps with the instructor.
- Have you ever preformed a cricothyrotomy in clinical practice?
    - Yes
    - No
- Have you ever performed a simulated cricothyrotomy on a mannequin or other simulation tool?
    - Yes
    - No
- How do you rate your satisfaction regarding previous cricothyrotomy procedural education through Marian University's simulation lab?
    - Extremely dissatisfied
    - Somewhat dissatisfied
    - Neither satisfied nor dissatisfied
    - Somewhat satisfied
    - Extremely satisfied
- What structure is punctured during a needle cricothyrotomy?
    - Cricoid
    - Cricothyroid membrane
    - Cricothyroid ligament
- Regarding the cricothyrotomy procedure, what are the absolute contraindications?
    - Tracheal transection
    - Pre-existing coagulopathy condition
    - Child less than 10 years old
    - All of the above
    - None of the above
- What anatomical structures or conditions make a cricothyrotomy more difficult but are NOT relative contraindications to performing the procedure? SATA

Post-test Survey

- What is your 4-digit identification code?
- What structure is punctured during a needle cricothyrotomy?
    - Cricoid
    - Cricothyroid membrane
    - Cricothyroid ligament
- Regarding the cricothyrotomy procedure, what are the absolute contraindications?
    - Tracheal transection
    - Pre-existing coagulopathy condition
    - Child less than 10 years old
    - All of the above
    - None of the above
- What anatomical structures or conditions make a cricothyrotomy more difficult but are NOT relative contraindications to performing the procedure? Select all that apply.
    - Obesity
    - Tracheal transection
    - Child less than 10 years old
    - Geriatric patient greater than 60 years old
    - Hematoma on the neck
    - Radiation to the neck
    - Squamous cell carcinoma of the trachea
- How long should a cricothyrotomy tube be in place?
    - < 6 hours
    - Until medically unnecessary
    - 7- 10 days
    - < 24 hours
- Once the tube is placed, how many milliliters of air should be placed in the cuff?
    - 2-3 ml
    - 5-6 ml
    - 8-10 ml
    - 10-15 ml
- You are placing the needle through the cricothyroid membrane. Which technique is most accurate?
    - Insert the needle directly into the trachea at a 90-degree angle
    - Insert the needle caudally at a 45-degree angle
    - Insert the needle rostrally at a 45-degree angle
    - The direction of the needle does not matter as long as the needle tip punctures the cricothyroid membrane

  - Obesity
  - Tracheal transection
  - Child less than 10 years old
  - Geriatric patient greater than 60 years old
  - Hematoma on the neck
  - Radiation to the neck
  - Squamous cell carcinoma of the trachea
- How long should a cricothyrotomy tube be in place?
  - < 6 hours
  - Until medically unnecessary
  - 7- 10 days
  - < 24 hours
- Once the tube is placed, how many milliliters of air should be placed in the cuff?
  - 2-3 ml
  - 5-6 ml
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  - 10-15 ml
- You are placing the needle through the cricothyroid membrane. Which technique is most accurate?
  - Insert the needle directly into the trachea at a 90-degree angle
  - Insert the needle caudally at a 45-degree angle
  - Insert the needle rostrally at a 45-degree angle
  - The direction of the needle does not matter as long as the needle tip punctures the cricothyroid membrane
- List the steps of the Seldinger technique for cricothyrotomy in order.
  - Advance the needle through the cricothyroid membrane
  - Palpate the cricothyroid membrane
  - Make a vertical midline incision
  - Place tracheostomy tape around the patient's neck
  - Tread a guide wire through the needle (or catheter if utilized)
  - Remove the dilator
  - Stabilize the cartilage
  - Inflate the cuff
  - Connect a ventilation device to the emergency airway catheter
  - Use the guide wire to advance the airway catheter assembly into the trachea

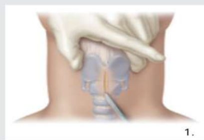
- List the steps of the Seldinger technique for cricothyrotomy in order.
  - Advance the needle through the cricothyroid membrane
  - Palpate the cricothyroid membrane
  - Make a vertical midline incision
  - Place tracheostomy tape around the patient's neck
  - Tread a guide wire through the needle (or catheter if utilized)
  - Remove the dilator
  - Stabilize the cartilage
  - Inflate the cuff
  - Connect a ventilation device to the emergency airway catheter
  - Use the guide wire to advance the airway catheter assembly into the trachea

Appendix I: Seldinger Procedure Instructions

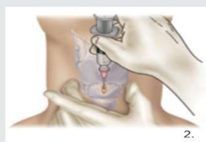
Seldinger

Technique Instructions*

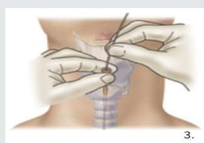
QUICK REFERENCE CARD



1. Carefully palpate the cricothyroid membrane. Stabilize the cartilage and make a vertical incision along the midline. (Figure 1)



2. Attach the syringe to either needle in the set. Then advance the needle at a 45-degree angle in a caudal direction through the midline incision and into the airway. (Figure 2)

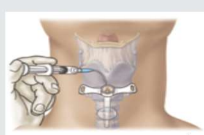


3. After you have accessed the trachea, remove the syringe. If using the catheter introducer needle, remove the syringe and needle, leaving the catheter in place. Then advance the wire guide, flexible end first, into the introducer catheter or the needle. (Figure 3)

4. Once the wire guide is within the trachea, remove the introducer catheter or the needle. (Figure 4)

5. Advance the airway catheter assembly over the wire guide and completely into the trachea. (Figure 5)

   Remove the dilator and the wire guide simultaneously.



6. Use a syringe to inflate the cuff; an 8-10 mL volume in the cuff will yield a cuff diameter of 22-29 mm. (Figure 6)

7. Secure the emergency airway catheter with the tracheostomy tape.

8. Connect the emergency airway catheter to a ventilation device.

* For complete instructions, contraindications, warnings, and precautions, see the Instructions for Use that are included with the product.

COOK MEDICAL

www.cookmedical.com

Appendix J: Tables

Table 6

Helpfulness of Teaching Methods Used in Simulation

Helpfulness of Teaching Methods	n	%
Pre-test		
Strongly Disagree	2	16.7
Disagree	2	16.7
Undecided	5	41.7
Agree	3	25.0
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	4	33.3
Strongly Agree	7	58.3

Note: n=12

Table 7

Promotion of Learning within the CRNA Curriculum through the Learning Materials and Activities Provided by the Curriculum versus the Simulation

Promotion of Learning	n	%
Pre-test		
Strongly Disagree	2	16.7
Disagree	2	16.7
Undecided	5	41.7
Agree	3	25.0
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	3	25.0
Strongly Agree	9	75.0

Note: n=12

Table 8

Enjoyment of Teaching Methods

Enjoyment of Teaching Methods	n	%
Pre-test		
Strongly Disagree	1	8.3
Disagree	3	25.0
Undecided	5	41.7
Agree	3	25.0
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	1	8.3
Agree	3	25.0
Strongly Agree	8	66.7

Note: n=12

Table 9

Teaching Materials Were Motivating and Helped Students Learn

Motivation and Helpfulness	n	%
Pre-test		
Strongly Disagree	2	16.7
Disagree	1	8.3
Undecided	6	50.0
Agree	3	25.0
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	4	33.3
Strongly Agree	8	66.7

Note: n=12

Table 10

Teaching Methods Suitable to Learning Style

Teaching Methods Suitable	n	%
Pre-test		
Strongly Disagree	1	8.3
Disagree	3	25.0
Undecided	6	50.0
Agree	2	16.7
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	4	33.3
Strongly Agree	8	66.7

Note: n=12

Table 11

Confidence in Mastering the Content of the Simulation Activity

Confidence in Mastery of Content	n	%
Pre-test		
Strongly Disagree	2	16.7
Disagree	2	16.7
Undecided	6	50.0
Agree	2	16.7
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	6	50.0
Strongly Agree	6	50.0

Note: n=12

Table 12

Confidence that the Simulation Covered Critical Content

Confidence in Content Coverage	n	%
Pre-test		
Strongly Disagree	2	16.7
Disagree	3	25.0
Undecided	3	25.0
Agree	4	33.3
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	5	41.7
Strongly Agree	7	58.3

Note: n=12

Table 13

Confidence in Developing the Skills and Obtaining the Knowledge from the Simulation to Perform Necessary Tasks in a Clinical Setting

Confidence in Skill and Knowledge	n	%
Pre-test		
Strongly Disagree	2	16.7
Disagree	2	16.7
Undecided	5	41.7
Agree	3	25.0
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	5	41.7
Strongly Agree	7	58.3

Note: n=12

Table 14

Helpfulness of Resources Instructors Used to Teach Simulation

Helpfulness of Resources	n	%
Pre-test		
Strongly Disagree	1	8.3
Disagree	2	16.7
Undecided	6	50.0
Agree	3	25.0
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	5	41.7
Strongly Agree	7	58.3

Note: n=12

Table 15

Student Responsibility to Learn from the Simulation Activity

Student Responsibility	n	%
Pre-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	3	25.0
Agree	8	66.7
Strongly Agree	1	8.3
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	5	41.7
Strongly Agree	7	58.3

Note: n=12

Table 16

Knowing How to Get Help with Confusing Concepts

How to Get Help	n	%
Pre-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	1	8.3
Agree	10	83.3
Strongly Agree	1	8.3
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	4	33.3
Strongly Agree	8	66.7

Note: n=12

Table 17

Using Simulation Activities to Learn Critical Aspects of Skills

Using Activities to Learn Critical Aspects of Skills	n	%
Pre-test		
Strongly Disagree	0	0.0
Disagree	1	8.3
Undecided	1	8.3
Agree	9	75.0
Strongly Agree	1	8.3
Post-test		
Strongly Disagree	0	0.0
Disagree	0	0.0
Undecided	0	0.0
Agree	5	41.7
Strongly Agree	7	58.3

Note: n=12

Table 18

Responsibility of Instructors to Educate on Simulation during Class

Responsibility of Instructors	n	%
Pre-test		
Strongly Disagree	0	0.0
Disagree	2	16.7
Undecided	4	33.3
Agree	6	50.0
Strongly Agree	0	0.0
Post-test		
Strongly Disagree	0	0.0
Disagree	3	25.0
Undecided	1	8.3
Agree	4	33.3
Strongly Agree	4	33.3

Note: n=12

Table 19

Correct Identification of Factors that Increase the Difficulty of a Cricothyrotomy

Correct Factors for Increased Difficulty	n	%
Obesity		
Pre-test	12	100
Post-test	12	100
Hematoma		
Pre-test	9	75
Post-test	12	100
Radiation		
Pre-test	11	91.7
Post-test	12	100

Note: n=12

Table 20

Incorrect Identification of Factors that Increase the Difficulty of a Cricothyrotomy

Incorrect Factors for Increased Difficulty	n	%
Tracheal Transection		
Pre-test	8	66.7
Post-test	3	25.0
Child less than 10 years old		
Pre-test	9	75.0
Post-test	6	50.0
Geriatrics		
Pre-test	4	33.3
Post-test	4	33.3
Squamous Cell Cancer		
Pre-test	10	83.3
Post-test	7	58.3

Note: n= 12

Table 21

Correct Placement Order of the Steps of the Cricothyrotomy Procedure

Correct Order of Steps	n	%
Palpate the cricothyroid membrane		
Pre-test	11	91.7
Post-test	11	91.7
Stabilize the cartilage		
Pre-test	10	83.3
Post-test	11	91.7
Make a vertical midline incision		
Pre-test	5	41.7
Post-test	11	91.7
Advance the needle through the membrane		
Pre-test	4	33.3
Post-test	11	91.7
Tread the guidewire through the needle/catheter		
Pre-test	4	33.3
Post-test	10	83.3
Use the guidewire to advance the airway assembly		
Pre-test	8	66.7
Post-test	10	83.3
Remove the dilator		
Pre-test	5	41.7
Post-test	11	91.7
Inflate the cuff		
Pre-test	9	75.0
Post-test	10	83.3
Place tracheostomy tape around the neck		
Pre-test	5	41.7
Post-test	8	66.7
Connect the ventilation device		
Pre-test	3	25.0
Post-test	9	75.0

Note: n=12