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Using Ultrasound to Identify the Cricothyroid Membrane in Patients with a Difficult Airway: A teaching Module

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Using Ultrasound to Identify the Cricothyroid Membrane in Patients with a Difficult Airway: A Teaching Module

A DNP Project Presented to the Faculty of the
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Abstract

Impact Statement: In patients undergoing anesthesia with difficult airways the use of ultrasound to accurately identify the cricothyroid membrane preoperatively will decrease complications related to cricothyrotomies.

Background: In a cannot intubate cannot ventilate scenario an emergency cricothyrotomy is the final step in the emergency airway management algorithm. A successful cricothyrotomy is achieved by placing a tube through the CTM allowing access to the trachea. Currently, the palpation method remains the most popular method for locating the CTM despite research that shows ultrasound use is superior.

Objectives: This project aims to compare the accuracy of locating the CTM utilizing ultrasound vs. palpation.

Method: A literature review was conducted comparing ultrasound and palpation in accurately locating the CTM. An online educational module was created to present to anesthesia providers as well as a pre and post-survey to assess the degree of knowledge acquired. The project was presented to FIU anesthesia alumni using an anonymous online platform for survey and module delivery as well as data collection.

Results: In total six FIU Alumni participated in the teaching module. Participants showed a solid baseline knowledge related to cricothyrotomies. There was a 33% increase in participants who indicated they would be extremely likely to use any technique following the educational module. There was also a 33% increase in participants who indicated they were extremely confident in accurately identifying the CTM using ultrasound following the teaching module.

Discussion: Data from the survey indicates participants increased their knowledge related to using ultrasound to locate the CTM. Data also indicates participants were more confident in their ability to use ultrasound to locate the CTM.

Conclusion: The educational module improved participants' knowledge and confidence related to using ultrasound to locate the CTM.

*Key Words***:** cricothyroid membrane, ultrasound, palpation, and cricothyrotomy.

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I. Introduction

Problem Identification

In a cannot intubate cannot ventilate scenario an emergency cricothyrotomy is the final step in the emergency airway management algorithm. A successful cricothyrotomy is achieved by placing a tube through the cricothyroid membrane (CTM) allowing access to the trachea. The location of the CTM is inferior to the thyroid cartilage, superior to the cricoid cartilage, and medial to the bilateral cricothyroideus muscles.[1] Currently most providers use a palpitation technique to locate the CTM. Evidence shows that providers are not able to accurately locate the CTM in both cadavers and volunteers while in stable non-emergent settings.[2]

An alternative strategy to locate the CTM is utilizing ultrasonography. To accurately locate the CTM utilizing ultrasonography a provider must be knowledgeable on operating an ultrasound and the anatomy surrounding the CTM. Studies have shown that most anesthesia providers are not competent in accurately locating the CTM whether it be using palpation technique or ultrasound. This DNP project is designed to educate nurse anesthetists on how to accurately locate the CTM in patients with predicted difficult airways utilizing ultrasonography.

Background

As stated previously, an emergency cricothyrotomy is the final step in the emergency airway management algorithm. Accurate identification of the CTM is critical for a cricothyrotomy to be successful.[3] Studies have continued to show that even experienced anesthesia providers often misidentify the CTM. Misidentification of the CTM in a cannot intubate cannot oxygenate can lead to failures and serious complications, including injury to the brain and death.[3] Current data from the fourth National Audit project on major airway

complications showed that fifty-two percent of cricothyrotomies failed, with device misplacement being the most common cause.[3]

An alternative to the palpation technique is ultrasonography. A high-frequency linear transducer is used to locate the CTM. The provider begins by transversely placing the transducer on the patient's anterior neck just superior to the sternal notch.[2] A dark horseshoe-shaped structure will appear representing the trachea.[1] The provider will then slide the transducer cephalad until a hypoechoic arch-shaped structure appears representing the cricoid cartilage.[2] By moving the transducer further cephalad the provider will reach the CTM which will appear as a hyperechoic white line.[2] If the provider continues to move the transducer cephalad they will reach a hyperechoic triangular structure which they should be able to recognize as the thyroid cartilage.[2] At this point the provider should recognize the need to move the transducer caudally to the center of the CTM. By using an ultrasonography, the provider can visualize the structures of and around the CTM leading to accurate identification.[2]

Scope of the Problem

In any situation where a provider is unable to intubate or ventilate an emergency cricothyrotomy is the final step in any emergency airway algorithm. The incidence of cannot intubate cannot ventilate situations is found to be around 1 in 32,000 cases.[4] Tachibana et al[5] found the incidence of cannot intubate, cannot ventilate in cases conducted under general anesthesia to be 3 in 97,854 (0.003%) with all incidents occurring during the induction of general anesthesia. Though not common, this situation can lead to catastrophic consequences such as anoxic brain injury and death.[4] Along with this, the incidence of emergency cricothyrotomies varies greatly in the literature anywhere from 0 to 18.5% for unspecified health care professionals, and for trauma anesthesiologists and emergency medicine doctors, the incidence is

0.2-0.3%.[6] The incidence of emergency cricothyrotomy greatly depends on location, qualifications, and experience of the health care provider and the medical condition of the patient.[6]

Consequences of the Problem

Cannot intubate cannot ventilate can lead to catastrophic outcomes for patients. Inability to ventilate and thus provide oxygen to a patient can lead to cardiac arrest, anoxic brain injury, and ultimately death.[6] Thus, it is obvious the importance of providers' ability to obtain an emergency airway. As mentioned previously, for an emergency airway to be established the provider must accurately locate the CTM. Inability to accurately locate the CTM can lead to major complications such as device misplacement, esophageal perforation, subcutaneous emphysema, and hemorrhage.[3] With any delay or complication the patient is further deprived of oxygen increasing the likelihood of anoxic injury or death.

Knowledge Gap

According to the 2022 American society of Anesthesiologists Practice Guidelines for Management of the Difficult airway algorithm when a cannot intubate cannot ventilate scenario arises and the patient cannot be woken up the final step is to perform an emergency invasive airway.[7] To successfully establish an emergency airway the provider must first accurately locate the CTM. Studies show palpation continues to be the technique used by most providers to locate the CTM. Studies also continue to show the palpation technique to be inferior in locating the CTM when compared to ultrasonography.

The most obvious reason for providers to choose palpation over ultrasonography is lack of provider competence and experience with point of care ultrasound (POCUS). Currently, there is not a single structured national POCUS curriculum utilized by anesthesiology residency

training programs across the united states.[8] Many providers are tasked with learning POCUS on their own, or paying for additional training through different programs.

II. Literature Review

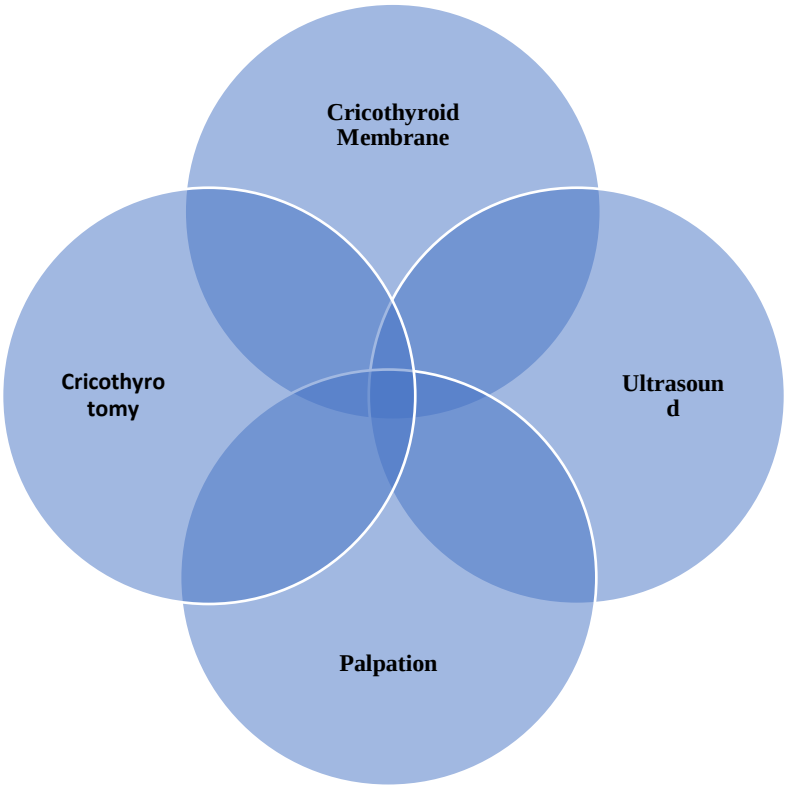
Methodology for Literature Review

A literature search was carried out utilizing the databases PubMed and Cumulative Index to Nursing and Allied Health Literature (CINAHL). Limits applied to the search included full text available, English language, peer-reviewed or meta-analysis, between the dates of January 2010 and October 2022, and human studies. Articles were excluded if they were from outside the mentioned dates, were not primary research, or were not human studies. Inclusion criteria included randomized trials or meta-analysis, studies on either ultrasound or palpation to identify the CTM, within the specific date, and peer reviewed. The abstracts of articles were screened by the author to decide if they should be included in the review. In total ten articles were selected to be included in the literature review. The articles are listed in a matrix included at the end of the review. The matrix includes a quality review of each article selected.

Keywords

Based on the PICO question the following key words were identified: “cricothyroid membrane”, “ultrasound”, “palpation”, and “cricothyrotomy”.

Figure 1. Search Keywords



Results

Siddiqui et al[3] hypothesized that preoperative identification of the CTM utilizing ultrasonography would reduce complications associated with cricothyrotomy. To test this, 47 anesthesia trainees were randomized to either digital palpation or ultrasonography groups to perform cricothyrotomies on human cadavers.[3] All participants in the study received a ten minute didactic lecture on cricothyrotomy using the Portex cricothyrotomy kit followed by a three minute demonstration of ultrasonographic and conventional digital palpation technique to identify the anatomical landmarks and CTM.[3] All participants in the study also received at least five minutes of hands on training with ultrasound using the Portex cricothyrotomy device on human cadavers.[3]

Siddiqui et al[3] found the incidence of moderate-severe injury rate was almost three times greater in the digital palpation group than in the ultrasonography group (74% vs. 25%). Furthermore, 15 cadavers had what was considered to be difficult or impossible neck landmarks and the incidence rate of moderate-severe injuries using ultrasonography was only 33%. %. This was statistically significant when compared with the 100% incidence of moderate-severe injuries in the 12 cadavers of the digital palpation group.[3] It was also found that 63% of the ultrasonography group inserted the Portex device correctly via the CTM, compared with only 39% of the palpation group.[3] Another finding was the mean insertion time in the ultrasonography group was significantly longer than in the digital palpation group (191.6s vs. 110.5s).[3] Siddiqui et al[3] findings were consistent with previous literature indicating conventional digital palpation is inaccurate in identifying the CTM. Siddiqui et al[3] concluded the study suggests ultrasound guidance before airway management, especially in patients with difficult palpable neck landmarks and difficult airways.

In a subsequent randomized control trial Siddiqui et al[9] hypothesized that ultrasound is superior in accurately locating the CTM when compared to palpation. The trial included 223 adult patients with neck pathologies that included previous neck surgery, irradiation, and/or neck mass. The subjects first underwent a neck computed-tomography scan after which the midpoint of the CTM was identified.[9] The subjects were then randomly assigned to either the palpation or ultrasonography group.[9]

Assessment of the CTM using either external palpation or ultrasonography was carried out by anesthesia fellows in which they would mark what they believed to be the midpoint of the CTM.[9] Success was defined as the proportion of accurate attempts within 5mm distance from the computed-tomography point to the ultrasonography point or external palpation point.[9] Results

showed there was a 10-fold percentage of accurate attempts in the ultrasound (81%) than the external palpation group (8%).[9] Furthermore, the average distance from the target was 3.4mm in the ultrasonography group compared with 16.6mm in the external palpation group.[9]

Alerhand[2] produced a narrative to summarize the prospective studies evaluating CTM identification. The objective of the narrative was to display the inaccuracy of the palpation technique and also detail the use of ultrasonography as a superior means of accurately identifying the CTM.[2] Alerhand[2] conducted a literature review using PubMed and Google Scholar databases with the search date from 1980 to December 2017.[2] Search terms for the review included "cricothyroid membrane + ultrasound OR point-of-care ultrasound", "airway + ultrasound OR point-of care ultrasound", and "cricothyrotomy + ultrasound OR point-of-care ultrasound".[2]

Alerhand[2] found the studies showed the land palpation technique is inaccurate for identifying the CTM with one study showing a success rate of 62% and another showing only 30% of attempts to be accurate.[2] Alerhand[2] hypothesized accurately locating the CTM using palpation in an emergent situation would likely be even lower as both of these studies were conducted in controlled situations. Alerhand's[2] review concluded that identification of the CTM using palpation is more difficult in the obese and female population. All studies reviewed showed a higher incidence of accurately locating the CTM when using ultrasonography compared to palpation.[2]

You-Ten et al[10] conducted a randomized control trial to determine the accuracy of identifying the CTM in women in labor utilizing ultrasonography compared to digital palpation. Participants were non-distressed women between 37-40 weeks gestation.[10] The study included a total of 20 and 21 anesthesia providers were randomly assigned to palpate the CTM of 28 non-obese and 27 obese pregnant patients, respectively.[10] The primary outcome of the study was the

absolute distance of the digital palpation point from the targeted ultrasound point.[10] Secondary measures included accuracy of palpation defined as less than or equal to 4mm from ultrasound mark and palpation time.[10]

Results of the study showed the CTM was correctly identified in only 39% of the obese compared with 71% of non-obese patients. The study showed that increased neck circumference in obese patients was significantly associated with inaccuracy in locating the CTM.[10] You-Ten et al[10] concluded that pre-procedural ultrasound may be a useful tool to help improve the accurate identification of neck landmarks for cricothyrotomy.[10]

Lavelle et al[11] also conducted a study utilizing obese pregnant patients in which accuracy of locating the CTM with ultrasonography was compared to palpation. Results of this study showed the mean distance from the midpoint of the CTM was 2.5mm in the ultrasonography group compared to 5.5mm in the palpation group.[11] The CTM was accurately located 20/28 (71%) of the time in the ultrasonography group compared with 11/28 (39%) in the palpation group.[11] As with Siddiqui et al[3] results, Lavelle et al[11] found the time it takes to locate the CTM to be significantly longer 23.5s with ultrasonography compared to palpation 16.9s.

Forshaw et al[12] conducted a study comparing ultrasonography and palpation in locating the CTM in the pediatric patient. In total there were 21 participants and the median age was 4 years old.[12] Forshaw et al[12] found the CTM was accurately identified 10/11 (90%) in the palpation group compared with 8/11 (72%) in the ultrasonography group. Although not statistically different, this was the only study identified where the palpation group was more accurate in locating the CTM when compared with ultrasonography. As with previous studies, Forshaw et al[12] found the mean time to identify the CTM was significantly longer in the ultrasonography group (35.6s) when compared to the palpation group (14.1s). Forshaw et al[12]

concluded that in the event of an emergency cricothyroidotomy the utilization of the palpation technique to identify the CTM in children might confer a time benefit for progression to cricothyroidotomy.

Hung et al[13] performed a meta-analysis comparing trials that evaluated the accuracy of CTM identification by using ultrasound-guided or digital palpation techniques. In total, eight studies met inclusion criteria for the analysis. Results of the meta-analysis indicated a significantly lower failure rate of the ultrasound-guided technique when compared with the digital palpation technique.[13] As with the previous study mentioned, Hung et al[13] found that ultrasound guided technique resulted in longer procedural time when compared to digital palpation, however the difference did not meet statistical significance.

Kristensen et al[14] conducted a randomized cross-over comparison comparing the transverse and ultrasound-guided identification of the CTM, to determine which was faster and more successful. In total 42 anesthetists participated in the study. They each received a one-hour structured training program consisting of e-learning, a lecture and hands on training, and then applied both techniques to obese females with body mass index 39.0-43.9 kg/m[14].

The mean time to identify the CTM was 24.0 seconds using the transverse technique compared with 37.6 seconds utilizing the longitudinal technique.[14] Overall, successful identification of the CTM was achieved by 38 (90%) of techniques using either technique.[14] The authors advocated for the learning and use of either ultrasound technique for the identification of the CTM before starting anesthesia in difficult airway patients, especially when anatomical landmarks are impalpable.[14]

Kwon et al[15] conducted a retrospective review to determine the incidence and outcomes of patients who underwent cricothyrotomy in a “cannot intubate, cannot oxygenate” (CICO)

situation. The study took place at University hospitals in Korea where they reviewed medical records of patients who experienced a CICO situation that led to the need for a cricothyrotomy between March 2007 and October 2018.[15] In total 10,187 intubations were performed with 23 patients identified that received a cricothyrotomy.

The hospital wide incidence of cricothyrotomy was 2.3 per 1000 tracheal intubations with a 95.7% being performed in the emergency department and one attempted in the endoscopy room.[15] Of the 23 patients identified in the study as receiving a cricothyrotomy the survival rate at hospital discharge was 47.8%.[15] Successful cricothyrotomy was performed in 17 patients (73.9%) and 9 patients (52.9%) survived.[15] Six patients were identified as having a failed cricothyrotomy of which only 2 (33.3%) survived.[15] Of the failed cricothyrotomies various methods of securing the airway were established including tracheal intubations, nasotracheal intubation, and tracheostomy.[15]

Rai et al[16] performed a systematic review with the goal of comparing ultrasonography use in identifying the CTM prior to cricothyrotomies to palpation in the general population, identify its indications in subjects with ill-defined neck anatomy, and determine it role in defining neck anatomy. To perform the review the databases All Ovid MEDLINE and Ovid EMBASE Classic+Embase with the search period of 1947 to July 17, 2019 were used.[16] Keywords included “ultrasound” and “Cricothyroid membrane”.[16] Overall, fourteen articles were selected that included the use of CTM localization and/or the cricothyrotomy procedure itself were included.[16] The fourteen articles selected included three were randomized control trials, nine observational studies, and two descriptive studies.

Results from the review showed that ultrasonography had greater accuracy in locating the CTM when compared to palpation.[16] As highlighted previously, the review agreed that when

compared to palpation, ultrasonography took a greater amount of time.[16] Interestingly, the times were comparable when the patient was deemed to have a difficult airway.[16] Rai et al[16] concluded that ultrasonography is superior to palpation for accurately locating the CTM especially in those with difficult airway anatomy and its pre-emptive use should be utilized during difficult airway management.[16]

Citation	Design/ Method	Sample/ Setting	Major Variables Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/ Level
Siddiqui et al.,[9] 2018	Prospective, single-center, single-blinded randomized control trial comparing the accuracy of identifying CTM in patients with neck pathologies	In total, 340 subjects scheduled for a neck computed tomography scan at University Health Network hospitals were assessed for eligibility. Of those 340, 117 subjects were excluded from the study. patients who were unable to lie flat, those who were unable to maintain a neutral neck position, and those who refused to participate in the study were excluded at the time of recruitment. A total of 223 patients with poorly defined neck landmarks	Independent variables were external palpitation and ultrasound use to identify CTM Dependent variable was the proportion of accurate attempts within a 5-mm distance from the computed tomography point	For continuous variables, means and SDs were presented and compared using independent two-sample *t*-tests. Normal distribution was checked by examining the histograms. The statistical model was changed from a logistic regression model to a Poisson regression model to examine the rate of successful identification of the cricothyroid membrane and to calculate risk ratios. The	The percentage of accurate attempts, defined as a distance of 5 mm or less, was 10-fold greater in the ultrasound than the external-palpation group (81% *vs.* 8%; 95% CI, 63.6 to 81.3%; $P <$ 0.0001). The mean ± SD distance measured from the external palpation to the computed tomography point was five-fold greater than the ultrasound to computed tomography point (16.6 ± 7.5 *vs.* 3.4 ± 3.3 mm; 95% CI, 11.67 to 14.70; $P <$ 0.0001). Poisson regression	Ultrasonography was significantly more accurate than external palpation in localizing the CTM of patients with poorly defined neck landmarks.	The use of ultrasonography over the conventional approach of external palpation is supported for the prelocalization of the cricothyroid membrane in patients with neck pathology before airway management in anticipation of difficult airways.	Level II. Limitations included the cricothyroid membrane was assessed on patients in the neutral neck position. The location of the cricothyroid membrane is variable depending on the position of the neck,8 and a less-than-ideal neutral neck position could have affected the accuracy of the cricothyroid membrane. However, a donut-shaped pillow was used to minimize head movement and maintained the neck in a neutral position during the computed tomography scan. The cricothyroid membrane was identified by two study investigators (D.D., S.B.) using ultrasonography and external palpation. The homogeneity of the

		completed the study, with 109 and 114 patients randomized to the external palpation and ultrasound groups, respectively.		distance from the target location was compared between the groups using a *t-test*. SAS version 9.3 (SAS Institute, USA) was used for the statistical analysis.	analysis demonstrated that the risk ratio of inaccurate localization of the cricothyroid membrane was 9.14-fold greater with the external palpation than with the ultrasonography ($P < 0.0001$).			assessors could bias the outcomes through learning with repeated assessments
You-Ten et al.,[10] 2015	Randomized control trial comparing the accuracy of identifying the CTM in women in labor using conventional digital palpation and ultrasonography.	The sample included a total of 28 obese and 28 non-obese non-distressed women between 37-40 weeks gestation, in labor. Participants were anesthesia staff, fellows, and residents working in labour and delivery at the hospital. A total of 20 and 21 participants were randomly assigned to palpate the cricothyroid membrane of non-obese and	Independent variables were palpitation and ultrasound use to identify CTM Dependent variable was the accuracy in locating CTM.	Statistical analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC, USA). Quantitative differences between groups were analyzed using the Mann–Whitney Wilcoxon and Fisher's exact tests. Analysis of covariance was performed to investigate group differences in US-DP distance while controlling for other factors	The evidence of the studies demonstrated that physicians are not sufficiently accurate in using landmark palpation to locate CTM. Evidence also showed the superiority of ultrasound compared to landmark palpation.	Results suggest that anesthetists poorly localize the cricothyroid membrane by conventional palpation in obese women in labour and that ultrasound improves accuracy	The use of ultrasound should be incorporated into the pre-intubation checklist for the anticipated airway in which cricothyrotomy may be needed.	Level I. This study has several limitations. The cricothyroid membrane was measured with patients in a slightly extended neck position; however, the location of the cricothyroid membrane can vary with different positions of the neck. Although the neck was slightly extended for all patients, we did not formally measure the angle of neck extension.

		obese patients, respectively.		differing between the two study groups				
Siddiqui et al.,[3] 2015	RCT in which 47 trainees were randomized to digital palpation and ultrasound groups. Cricothyrotomy was performed on human cadavers by using a portex device.	47 trainees were randomized to digital palpation (n=23) and ultrasound (n=24).	Independent variables were digital palpation and ultrasound. Dependent variable was the complication rate of cricothyrotomy as measured by the severity of injuries.	The primary outcome measure was the complication rate as assessed by the severity of injuries, defined as the incidence and severity of posterior laryngeal and tracheal wall injuries, as graded by two anesthesiologists using the grading system (none [no injury]; mild [< 5-mm laceration]; moderate [> 5-mm laceration or partial puncture]; and severe [> 10-mm laceration or full puncture]). In this study, the scale was dichotomized	Ultrasound guidance significantly decreased the incidence of injuries to the larynx and trachea (digital palpation: 17 of 23 = 74% *vs.* ultrasound: 6 of 24 = 25%; relative risk, 2.88; 95% CI, 1.39 to 5.94; *P* = 0.001) and increased the probability of correct insertion by 5.6 times (*P* = 0.043) in cadavers with difficult and impossible landmark palpation (digital palpation 8.3% *vs.* ultrasound 46.7%). Injuries were found in 100% of the grades 3 to 4 (difficult–impossible landmark	The incidence of moderate–severe injury rate was almost three times greater in the digital palpation group than in the ultrasonography group (17 of 23 = 74% *vs.* 6 of 24 = 25.0%; *P* = 0.001) with an RR of 2.88 (95% CI, 1.39 to 5.94).	Preprocedural ultrasound guidance in cadavers with poorly defined neck anatomy significantly reduces complications and improves correct insertion of the airway device in the cricothyroid membrane.	Level II. Limitations include only the use of the trocar over needle technique with the portex device, limited sample size, and lack of fresh cadavers with normal tissue characteristics

				to none–mild and moderate–severe injuries. All the recorded variables were entered into a Microsoft Excel (Microsoft Corp., USA) spreadsheet and were analyzed using SAS version 9.01 (SAS Institute, Inc., USA) statistical software.	palpation) cadavers by digital palpation compared with only 33% by ultrasound ($P <$ 0.001).			
Alerhand,[2] 2015	This is a narrative review to summarize the findings of prospective studies evaluating cricothyroid membrane (CTM)identification and consider their applicability to emergency medicine	This review examined five different studies examining ultrasound vs. palpation for locating CTM.	Independent variables were palpitation and ultrasound use to identify CTM. Dependent variable was the accuracy in locating CTM.		The evidence of the studies demonstrated that physicians are not sufficiently accurate in using landmark palpation to locate CTM. Evidence also showed the superiority of ultrasound compared to landmark palpation.	Ultrasound is superior to palpation in properly identifying the CTM.	The use of ultrasound should be incorporated into the pre-intubation checklist for the anticipated airway in which cricothyrotomy may be needed.	Level I
Kwon et al.,[15] 2019	A retrospective	Sample included 23 hospitalized	Independent variables	Data on patient characteristics,	A total of 10,187 tracheal	The success rate	The success rate of	Level III. Limitations included a small study

	study to determine the incidence and outcomes of the patients underwent cricothyrotomy in a “cannot intubate, cannot oxygenate” situation at university hospitals in Korea.	patients who underwent cricothyrotomy.	cricothyrotomy. Dependent variable included the incidence and outcomes of patients undergoing cricothyrotomy	indication for cricothyrotomy, cricothyrotomy technique, operator characteristics, and outcome variables were analyzed using descriptive statistics. Continuous variables are expressed as the median (interquartile range). Categorical variables are expressed as numbers (percentages). All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) Version 24.0 (IBM Corporation, Armonk, NY).	intubations were performed and 23 patients received cricothyrotomy. Hospital-wide incidence of cricothyrotomy was 2.3 per 1000 tracheal intubations (0.23%). The majority of cricothyrotomy procedures (22 cases, 95.7%) were performed in the ED; 1 cricothyrotomy was attempted in the endoscopy room. In the ED, 5663 intubations were performed and the incidence of cricothyrotomy was 3.9 per 1000 tracheal intubations (0.39%). Five patients who had good recovery were discharged to home and 3 patients with burn injuries were transferred to the professional burn	for cricothyrotomy in a CICO situation was 74% and the survival rate was 48%	cricothyrotomy and survival rate in the CICO situation were not high. To avoid CICO situations, a comprehensive strategy in airway management in critically ill patients is necessary.	population, no data pertaining to characteristics of difficult airway or complications experienced, and no data concerning the partitioner's experience who attempted the cricothyrotomy.

					hospital after securing their airway			
Chen et al.,[13] 2021	Meta-analysis evaluating the accuracy of cricothyroid membrane identification using ultrasound-guided or digital palpation techniques	Initially, a total of 196 records were identified. After excluding duplicate records (*n*=118) and other reports by title and abstract (*n*=66), 12 full-text articles were assessed for eligibility. Finally, eight studies published from 2014 to 2020 were considered relevant and were read in full.	Independent variables: digital palpation and ultrasonography. Dependent variable accuracy of cricothyroid membrane identification	All of the statistical analyses were performed with Review Manager software (RevMan 5.3; The Cochrane Collaboration, Oxford, UK). A random-effects model for analysis was used because of the anticipated clinical between-study heterogeneity.	The pooled RR was 0.50 (95% CI: 0.33–0.76; *P*=0.001), indicating a significantly lower failure rate of the ultrasound-guided technique compared with the digital palpation technique	Results of the current study show that the ultrasound-guided approach offered a significantly higher success rate in the identification of the cricothyroid membrane than that using the palpation technique.	Findings support that identification of the cricothyroid membrane should be done during the preoperative evaluation whenever possible and that examination of the patient should be performed with ultrasonography if landmarks are not clear.	Level II. Limitations include a lack of cricothyroidotomy in studies reviewed. Second, the number of examiners, characteristics of subjects to be examined, and study design may contribute to high heterogeneity amongst the included studies. Third, the issue of whether the insignificant prolongation in procedural time associated with the use of an ultrasound-guided technique was partly attributable to the heterogeneity of the included studies needs to be addressed by further large-scale studies.
Lavelle et al.,[11] 2021	This prospective observational study recruited 28 obese obstetric patients. The cricothyroid membrane was identified	Sample included 28 obstetric patients at the University Maternity Hospital in Limerick, Ireland. Inclusion criteria were: late second	Independent variables included palpation and ultrasound techniques. Dependent variable was the distance between the	Recorded variables were analyzed using Sigma Stat 2.0 statistical software. Descriptive statistics included measures on	Distance from the cricothyroid membrane midpoint was shorter in Group U than in Group L (2.5 mm vs 5.5 mm, *P*=0.002). The proportion of correctly	Results show that US identification of the CTM in a skilled clinician's hands is more	Ultrasound CTM localization was more accurate but slower than the landmark technique in obese obstetric patients. As such, we recommend the	Level III. Limitations include a single experienced participant for assessment, the CTM was only identified by a single operator, the degree of neck extension was different in each

	using ultrasound, marked with an ultraviolet pen, and covered with a dressing. The candidate was asked to perform cricothyroid membrane identification using the landmark technique (group L) followed by ultrasound (group U).	or third trimester of pregnancy, age ≥18 years, and a booking BMI ≥35 kg/m^2. Exclusion criteria were: age <18 years, known neck abnormality, previous neck surgery, inability to lay flat, active labor, and patient refusal. The participating clinician was an experienced specialist anesthetist with a special interest in high-risk obstetric anesthesia.	actual and estimated CTM midpoint.	central tendency, dispersion, and 95% confidence intervals (CIs). Categorical data are presented as numbers and percentages and were analyzed by chi-square or Fisher exact tests as appropriate. Continuous data were analyzed by the student-t test and/or ANOVA, as appropriate. Associations were determined by regression analyses	identified cricothyroid membranes was greater in group U than in group L (71% vs 39%, *P*=0.015). The time required for identification was shorter in group L than in group U (16.9 s vs 23.5 s, *P*=0.001). Visual analog scores for ease of identification were lower in group U than in group L (2.4 cm vs 4.2 cm, *P*=0.013	accurate in terms of distance from the CTM midpoint and proportion of correct estimates than palpation.	use of pre-procedural identification of the cricothyroid membrane in this patient population and formal training in ultrasound-guided identification of the CTM.	woman as their comfort level dictated it, the assessment sequence was not randomized and there was no interval between the landmark and ultrasound assessment which could contribute to recall bias. No declarations of interest were included.
Kristensen et al.,[14] 2016	Randomized cross-over comparison. This study aimed to compare the transverse and longitudinal techniques in a group of	42 anesthetists performed ultrasound investigations at the Department of Anesthesia, Centre of Head and Orthopedics, Rigs Hospitalet, University	Independent variables included transverse and longitudinal techniques for ultrasound. Dependent variable included time	Measurements included time and correct identification. The time it took to perform the procedures were compared	The transverse technique was faster than the. longitudinal technique in identifying the cricothyroid membrane, with a mean (SD) of 24.0 (12.4) s	Results showed that the transverse technique requires less time in identifying CTM and either	The authors advocate the learning and application of these two techniques for the identification of the cricothyroid membrane	Level III. No limitations were described in the article. No external funding and no competing interests were declared by the authors.

	anesthetists who had followed a brief structured training program	Hospital of Copen-hagen, Denmark	to identification of CTM and success rate for identification of CTM.	using the unpaired Student's t-test. The success rates between the subjects were compared using the two-tailed Fisher's exact test.	vs37.6 (17.9) s, respectively (p=0.0003). Successful identification of the cricothyroid membrane with the transverse and the longitudinal method was achieved by 38 (90%) of anesthetists using each technique. All anesthetists were successful in identifying the cricothyroid membrane with at least one of the techniques	technique can be used to accurately identify the CTM.	before starting anesthesia in difficult patients, especially when anatomical landmarks are impalpable. Further use in emergencies is feasible, if clinicians have experience and the ultrasound machine is readily available	
Raiet al.,[16] 2020	The systematic review seeks to compare ultrasound to palpation in the general population, identify its indications in subjects with ill-defined neck anatomy, and determine its role in defining neck anatomy.	In total 1870 articles were identified. In the end, 14 studies were included. Articles were only included if they met all of the following criteria: (a) studies related to the use of US for CTM identification and/or cricothyrotomy (b) studies were	Independent variables included ultrasound and palpation Dependent variable included the localization of CTM	N/A	N/A	Ultrasound is superior to palpation in accurately identifying the CTM.	US-guided CTM identification has enhanced accuracy, higher success, and lower complication rates compared to DP, especially in populations with difficult airway anatomy. US-guided CTM localization and subsequent cricothyrotomy should be	Level I. Limitations included Many of the studies included in this review utilized cadavers and/or volunteer subjects, thereby minimizing any discussion around patient-centered outcomes as it relates to CTM identification. Several of the volunteer studies compared DP to US for CTM identification using US as the reference standard,

		on human subjects (c) subjects were older than 12 years of age (d) studies were full-text English articles published in peer-reviewed scientific journals. Broadly, articles were rejected due to one or more of the following reasons: (a) neck surgical procedures not related to airway instrumentation (b) neck US studies not specifically related to airway US (c) airway US related to tracheostomy procedures but not cricothyrotomy (d) studies on pediatric (<12 years) population (e) experimental animal studies (f) abstracts, case reports or					performed in the extended head and neck position to maximize precision. US has a crucial role to play in objectively defining anatomical parameters of the CTM and confirming guidelines set by the DAS. Objective anatomical parameters should be used to better guide research and training of physicians involved in airway management. Effective training and practice can optimize US-guided CTM identification times. US should have a pre-emptive role in accurate localization of the CTM before airway	thereby limiting the conclusions one could draw from these studies.

		systematic reviews (g) same selected study appearing in more than one database.					management, especially in populations with difficult airway anatomy.	
Forshaw et al.,[12] 2020	RCT comparing ultrasound and palpation in identifying the CTM in children	Twenty-two patients were recruited for the study. Children requiring MRI sequences covering the neck under general anesthesia were recruited and randomized to palpation or US study groups.	Independent variables include palpation and ultrasound. Dependent variable identification of CTM and time	Information was not included in the article	The CTM was correctly identified in 10/11 *vs* 8/10 (*P*=0.50) in the palpation *vs* US group. The mean time to identify the CTM was 14.18 s [standard deviation (SD) 7.64] *vs* 35.60 s (SD 20.69) (*P*=0.004) in the palpation *vs* US group.	No statistically significant difference was seen between rates of successful CTM identification between the two groups. The time taken to identify the CTM, however, was significantly longer in the US group.	The utilization of the palpation technique to identify the CTM in children might confer a time benefit for progression to cricothyroidotomy. In addition, the use of palpation does not rely on the immediate availability of a US machine in a critical scenario.	Level II. Limitations were not included in the study.

Discussion/Summary of Evidence

Studies have continued to show that even experienced anesthesia providers often misidentify the CTM. In one study in which experienced anesthesia providers used the palpation technique to identify the CTM they misidentified the CTM in 76% of females and 28% of males.[17] Results of a study comparing digital palpation versus the use of ultrasound to verify CTM showed accurate identification of the CTM was achieved just 8% of the time with palpation compared to 81% of the time using ultrasound.[3]

To accurately identify the CTM ultrasonography can be used. A high-frequency linear transducer is utilized to locate the CTM. By utilizing ultrasonography the provider can visualize the structures of and around the CTM leading to accurate identification.[2] Previous studies that explored the use of the high-frequency linear ultrasound transducers to delineate the CTM found that in cadavers with proclaimed difficult or impossible landmark palpation, ultrasound guidance increased the likelihood of correct airway device insertion by over five times compared to palpation, while also reducing the frequency of both laryngeal and tracheal injuries.[2]

Currently, most anesthesia providers are only trained to use the palpation technique to accurately identify the CTM. As mentioned previously studies show providers commonly misidentify the CTM in controlled situations. The lack of accuracy in correctly identifying the CTM in controlled scenarios would only be magnified in an emergent cannot intubate cannot ventilate scenario where a cricothyrotomy is needed. Cricothyrotomies can lead to serious complications including esophageal perforation, subcutaneous emphysema, and hemorrhage due to improper device insertion.[3] In a study in which cricothyrotomies were attempted in cadavers with impossible or difficult landmarks there was a 100% incidence of moderate to severe injuries with the palpation technique, compared to only a 33% incidence when ultrasonography was

used.[3] Studies continue to show superiority in utilizing ultrasonography to accurately locate the CTM when compared to palpation. Anesthesia provider competence in locating the CTM can lead to decreased complications for patients.

Conclusion

A cannot intubate cannot ventilate scenario can lead to catastrophic results for the patient. When faced with this scenario it is imperative the provider establish an airway in as timely a fashion as possible as to avoid anoxic injuries or death. In the cannot ventilate cannot intubate scenario the provider may need to establish an airway through an emergency cricothyrotomy. Success for this procedure is reliant on the accurate identification of the CTM.

Studies continue to show that ultrasonography is superior in accurately locating the CTM when compared to the palpation technique.[3,9,10] It should be a priority for all providers to become proficient in utilizing POCUS to locate the CTM. Utilization of ultrasonography can drastically reduce the complications that can happen when performing a cricothyrotomy.[3]

III. Purpose and PICO Clinical Question

Purpose

The purpose of this project was to create and present an educational module to FIU alumni anesthesia providers about the superiority of utilizing ultrasonography compared to palpation to accurately identify the CTM in patients with a difficult airway.

PICO Clinical Question

In patients with a difficult airway (P), does utilizing ultrasonography t (I) compared to digital palpation (C) result in more accurate identification of the cricothyroid membrane (O)?

PICO

Population (P): Patients with difficult airway

Intervention (I): Utilizing ultrasonography to identify the cricothyroid membrane

Comparison (C): Digital Palpation

Outcomes (O): Accurately identify the cricothyroid membrane

IV. Organizational Assessment

The SMART model will guide the goals and outcomes of this program. The objectives must be specific, measurable, achievable, realistic, and time based.

Specific

FIU alumni will participate in an evidence-based educational module discussing the importance of accurately locating the CTM in patients with difficult airways and the superiority of utilizing ultrasonography compared to digital palpation.

Measurable

The success of the educational module will be determined through the examination of a survey that will be offered to the participants in the study. Outcomes will be evaluated based on pre- and posttest questionnaire, knowledge on identifying the CTM utilizing ultrasound, and individual confidence in utilizing ultrasonography to accurately locate the CTM.

Achievable

FIU alumni were educated on the importance of utilizing ultrasonography to accurately locate the CTM and the steps involved.

Realistic

FIU alumni will be educated on the utilization of ultrasonography to locate the CTM and the recent research supporting this technique by the student registered nurse anesthetist (SRNA).

A PowerPoint presentation guided the educational experience, and a test questionnaire was offered before and after the education.

Time-Based

The educational module was developed over a six-month period. With successful implementation of this educational module, FIU alumni will increase their knowledge and confidence in utilizing ultrasonography to locate the CTM of patient with difficult airways.

Goals and Outcomes

The utilization of ultrasonography produces a visual representation of the precise structures for which the physician would palpate if performing a cricothyrotomy.[2] By utilizing ultrasonography the provider substantially increases their accuracy in locating the CTM and decreases complications such as misplacement or creation of false tracts.[1] The goal of this Doctor of Nursing Practice (DNP) project is that eighty percent of the Florida International University (FIU) alumni will declare they are at a minimum somewhat confident in their ability to utilize ultrasonography to locate the CTM in patients with an anticipated difficult airway.

Currently, at most facilities patients with potentially difficult airways are identified by factors such as mallampatti score, thyromental distance, neck circumference, mouth opening, and other indicators. Once a patient has been identified as potentially having a difficult airway, there is often no set policy or procedure specifying what further steps should be taken to prepare for the potentially difficult airway. It is up to the individual provider to prepare as they deem necessary, which usually results in setting up a video laryngoscope in the operating room the patient will occupy. The education provided in this project hopes to educate FIU alumni on the importance of utilizing ultrasonography to locate the CTM in patients with anticipated difficult airways.

SWOT

The strengths of FIU alumni related to this project include their access to an ultrasound machine. Most anesthesia departments have access to at least one ultrasound that can be used to locate the CTM in patients with anticipated difficult airways. Another strength is the patient population. With the rise of obesity in America FIU alumni are sure to encounter a high percentage of obese patients in their practice. They may also practice anesthesia in facilities that encounter other populations with a high incidence of difficult airways such as obstetrics and trauma. These patient populations benefit from preoperatively locating the CTM as these are both factors of a difficult airway.

Opportunities to benefit from this program include the fact that currently many facilities have no set policy for patients with anticipated difficult airways. At the same time, nurse anesthetists receive no formal training at FIU on how to use ultrasonography to locate the CTM. This presents the opportunity to further FIU alumni's education and also improve safety for patients.

Many threats may prevent this program from reaching its stated goal. The number one threat is participation from FIU alumni. With a busy work schedule and limited downtime, it may be difficult to engage the staff in training. Another threat is production pressure. At many facilities, there is limited time for nurse anesthetists to perform their preoperative assessments. While locating the CTM with ultrasonography has been shown to only add a few minutes at most to preoperative assessment time, staff may feel that even these few minutes slow them down.

Sustaining Change

If this project is successful FIU alumni will be competent in utilizing ultrasonography to locate the CTM of patients. As mentioned previously, this skill can prove to be vital in successfully obtaining an airway in a cannot ventilate cannot intubate situation. Possessing confidence in this skill will enable them to teach future staff and student registered nurse anesthetists (SRNAs) so that they too can be successful. Along with staff teaching others, Clint Roberts will leave the educational PowerPoint with the FIU alumni to distribute to others. These steps will ensure current and future nurse anesthetists sustain practice change.

V. Methodology for Proposal

Project Setting and Participants

The setting for this project will be locations where current FIU alumni practice. The project will be conducted by SRNA Clint Roberts. Participants in this project will be FIU alumni. As stated previously the goal of this project is for eighty percent of FIU alumni to declare they are at a minimum somewhat confident in their ability to utilize ultrasonography to locate the CTM. All identities of participants will be kept confidential. Guidelines and policies from the Office for Human Research Protections will be used for the protection of all human subjects involved in the project. HIPAA standards will be followed at all times.

Intervention and Procedures

This program will be accomplished by participants taking a ten-question pre-test followed by an educational voiceover PowerPoint presentation lasting 10 minutes. The presentation will include education on the importance of being able to accurately locate the CTM, visuals, steps used to locate the CTM utilizing ultrasonography, and images showing the

anatomy of the CTM when using ultrasonography. The presentation will be presented to FIU alumni by SRNA Clint Roberts.

Following the presentation and practice session, the FIU alumni will take a ten-question post-test to determine their level of confidence in accurately locating the CTM using ultrasonography. The questionnaire will include ten questions regarding anatomy and the steps to properly use the ultrasound to locate the CTM. There will also be a personal rating scale in which FIU alumni will rate their confidence level in accurately locating the CTM using ultrasound. The scale will range from extremely confident to extremely unconfident. The questionnaire will be distributed to FIU alumni by Clint Roberts, and he will also be responsible for assessing the data and reporting the results.

Data

All questionnaire results collected will be kept confidential. The main data points to be collected are the correct percentage score of the questions and the confidence level rating. Microsoft Excel will be used to keep track of and analyze the data. The results from the ten questions will highlight the degree to which the FIU alumni understand how to properly use an ultrasound to locate the CTM and their knowledge of CTM anatomy. The confidence rating will show if the PowerPoint presentation was effective in educating the FIU alumni on how to properly locate the CTM using ultrasound. A rating of somewhat or extremely confident will show confidence. All ratings will be entered, and an average calculated using Microsoft Excel. If the FIU alumni are confident in using ultrasound to locate the CTM this will implicate they can use the skill on future patients with predicted difficult airways.

Timeline

In January time will be spent further researching the project. During this time research articles will continue to be screened to obtain relevant information. During the months of February and March, the PowerPoint will be constructed. Construction of the PowerPoint will include translating previous research, locating or creating video demonstrations, and obtaining ultrasound pictures of numerous different CTM examples. The PowerPoint will continue to be improved in April and the questionnaire will also be created. In May the FIU alumni will be notified of the educational PowerPoint being presented in June. In June the PowerPoint will be presented and the questionnaires will be completed by the FIU alumni. Following data collection results will be analyzed and final results should be available in July.

VI. Results

Demographics

The Demographics of the participants are illustrated in Table 1. A total of six FIU alumni anesthesia providers completed, after agreed informed consent, the pre-test survey, the educational voiceover PowerPoint presentation, and the post-test survey. Two participants only partially completed the pretest questions, due to this their responses were not included in the results.

Five (83.3%) of the participants were between the age of 26 and 30 and one participant (16.6%) did not indicate their age. Three (50%) of the participants identified themselves as male and three as female (50%). Two (33.3%) participants identified themselves as Hispanic and four (66.6%) as Caucasian. All of the participants (n=6, 100%) indicated that they were a CRNA of which all 6 (100%) indicated they currently held a Doctorate in Nursing Practice (DNP) degree. When asked to indicate how long the participant has been an anesthesia provider, the results

varied: 1 to 2 years (*n*=4, 66.6%), 2 to 5 years (*n*=1, 16.6%), 5 to 10 years (*n*=0, 0%), and greater than 10 years (*n*=1, 16.6%).

Table 1. Participants' Demographics

Participants (*n*=6)	Number	%
Gender		
Male	3	50
Female	3	50
Ethnicity		
Caucasian	4	66.6
Hispanic	2	33.3
Position		
CRNA	6	100
Level of Education		
DNP	6	100
Years of Experience		
1-2	4	66.6
2-5	1	16.6
>10	1	16.6

Pretest Knowledge Related to Cricothyrotomy

Questions related to cricothyrotomies were used to assess the participants' baseline knowledge on the subject. The pretest survey revealed an overall sufficient knowledge related to cricothyrotomies per the data score on each question.

The first question asked during a cannot intubate cannot oxygenate scenario is what is the final step in the emergency airway management algorithm. Six (100%) of the participants answered correctly "cricothyrotomy". The next question asked which structure a tube is placed through during a cricothyrotomy. Six (100%) of the participants answered correctly "cricothyroid membrane". Six (100%) of the participants correctly answered complications of a cricothyrotomy include all of the following except "carotid artery puncture". Six (100%) of the participants correctly answered "true" when asked if palpitation has a higher incidence of misidentifying the cricothyroid membrane when compared to ultrasound.

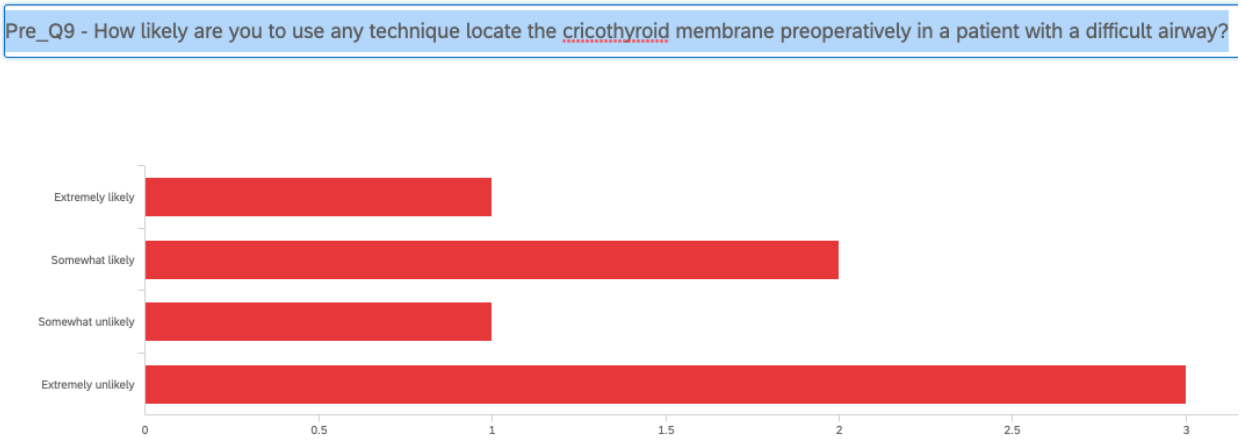
Pretest Knowledge Related to Ultrasound Use

When asked if ultrasound subjectively defines neck anatomy six (100%) participants correctly answered “false”. Six (100%) of participants correctly answered “true” when asked if a high-frequency transducer should be used when locating the cricothyroid membrane with ultrasound. When asked when using ultrasound to identify the cricothyroid membrane where should the practitioner initially place the transducer, five (83.3%) participants correctly chose “just superior to the sternal notch”, while one (16.6%) participant incorrectly chose “sternal notch”. When asked when using an ultrasound how the cricothyroid membrane appears, two (33.6%) participants correctly chose “hyperechoic white line”, while two (33.6%) incorrectly chose “hypoechoic arch shape” and two (33.6%) chose “hyperechoic triangular shape”.

Pretest Knowledge Related to Personal Confidence

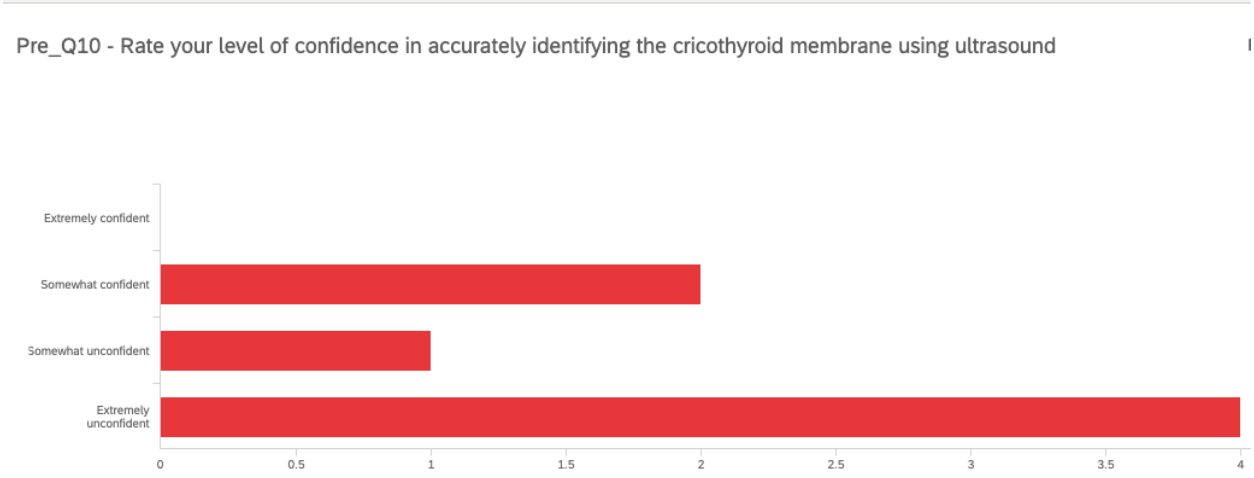
As seen in Figure 2, when asked how likely participants are to use any technique to locate the cricothyroid membrane preoperatively in a patient with a difficult airway one (16.6%) participant answered “extremely likely”, two (33.6%) answered “somewhat likely”, one (16.6%) answered “somewhat unlikely, and two (33.6%) answered “extremely unlikely.

Figure 2. Pre-test question 9



As seen in figure 3, when asked to rate their level of confidence in accurately identifying the cricothyroid membrane using ultrasound zero (0%) answered “extremely confident”, two (33.6%) answered “somewhat confident”, one (16.6%) answered “somewhat unconfident”, and three (50%) answered “extremely unconfident”.

Figure 3. Pre-test question 10



Posttest Knowledge Related to Cricothyrotomy

The first question asked during a cannot intubate cannot oxygenate scenario what is the final step in the emergency airway management algorithm. Six (100%) of the participants answered correctly “cricothyrotomy”. The number of participants who responded correctly to this question (100%) remained unchanged following the education module. The next question asked which structure a tube is placed through during a cricothyrotomy. Six (100%) of the participants answered correctly “cricothyroid membrane”. The number of participants who responded correctly to this question (100%) remained unchanged following the education module. When asked complications of a cricothyrotomy include all of the following, five (83.3%) of the participants correctly answered “carotid artery puncture” except and one (16.6%) incorrectly answered “failure to obtain airway”. The percentage of correct participants for this question decreased by 16.6%. Six (100%) of the participants correctly answered “true” when

asked if palpitation has a higher incidence of misidentifying the cricothyroid membrane when compared to ultrasound. The number of participants who responded correctly to this question (100%) remained unchanged following the education module.

Posttest Knowledge Related to Ultrasound Use

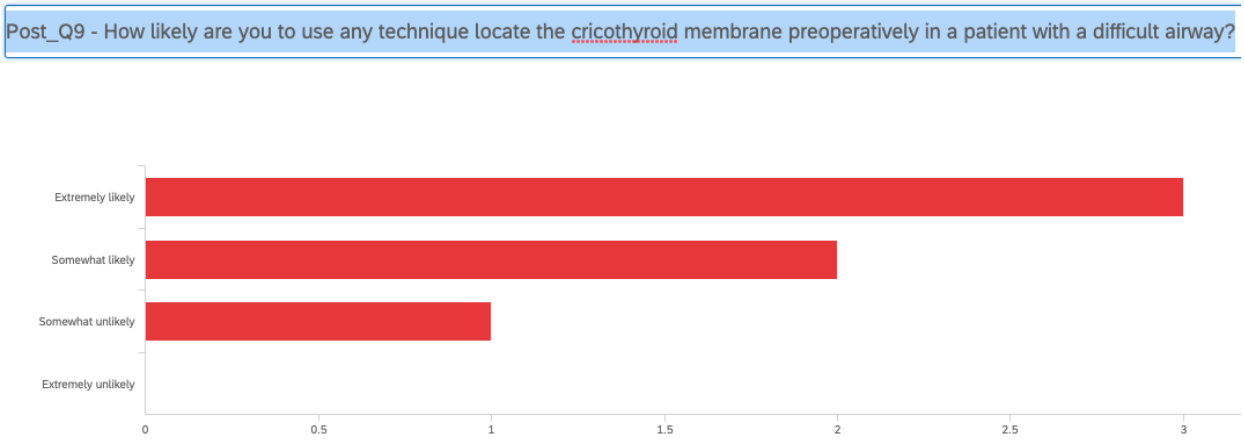
When asked if ultrasound subjectively defines neck anatomy six (100%) participants correctly answered “false”. The number of participants who responded correctly to this question (100%) remained unchanged following the education module. Six (100%) of participants correctly answered “true” when asked if a high-frequency transducer should be used when locating the cricothyroid membrane with ultrasound. The number of participants who responded correctly to this question (100%) remained unchanged following the education module. When asked when using ultrasound to identify the cricothyroid membrane where should the practitioner initially place the transducer, six (100%) participants correctly chose “just superior to the sternal notch”. This represents a 16.6% increase in correct responses following the educational module. When asked when using an ultrasound how does the cricothyroid membrane appear, four (66.6%) participants correctly chose “hyperechoic white line”, while one (16.6%) incorrectly chose “dark horseshoe shape” and one (16.6%) chose “hyperechoic triangular shape”. This represents a 33.2% increase in correct responses following the educational module.

Posttest Knowledge Related to Personal Confidence

As seen in Figure 4, when asked how likely participants are to use any technique to locate the cricothyroid membrane preoperatively in a patient with a difficult airway three (50%) participants answered “extremely likely”, two (33.6%) answered “somewhat likely”, one (16.6%) answered “somewhat unlikely, and none (0%) answered “extremely unlikely. This represents a 33.3% increase in those who responded with “extremely likely”, no change in those

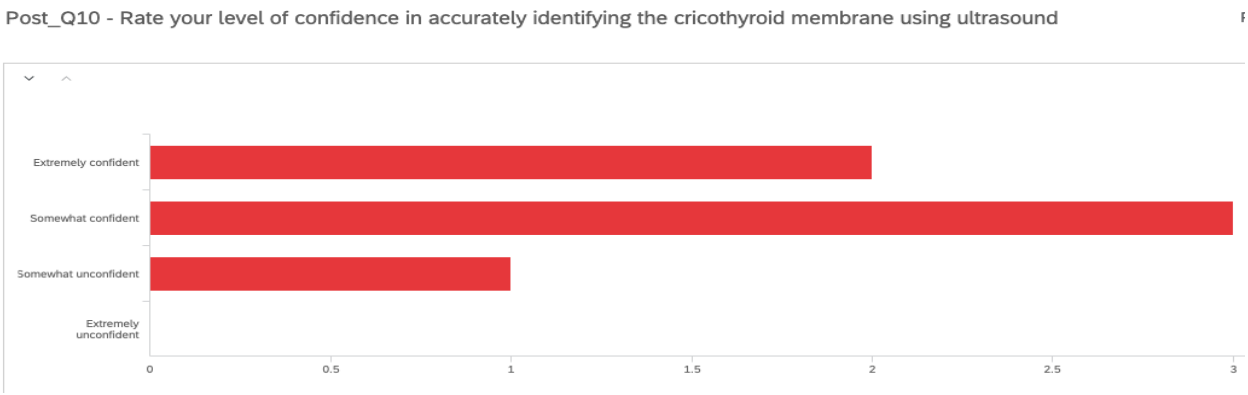
who answered “somewhat likely” and “somewhat unlikely, and a 33.6% decrease in those who answered “extremely unlikely”.

Figure 4. Post-test question 9



As seen in Figure 5, when asked to rate their level of confidence in accurately identifying the cricothyroid membrane using ultrasound two (33.6%) answered “extremely confident”, three (50%) answered “somewhat confident”, one (16.6%) answered “somewhat unconfident”, and zero (0%) answered “extremely unconfident”. This represents a 33.6% increase in those who answered “extremely confident”, a 16.6% increase in those who answered “somewhat confident", no change in those who answered “somewhat confident, and a 50% decrease in those who answered “extremely unconfident” following the educational module.

Figure 5. Post-test question 10



VII. Discussion

Limitations

Limitations of the study included a small sample size. While the study was only conducted using FIU alumni, a larger group would have been superior in strengthening the results of the project. Another limitation was time. Providers only had a limited amount of time to watch the educational module and then complete the post-test survey. It would likely have been more beneficial if participants had more time to review the material. Lastly, the project was completed solely online with no interaction between the creator and FIU alumni. It would likely have been of benefit if the information was conveyed in an in-person setting.

Implications for Practice

Utilizing evidence-based practice has been shown to improve clinical outcomes and increase patient safety. The impact of this intervention will aid providers in recognizing the importance of using ultrasound to locate the CTM in patients with difficult airways and using ultrasound to accurately locate the CTM. By implementing this intervention complications related to cricothyrotomies can be decreased leading to better outcomes for patients.

Conclusion

A review of the literature highlighted that utilizing ultrasound is superior to palpation when attempting to accurately locate the CTM. Utilizing ultrasound has also been shown to lead to fewer complications when performing a cricothyrotomy. The results of the pretest demonstrate improvement in most of the topics explored in the questions asked of the participants. This project successfully met the objectives of improving the provider's knowledge and confidence in using ultrasound to accurately locate the CTM. Following the educational module over 83% of participants expressed they were at least somewhat confident in using ultrasound to locate the

CTM and participants were much more likely to use ultrasound to locate the CTM in patients preoperatively after completing the educational module.

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Appendix

Appendix A. Letter of Support

FIU
Department of Nurse Anesthesiology

Nicole Wertheim College of Nursing & Health Sciences

February 7, 2023

Vicente Gonzalez, DNP, CRNA, APRN
Department of Nurse Anesthesiology
Florida International University

Dr. Vicente Gonzalez,

Thank you for inviting FIU alumni to participate in the Doctor of Nursing Practice (DNP) project conducted by Clint Roberts entitled *"Using Ultrasound to Identify the Cricothyroid Membrane in Patients with a Difficult Airway: A Teaching Module"* in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthesiology at Florida International University. I have granted the student permission to conduct the project using our providers.

Evidence-based practice's primary aim is to yield the best patient outcomes by selecting interventions supported by the evidence. This proposed quality improvement project seeks to utilize the latest literature to increase providers awareness of using ultrasound to locate the cricothyroid membrane in patients with a difficult airway.

We understand that participation in the study is voluntary and carries no overt risk. All Anesthesiology providers are free to participate or withdraw from the study at any time. The educational intervention will be conveyed by a 15-minute virtual
PowerPoint presentation, with a pretest and posttest questionnaire delivered by a URL link electronically via Qualtrics, an online survey product. Responses to pretest and posttest surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password-encrypted digital cloud, and only be accessible to the investigators of this study: Clint Roberts and Dr. Vicente Gonzalez.

Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. Clint Roberts will behave professionally, follow standards of care, and not impede hospital performance. We support the participation of our Anesthesiology providers in this project and look forward to working with you.

Sincerely,

Jorge A. Valdes, DNP, CRNA, APRN,
FAANA Chair, Department of Nurse
Anesthesiology Associate Professor

Appendix B. IRB Approval

FIU | Research & Economic Development
FLORIDA INTERNATIONAL UNIVERSITY

MEMORANDUM

To: Dr. Vicente Gonxalez

CC: Clint Roberts

From: Carrie Bassols, BA, IRB Coordinator CeB

Date: March 2, 2023

Proposal Title: "Using Ultrasound to Identify the Cricothyroid Membrane in Patients with a Difficult Airway: A Teaching Module"

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #: IRB-23-0076 **IRB Exemption Date:** 03/02/23
TOPAZ Reference #: 112818

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
1) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix C. Letter of Recruitment

FIU Department of Nurse Anesthesiology

Nicole Wertheim College of Nursing & Health Sciences

Using Ultrasound to Identify the Cricothyroid Membrane in Patients with a Difficult Airway: A Teaching Module

Dear FIU alumni Perioperative Providers:

My name is Clint Roberts, and I am a student from the Anesthesiology Nursing Program Department of Nurse Anesthesiology at Florida International University. I am writing to invite you to participate in my quality improvement project. The goal of this project is to increase health care providers' awareness on using ultrasound to locate the cricothyroid membrane in patients with a difficult airway. You are eligible to take part in this project because you are a part of the FIU alumni perioperative provider.

If you decide to participate in this project, you will be asked to complete and sign a consent form for participation. Next, you will complete a pre-test questionnaire, which is expected to take approximately 5 minutes. You will then be asked to view an approximately 15 minutes long educational presentation online. After going through the educational module, you will be asked to complete the post-test questionnaire, which is expected to take approximately 5 minutes. *No compensation will be provided.*

Remember, this is completely voluntary. You can choose to be in the study or not. If you'd like to participate or have any questions about the study, please email or contact me Clint Roberts at 352-321-9079 or Crobe112@fiu.edu.

Thank you very much.

Sincerely,

Clint Roberts
352-321-9079 / Crobe112@fiu.edu

Appendix D. Informed Consent

FIU | FLORIDA INTERNATIONAL UNIVERSITY

CONSENT TO PARTICIPATE IN A QUALITY IMPROVEMENT PROJECT

Using Ultrasound to Identify the Cricothyroid Membrane in Patients with a Difficult Airway: A Teaching Module

SUMMARY INFORMATION

Things you should know about this study:

- **Purpose:** Educational module to increase providers awareness on using ultrasound to locate the cricothyroid membrane in patients with difficult airway
- **Procedures:** If the participant chooses to participate, they will be asked to complete a pretest, watch a voice PowerPoint, and then a post test
- **Duration:** This will take about a total of 20 minutes total.
- **Risks:** There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.
- **Benefits:** The main benefit to you from this research is increase the participants knowledge on using ultrasound to locate the cricothyroid membrane
- **Alternatives:** There are no known alternatives available to the participant other than not taking part in this quality improvement project.
- **Participation:** Taking part in this quality improvement project is voluntary.

Please carefully read the entire document before agreeing to participate.

NUMBER OF STUDY PARTICIPANTS:

If the participant decides to be in this study, they will be one of approximately 10 people in this research study.

PURPOSE OF THE PROJECT

The participant is being asked to be in a quality improvement project. The goal of this project is to increase providers' knowledge on using ultrasound to locate the cricothyroid membrane in patients with a difficult airway. If you decide to participate, you will be 1 of approximately 10 participants.

DURATION OF THE PROJECT

The participation will require about 20 minutes

PROCEDURES
If the participant agrees to be in the project, PI will ask you to do the following things:
1. Complete an online 10 question pre-test survey via Qualtrics, an Online survey product for which the URL link is provided
2. Review the educational PowerPoint Module lasting 15 minutes via Qualtrics, an Online survey product for which the URL link is provided.
3. Complete the online 10 question post-test survey via Qualtrics, an Online survey product for which the URL link is provided.

RISKS AND/OR DISCOMFORTS
The main risk or discomfort from this research is minimal. There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.

BENEFITS
The following benefits may be associated with participation in this project: An increase in participants knowledge on using ultrasound to locate the cricothyroid membrane in patients with a difficult airway. The overall objective of the program is to increase the providers' knowledge based on the current literature.

ALTERNATIVES
There are no known alternatives available to the participant other than not taking part in this project. However, if the participant would like to receive the educational material, it will be provided to them at no cost.

CONFIDENTIALITY
The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, PI might publish, it will not include any information that will make it possible to identify the participant. Records will be stored securely, and only the project team will have access to the records.

PARTICIPATION: Taking part in this quality improvement project is voluntary.

COMPENSATION & COSTS
There is no cost or payment to the participant for receiving the health education and/or for participating in this project.

RIGHT TO DECLINE OR WITHDRAW
The participation in this project is voluntary. The participant is free to participate in the project or withdraw the consent at any time during the project. The participant's withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator

reserves the right to remove the participant without their consent at such time that they feel it is in their best interest.

RESEARCHER CONTACT INFORMATION

If you have any questions about the purpose, procedures, or any other issues relating to this research project, you may contact Clint Roberts at 352-321-9079/Crobe112@fiu.edu and Vince Gonzalez at Gonzalv@fiu.edu .

IRB CONTACT INFORMATION

If the participant would like to talk with someone about their rights pertaining to being a subject in this project or about ethical issues with this project, the participant may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT

I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the "consent to participate" button below I am providing my informed consent.

Appendix E. Data Collection Instrument (Pre- and Post-test Survey)

Pretest and Posttest Questionnaire:

Using Ultrasound to Identify the Cricothyroid Membrane in Patients with a Difficult Airway: A Teaching Module

INTRODUCTION

The primary aim of this QI project is to increase providers awareness of using ultrasound to locate the cricothyroid membrane in patients with difficult airway

Please answer the question below to the best of your ability. The questions are either in multiple choice or true/false format and are meant to measure knowledge on using ultrasound to locate the cricothyroid membrane.

PERSONAL INFORMATION

1. **Gender:** Male Female Other_____
2. **Ages 25 and above: _____**
3. **Ethnicity:** Hispanic Caucasian African American Asian Other_____
4. **Position/Title:** CRNA Anesthesiologist Resident Anesthesiologist Assistant
5. **Level of Education:** Certificate Bachelors Masters DNP PhD
6. How many years have you been a perioperative provider?

   Over 10 5-10 years 2-5 years 1-2 years

QUESTIONNAIRE

1. **During a cannot intubate cannot oxygenate scenario what is the final step in the emergency airway management algorithm?**
    a. Awake the patient
    b. Place a Laryngeal Mask airway
    c. Cricothyrotomy
    d. Call for help
2. **Cricothyrotomy is achieved by placing a tube through which structure?**
    a. Cricothyroid membrane
    b. Thyroid
    c. Cricothyroid joint
    d. Cricothyroid muscle
3. **Complications of a cricothyrotomy include all of the following except**
    a. Device misplacement
    b. Airway trauma
    c. Airway trauma
    d. Carotid artery puncture
4. **Palpation has a higher incidence of misidentifying the cricothyroid membrane when compared to ultrasound?** True or False
5. **Ultrasound subjectively defines neck anatomy?** True or False
6. **A high frequency linear transducer should be used when locating the cricothyroid membrane with ultrasound?** True or False
7. **How likely are you to use any technique locate the cricothyroid membrane preoperatively in a patient with a difficult airway?**

a. Most likely

b. Somewhat likely

c. Somewhat unlikely

d. Most unlikely

8. How likely are you to use an ultrasound to locate the cricothyroid membrane preoperatively in a patient with a difficult airway?

a. Most likely

b. Somewhat likely

c. Somewhat unlikely

d. Most unlikely

9. When using an ultrasound to identify the cricothyroid membrane where should the practitioner initially place the transducer?

a. Just superior to the sternal notch

b. Just inferior to the sternal notch

c. Sternal notch

d. Mandible

10. When using ultrasound how does the cricothyroid membrane appear

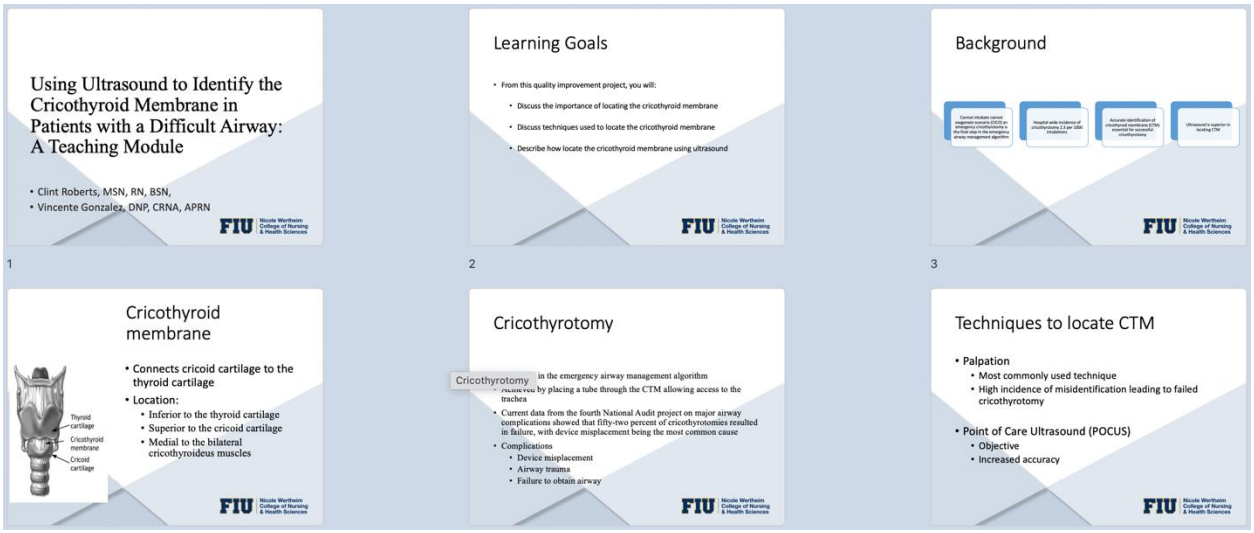
a. Dark horseshoe shape

b. Hypoechoic arch shape

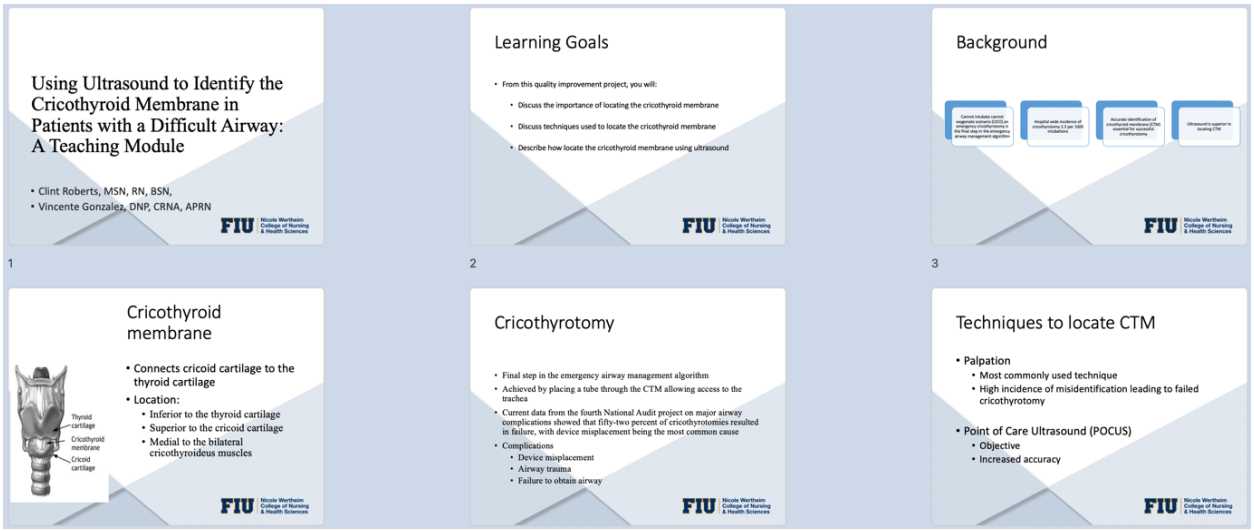
c. Hyperechoic white line

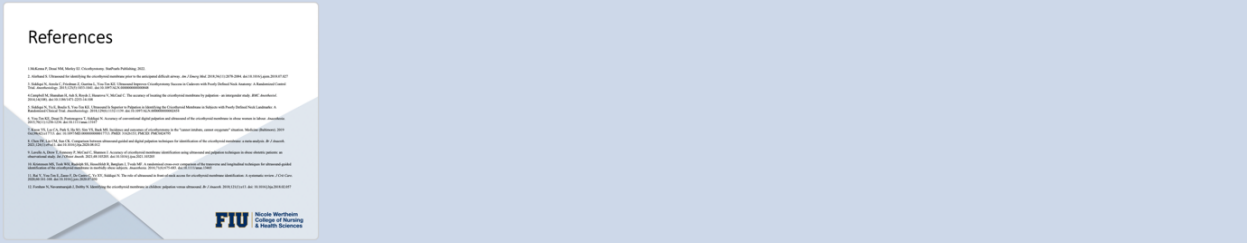
d. Hyperechoic triangular structure

Appendix F. PowerPoint Presentation for Educational Module



Appendix G. PowerPoint Presentation for DNP Symposium




References
FIU
Nicole Wertheim
College of Nursing
& Health Sciences