11-30-2022

An Educational Module Explaining the Utilization of Airway Ultrasonography as Standard of Care for Preoperative Airway Assessment

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An Educational Module Explaining the Utilization of Airway Ultrasonography as Standard of Care for Preoperative Airway Assessment

A DNP Project Presented to the Faculty of the Nicole Wertheim College of Nursing and Health Sciences, Florida International University

In partial fulfilment of the requirement for the Degree of Doctor of Nursing Practice

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Abstract

Background: One of the most life-threatening complications during anesthesia is an unrecognized difficult airway. Difficult airway patients are more prone to intraoperative complications including airway edema, periods of hypoxia, and trauma to the airway. Failure to oxygenate due to an unpredicted difficult airway can result in permanent organ damage. Standardizing the method in which providers classify airways preoperatively including handheld ultrasonography could help decrease the incidence of unpredicted difficult intubations. This quality improvement project assessed whether anesthesia providers would benefit from an education module on ultrasound parameters to differentiate difficult versus easy intubations to increase ultrasound airway anatomy knowledge, skill, and predictive abilities. There were three participants, all are certified registered nurse anesthetists (CRNAs). The project involved a pretest, PowerPoint presentation, and posttest. Based on the results, an educational module on airway assessment utilizing ultrasound parameters compared to no ultrasound parameters increases knowledge in ultrasound airway anatomy, skill, and predictive ability in detecting a difficult versus easy intubation.

Keywords: Airway, Difficult Airway, Difficult Intubation, Airway Ultrasonography, Preoperative Airway Assessment, Mallampati Score.

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I. Introduction

Background and Problem Identification

Accurate airway assessment is the first step towards avoiding potential complications and is the most important factor in airway management for anesthesia providers.[1] One of the most life-threatening complications during anesthesia is an unrecognized difficult airway. Difficult airway patients are more prone to intraoperative complications including airway edema, periods of hypoxia, and trauma to the airway. [2] Failure to oxygenate due to an unpredicted difficult airway can result in permanent organ damage.[3] Standardizing the method in which providers classify airways preoperatively including point of care ultrasonography in real time in comparison to the traditional methods of airway assessment including Mallampati score, visual inspection, and thyromental distance could help decrease the incidence of unpredicted difficult intubations.

Identification of a difficult airway prior to intubation allows for optimal preparation, proper equipment selection, and the participation of experienced personnel. Traditionally, pre-intubation evaluation of the airway has depended on clinical parameters such as body mass index (BMI), neck circumference, and the Mallampati scoring system. A meta-analysis of 55 studies identified that only 35% of difficult intubations had a Mallampati score of III or IV, classifying these patients as difficult airways preoperatively.[4] Although Mallampati is one of the most commonly used clinical tools to predict a difficult laryngoscopy, the scoring is based on patient compliance and patient body position, which can significantly impact the accuracy of difficult airway prediction.[5]

Only one in four patients who are identified to have a difficult airway upon intubation with direct laryngoscopy are determined utilizing the common assessment tools including Mallampati score and physical features such as neck circumference and tongue size.[6] Ninety three percent of difficult intubations are usually unexpected, and most often the anesthesia provider is unaware of the issue prior to induction.[7] Furthermore, when a difficult intubation is predicted, the assessment of the airway is solely based upon Mallampati score and thyromental distance.[7] With a high percentage of difficult intubations being unexpected, anesthesia providers utilization of ultrasonography in the assessment of the airway in the preoperative setting can decrease an unexpected difficult airway.

The ultrasound machine is a simple, noninvasive, and safe method for providers to rapidly assess the airway in the operating room, emergency department, and intensive care unit. Ultrasound has the same efficacy of computed tomography (CT) scan in quantifying almost all dimensions of airway structures.[7] Ultrasound, X-ray, and CT scan have similar diagnosing abilities, but all are more reliable at predicting a difficult airway compared to the Mallampati score.[8] In a prospective single blind randomized clinical study conducted on 80 patients requiring general anesthesia necessitating endotracheal intubation, three parameters were utilized to assess the airway preoperatively.[7] Mallampati score, thyromental distance, and ultrasound-measured distance from skin to epiglottis at the level of the thyrohyoid membrane were all evaluated and scored. Abdelhady and colleagues found that the difficult laryngoscopy group displayed greater thickness of ultrasound measurement from skin to epiglottis with a *P* value of 0.002 compared to Mallampati score that was found to have a *P* value of 0.044.[7] The ultrasound measured skin to epiglottis parameter had a better predictive power than any of the traditional airway assessments including thyromental distance and the current standard of the Mallampati score. Abdelhady and

colleagues concluded that there is a strong correlation between ultrasound measurement of distance of skin to epiglottis (DSE) and difficult intubation, as well as this measurement being a better indicator of DI compared to traditional clinical airway tests including Mallampati score and thyromental distance.[7]

The current research surrounding preoperative assessment of the airway includes the Mallampati scoring system, neck mobility, neck circumference, upper lip bite test, thyromental distance, sternomental distance, and lower jaw protrusion maneuverability.[9] The Mallampati score is based upon visualization of anatomical oropharyngeal structures and relates them to intubation difficulty. The Mallampati score has become a standard part of an airway evaluation, although by itself the classification has a low positive predictive value in identifying patients who are difficult to intubate.[10] While seated, a patient is asked to open the mouth as widely as possible and maximally protrude the tongue.[10] The faucial pillars, uvula, soft palate, and hard palate are visualized and classified into a scoring system based on what is visible to the provider.

Various ultrasound measurements can be used to predict a difficult airway, but after extensive review of the current literature, it has been determined that two measured parameters are more specific at predicting DI compared to other measurements; including ultrasound measured distance of skin to epiglottis at the level of the thyrohyoid membrane (US-DSE), and anterior neck soft tissue thickness at the level of the vocal cords (ANS-VC). A prospective observational study at an academic tertiary hospital concluded that anterior neck thickness above 2.8 cm at the level of the hyoid bone and thyrohyoid membrane better predicts difficult laryngoscopy compared to that of the anterior neck thickness at the level of the vocal cords.[11] Abdelhady and colleagues concluded in their prospective single blind randomized clinical study consisting of 80 patients undergoing general anesthesia requiring endotracheal intubation that

US-DSE cut off point for difficult laryngoscopy was >1.85 cm with sensitivity of 80% and specificity of 70.8%.[7]

Ultrasound measured anterior neck soft tissue thickness at the level of the hyoid bone and thyrohyoid membrane, and ultrasound measured anterior neck soft tissue thickness at the level of the vocal cords, when compared to Mallampati score, measured tongue thickness, and incisor gap proved to be better indicators of difficult airways. Additionally, Adhikari and colleagues found that central measurements at the level of the hyoid bone and thyrohyoid membrane can be obtained in less than two minutes, which supports the utility of airway ultrasound in the critical care and emergency room setting, as well as preoperatively.[11] As increased anterior neck soft tissue thickness impairs forward mobility of pharyngeal structures leading to difficult laryngoscopy, anesthesia providers should be measuring this parameter preoperatively in all patients undergoing surgery requiring general anesthesia.[12] With the level of reliability and accuracy ultrasound can provider to anesthesia providers in the preoperative setting, this confirms that airway ultrasound should be a standard part of the preoperative airway assessment.

Scope of the Problem

Approximately 30% of anesthesia-related deaths result from failures of airway management, and an unanticipated difficult airway is an important source of peri-operative anesthetic complications and mortality.[13] The probability of a difficult airway in the general population undergoing anesthesia is 1% to 4%, and the tracheal intubation failure rate is approximately 1 in 2000 in the elective setting, and approximately 1 in 300 during rapid sequence induction in the obstetric setting.[14] Difficult glottic exposure contributes to difficult airway management with an incidence rate of 6.1% to 10.1%.[15]

The difficult laryngoscopy and tracheal intubation rate remains at 1.5-13%, which many providers attribute to the poor reliability of standardized protocols, algorithms, and different screening tools that fail to accurately diagnose a difficult airway.[7] A 17-month prospective observational study looked at 110 patients undergoing tracheal intubation and found the incidence of difficult intubation was 35.5% (39/110).[9] This was based on multiple factors including the presence of double chin, thick short neck, small thyromental distance, significantly higher body mass index (BMI) and a higher Mallampati score.[9] According to the closed claims analysis conducted by the American Society of Anesthesiologists, a leading cause of anesthesia-related patient injury is the inability to intubate the trachea and secure the airway. As a consequence, 85% of anesthesia related injuries result in either death or brain damage.[1]

Consequences of the Problem

Failed and difficult tracheal intubation (DTI) is associated with hypertension as defined by a systolic blood pressure of 200 mmHg or greater, oxygen desaturation as defined by pulse oximeter less than 90%, damage to teeth, admission to the intensive care unit (ICU), and increased complications at extubation.[14] Difficult tracheal intubations are also associated with life threatening arrhythmias, bronchospasm, postoperative laryngospasm, airway trauma, anesthesia awareness, 'can't intubate can't ventilate' (CICV) scenarios, and hypoxia causing brain damage, cardiac arrest, and death. Dental injury is also more common in the airway management of difficult to intubate patients.[16]

An American Society of Anesthesiologists' Closed Claims Project (ASACCP) analysis of difficult airway management cases indicated that when a difficult tracheal intubation was anticipated, almost 70% of anesthesia providers continued with routine general anesthesia and paralysis, not adapting or changing their practice based on their assessment, and 60% progressed

to a can't intubate can't ventilate scenario.[14] Poor outcomes were significantly more common in these cases than in cases managed differently upon the assessment of a difficult airway.[14] This statistic demonstrates the lack of new knowledge on ultrasonography in relation to assessing and managing a presumed difficult airway in the clinical setting.

Knowledge Gaps

Currently in clinical practice, many anesthesia providers are using the common and traditional airway assessment tools such as the Mallampati scoring system, thyromental distance, neck circumference, and tongue size to evaluate a patient's airway prior to intubation. The issue with these routine assessment skills is the limiting ability to distinguish between an easy and difficult airway. Visual inspection exams that do not consist of exact measurements such as Mallampati score and tongue thickness leave room for observer variability, and are often limited by patients who are obtunded, noncommunicative, or uncooperative. Different airway assessment tools that can provide more reliable information include X-ray exams, computer cosmography (CT) scans, magnetic resonance imaging (MRI), and airway ultrasonography. The use of preoperative airway ultrasonography is preferred compared to the other imaging studies due to the fact it is low cost, fairly easy to use, and does not require ionizing radiation.[8] With a simple, fast, and reliable exam, anesthesia providers are able to prepare for a difficult airway.

While the data supports preoperative airway ultrasound assessment to predict difficult intubation, the use of ultrasound in the clinical setting is lacking. There is a gap between translation of evidence to clinical practice. To facilitate the increased use of airway ultrasonography in clinical practice it would be beneficial to create an educational training module delivered to anesthesia providers. Many anesthesia providers are uneducated on how to

conduct an airway ultrasound assessment and therefore avoid utilizing the tool in clinical practice.

An airway ultrasound assessment can be conducted by placing the ultrasound probe under the floor of the mouth.[17] A sagittal view of the main oropharyngeal and laryngeal structures, including the hyoid bone, tongue, and suprahyoid muscles can be viewed in real time.[17] Airway ultrasound can visualize and assess many structures including the tongue, oropharynx, hypopharynx, epiglottis, larynx, vocal cords, cricothyroid membrane, cricoid cartilage, and trachea.[18] Measurements can then be taken of appropriate airway structures and compared to the normal value in order to predict changes and difficult intubation.

Measurements of anterior soft neck tissue thickness at the level at the hyoid bone and thyrohyoid membrane can be used to predict difficult direct laryngoscopies.[19] The inability to visualize the hyoid bone on ultrasound has high sensitivity and specificity for difficult intubations.[17] Additionally, the use of ultrasonography to assess tongue thickness and tongue to thyromental distance ratio can assist providers in predicting difficult intubations.[20] Abdelhady and colleagues found that patients with difficult laryngoscopy in the intraoperative period showed significantly greater thickness of distance from skin to epiglottis (DSE) utilizing ultrasound in the preoperative period.[7] It was also found that DSE was a better indicator in predicting DI compared to any of the preintubation screening tests such as Mallampati score and thyromental distance.[7]

Proposal Solution

Utilizing airway ultrasound in the preoperative period can aid clinicians in predicting a difficult intubation and assist anesthesia providers to prepare and utilize other airway options.

It is important for anesthesia providers to have a basic comprehension of ultrasound physics, how to select the proper transducer for the area of the body to be viewed, patient body habitus and how that may interfere with the image, probe orientation, and generalized understanding of basic airway anatomy.[19] An online educational module would ensure providers are well equipped to use the ultrasound to anticipate difficult airways in the clinical setting.

Model/simulation training has gained interest as an effective method for education in the medical field. Ramsingh and colleagues conducted a single-center, prospective, blinded trial consisting of twenty anesthesia residents of various years in training who underwent a training module using ultrasonography.[21] Residents were split into groups in which some received a 90-minute didactic lecture on the use of ultrasound, and the others received a 90-minute lecture in a simulation center that consisted of hands-on learning on mannequins. The study concluded that residents who received the more interactive type of training not only demonstrated improved image acquisition ability but also showed improved content retention as shown by the post-lecture model examination and multiple-choice examination.[21] This indicates that a hands-on training module provided to anesthesia providers will facilitate a greater depth of knowledge of airway ultrasound and encourage providers to make this practice a standard of care in operating rooms and outpatient centers across the country.

Ultrasonography has many benefits for use including reliability, portability, ability to be used at the bedside, radiation-free, cheap, fast, and accurate; it is therefore the best choice for airway assessment.[1] Ultrasonography is a fast, reliable, diagnostic tool used to assist anesthesia providers in assessing the airway and can help prevent intraoperative complications that follow a difficult intubation. Standardization of airway ultrasound in the preoperative setting in both

hospitals and outpatient surgical centers could lead to decreased incidence of unexpected and unanticipated difficult intubation.

II. Literature Review

Literature Review Methodology

Eligibility Criteria

This literature review was completed to identify airway ultrasound parameters that are more likely to predict difficult airways and difficult intubations compared to traditional methods of preoperative airway assessments including Mallampati score and visual inspection. Studies were included in this literature review if they fit inclusion criteria. Peer-reviewed primary research studies that were conducted on adult humans ages 18 to 60 years old undergoing surgery requiring the use of general anesthesia and an endotracheal tube were included. Studies must include a comparison of ultrasound measured airway parameters to a measured preoperative Mallampati score to be used for this literature review. Studies were excluded from this literature review if they were completed on animals, completed on children, greater than ten years old, duplicated in different databases, and if they did not include Mallampati scoring. For this specific literature review, only primary research articles consisting of prospective observational studies were used, so literature reviews and meta-analysis studies were excluded. The primary aim of this literature review is to compare ultrasound findings that most likely predict difficult intubation compared to traditional methods of airway assessments including the Mallampati scoring system and visual inspection.

Information Sources and Search Strategy

To complete the literature search, The Cumulative Index to Nursing and Allied Health Literature (CINAHL), Google Scholar, and PubMed were systematically searched. Key phrases

and words used in the search include “airway,” “difficult airway,” “difficult intubation,” “airway ultrasonography,” “preoperative airway assessment,” and “Mallampati score.” The Boolean search mode was utilized to display additional results by combining more than one term such as “airway ultrasound AND difficult intubation” and “Mallampati score AND difficult intubation.” Initially, over 521 articles were found using this method. PubMed produced 205 studies, CINAHL produced 152 studies, and Google Scholar produced 164 studies. The search was then narrowed by adjusting parameters to find studies completed in or after the year 2011. To complete the search, each article was analyzed to ensure the article related directly to the use of ultrasonography in the preoperative period to predict difficult airways in comparison to Mallampati score. Articles were excluded if the airway assessment was conducted without using ultrasonography, if the article was a literature review comparing different techniques of airway assessment in anesthesia, or if ultrasonography was not relevant to the airway specifically. The inclusion and exclusion criteria highlighted above resulted in five primary research studies that are included in this literature review.

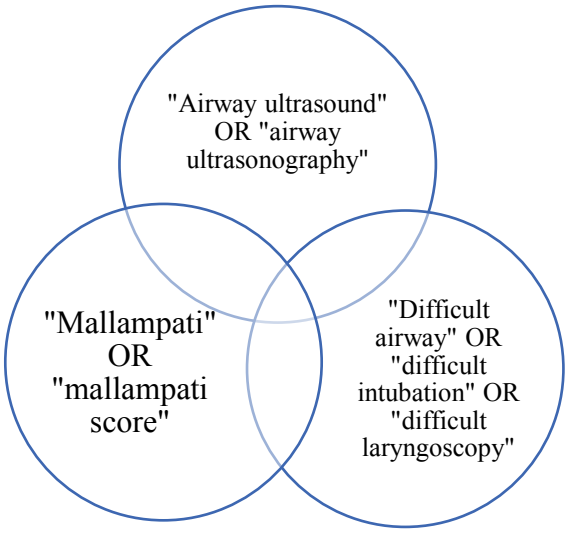

Diagram 1. Search Phrases and Keywords

Literature Review Results

Study Characteristics

All five studies that are included in this literature review are prospective observational studies. Each study compared preoperative measured ultrasound parameters of adult patients ages 18 to 60 requiring endotracheal intubation for general anesthesia to a preoperative Mallampati score determined by a provider. When comparing the five studies, two main ultrasound parameters proved to be more reliable at predicting a difficult airway or difficult intubation compared to Mallampati score and visual inspection. The two main ultrasound parameters that were measured in these five studies include distance from skin to epiglottis at the level of the hyoid bone and the thyrohyoid membrane, and anterior soft neck tissue thickness at the level of the vocal cords.

All five studies made comparisons of specific ultrasound measured parameters and compared these findings with a measured Mallampati score to see if both proved to indicate a potential difficult airway. Agarwal and colleagues focused on the visibility of the hyoid bone, tongue thickness, and anterior neck thickness from the skin to thyrohyoid membrane and hyoid bone versus Mallampati score. Adhikari et al also evaluated the anterior neck soft tissue thickness at the level of the hyoid bone and thyrohyoid membrane compared to Mallampati score. Abdelhady and colleagues focused on ultrasound-measured distance from skin to epiglottis at the level of the thyrohyoid membrane versus Mallampati score. Yadav et al evaluated the anterior neck soft tissue thickness at the level of the vocal cord compared to Mallampati. Reddy and colleagues assessed anterior neck soft tissue thickness at the level of the hyoid bone and the vocal cords and compared these two measured parameters to Mallampati. The literature review will evaluate the articles based on the measured ultrasound parameters

found to be better indicators of difficult laryngoscopy compared to traditional methods of airway assessment including Mallampati and visual inspection.

Individual Study Results

Ultrasound measured distance from skin to epiglottis at the level of the hyoid bone and the thyrohyoid membrane

Agarwal et al conducted a prospective, observational, double-blinded cohort trial that assessed tongue thickness, invisibility of the hyoid bone, and anterior neck soft tissue thickness from skin to thyrohyoid membrane and hyoid bone. The sample size for this study was calculated using the sample size calculator of the University of California, San Francisco. After obtaining ethical approval and written informed consent, patients of both sexes classified as American Society of Anesthesiologists (ASA) physical status I-III, ages 18 to 60 years old, undergoing tracheal intubation for surgery that was indicated under general anesthesia, were included in the study conducted between August 2018 to July 2019.[2] The overall sample size was 1,252 patients for eligibility, of which, 1,043 were included in the study. Exclusion criteria for this trial included upper airway anomaly, trauma or tumor in the airway, history of difficult airway, or suspected difficult airway.[2] A difficult airway is classified by a modified Mallampati test (MMP) grade 3 of 4, small thyromental distance (less than 6.5cm), and small inter-incisor distance of less than 3 cm.[2]

A skilled investigator performed the ultrasound procedure and recorded the measurements. A curved ultrasound probe was placed in the patient's oral cavity longitudinally under the patient's tongue with the head in a neutral position having the patient in sitting position. This completed the visibility of the hyoid bone assessment. A curvilinear ultrasound probe was then positioned beneath the mentum along the mid-sagittal plane and rotated 90

degrees to measure distance of neck thickness at the level of the hyoid bone and thyrohyoid membrane.[2] After the measurements were complete and the patient was induced utilizing Propofol, Midazolam, Fentanyl, and Vecuronium, an experienced provider performed direct laryngoscopy. The provider who performed the ultrasonographic examination was blinded to the preoperative airway assessment, and the provider for laryngoscopy was blinded to the ultrasonographic measurements. Patients were then classified based on easy intubation (EI) or difficult intubation (DI) which is defined as placement of the endotracheal tube that required more than two attempts, lasted greater than 10 minutes, or required alternate methods such as glidescope or fiberoptic bronchoscope.[2]

Results indicate that in total, 985 patients were classified as EI, and 58 as DI. The EI group had significantly lower Mallampati scores than the DI group and the means of the upper airway ultrasonography-based parameters were significantly higher in the DI compared to the EI group.[2] The anterior neck soft tissue thickness from skin to hyoid bone had the highest accuracy at 85%, while measured tongue thickness was the least accurate in predicting DI at 78.4%.[2] Anterior neck soft tissue thickness from the skin to hyoid bone greater than 1.4 cm, and anterior neck soft tissue thickness from the skin to thyrohyoid membrane greater than 2.4 cm were the cut off measurements for predicting a difficult intubation. When comparing the ultrasound measured parameters to Mallampati, Agarwal et al found that their patients had a higher proportion of modified Mallampati score of 2 in the difficult intubation group than in the easy intubation group. While Mallampati score of grade 1 or 2 is usually classified as easy intubation, Agarwal and colleagues acknowledge that the Mallampati is inadequate as a stand-alone test for predicting difficult intubation.[2] Limitations of the study conducted by Agarwal and colleagues (2020) include the unpredicted impact of functional components that assist with successful

intubation such as head position, degree of neck extension, and skills of the provider performing the laryngoscopy.

Abdelhady et al conducted prospective single blind randomized clinical study that evaluated three parameters for airway assessment including Mallampati score, thyromental distance, and ultrasound-measured distance from skin to epiglottis at the level of the thyrohyoid membrane. Abdelhady and colleagues indicate that during direct laryngoscopy, some patients have fat pads that can skew a providers view of the vocal cords. This would mean that the increasing thickness of pre-tracheal soft tissue or pre-epiglottic space could be strong predictors of difficult laryngoscopy.[8] After obtaining ethical approval and patients were provided with written informed consent, individuals from both sexes who were classified as American Society of Anesthesiologists (ASA) physical status I-III, ages 18 to 60 years old, undergoing endotracheal intubation for surgery that was indicated under general anesthesia with a body mass index (BMI) less than 40 kg/m^2 were included in the study.[8] Exclusion criteria for this study included patient refusal, patients who were unable to provide consent, patients with pre-existing airway malformations, cervical tumors or goiters, history of DI, pregnant patients, patients with tracheostomy tubes, and patients with maxillofacial abnormalities. The overall sample size began with 231 patients who were eligible to participate, that was narrowed down to 92 who met inclusion criteria, and finally 80 patients were analyzed using airway ultrasonography.

Abdelhady and colleagues measured ultrasonographic distance from skin to epiglottis (US-DSE) using a linear probe on patients in the supine position ensuring neutral head and neck position. Patients were instructed to keep their mouth closed and breathe slowly during measurements in order to minimize errors.[8] The epiglottis was identified at the thyrohyoid membrane, and the posterior and anterior boarders were identified on ultrasound. The distance in

centimeters was measured from the skin surface to the middle axis of the highest part of the epiglottis through the thyrohyoid membrane.[8] After measuring US-DSE, patients were brought to the operating room for standard induction of general anesthesia. Induction of anesthesia consisted of preoxygenation with 100% oxygen, and intravenous administration of Midazolam, Fentanyl, Propofol, and Rocuronium. The laryngoscopy was performed by an experienced provider having greater than two years of anesthesia experience, and patients were determined to be either easy or difficult intubation. The provider performing direct laryngoscopy was blinded to the findings of the preoperative airway ultrasound measurements and predictions.

Abdelhady and colleagues found that 65 patients were easy intubation as defined by a Cormack-Lehane grade 1 and 2, and 15 patients were a difficult intubation, as defined by a Cormack-Lehane grade 3 and 4.[8] It was determined that US-DSE greater than 1.85 cm reliably predicts DI during preoperative assessment in patients without any unanticipated difficult airway. It was also concluded that DSE was a better indicator in predicting DI compared to any of the preintubation screening tests such as Mallampati score and thyromental distance.[8] Mallampati score had a *P* value of 0.044, while US-DSE had a *P* value of 0.002.[8]

Limitations include a small sample size and only one race was analyzed. In addition, only one ultrasound parameter was measured and evaluated.[8] The one parameter that was measured was obtained by one provider which can also create a bias. Abdelhady and colleagues did not take into consideration the positioning of the patient for induction, the skill of the anesthesia provider conducting the induction, and external manipulation of the airway which could skew the results.

The last literature review that discusses ultrasound measured anterior soft neck thickness at the hyoid bone and thyrohyoid membrane was conducted by Adhikari and colleagues at an

academic medical center. Adhikari et al completed a prospective observational study on 51 patients undergoing elective surgery requiring endotracheal intubation ages 19 and older.[11] The main goal of the study was to determine if ultrasound measured tongue thickness, anterior neck soft tissue thickness at the hyoid bone and thyrohyoid membrane predicted difficult versus easy intubation, and also to compare the parameters likelihood of accurately predicting DI with the traditional airway screening exams such as Mallampati score, thyromental distance, and interincisor gap.[11] Inclusion criteria included endotracheal intubation for an elective surgery. Exclusion criteria included facial abnormalities such as facial fractures, maxillofacial abnormalities, tumors, and cervical spine fractures. Patients were also excluded if they have had a tracheostomy or were unable to provide written consent.[11] The provider performing the ultrasound was the primary investigator who was fellowship-trained in emergency ultrasound. The investigators involved in collecting data for the study were blinded to each other's ultrasound assessments to prevent skewed results.

Ultrasound measured airway parameters were completed using a linear array transducer having the patient in a supine position with head and neck in a neutral position. The anterior neck soft tissue thickness was measured from the skin at five different levels in short axis view. At each level, three separate measurements including central axis, 10 mm to the left, and 10 mm to the right were obtained.[11] The three measurements were then averaged to find the soft tissue thickness. After ultrasound measurements were completed and recorded, the patient went for surgery in which the grade of laryngoscopy was recorded. A Cormack-Lehane grade 1 or 2 was defined as an easy intubation, while a Cormack-Lehane grade 3 or 4 was defined as a difficult intubation.[11]

Adhikari and colleagues found that the average time it took the provider to obtain all ultrasound measurements was 9.6 minutes, and six of the 51 patients were classified as having a difficult intubation.[11] Adhikari et al found that the ultrasound measured anterior neck soft tissue thickness was greater in the difficult laryngoscopy group in comparison to the easy laryngoscopy group at the level of the hyoid bone compared to the thyrohyoid membrane.[11] The group found that anterior neck soft tissue thickness cutoff value of 2.8 cm measured at the thyrohyoid membrane can be used to detect difficult laryngoscopy. Adhikari and colleagues found that there was no significant correlation between Mallampati score and measured tongue thickness. Additionally, the study revealed that clinical screening tests did not correlate with ultrasound measurements, as ultrasound was able to detect difficult laryngoscopy faster and more accurately compared to the traditional screening methods.[11] Limitations to the study include a small sample size, uneven distribution of easy versus difficult intubation, and unanticipated variables including anesthesia provider experience, equipment used, number of intubation attempts, and the view of the glottis used for grading.[11]

Ultrasound measured anterior soft neck tissue thickness at the level of the vocal cords

Two studies analyze the effectiveness and validity of anterior neck soft tissue thickness at the level of the vocal cords (ANS-VC) as a means to predict difficult intubation. Yadav et al conducted a prospective observational study in an anesthesia department of a tertiary care center from January 2018 to June 2019.[5] Using a two-sided binomial test, a total sample size of 200 patients was determined for the research study. Inclusion criteria for Yadav and colleagues' trial include patients older than 18 years undergoing elective surgery that was indicated under general anesthesia with endotracheal intubation. Exclusion criteria consisted of patients who required

rapid sequence intubation (RSI), patients with abnormal cervical spine pathology, patients scheduled for fiberoptic intubation, uncooperative patients, and pregnant patients.[5]

Yadav and colleagues assessed the airway using traditional methods such as Mallampati scoring, thyromental distance (TMD), and hyomental distance ratio (HMDR); along with ultrasound measured parameters including anterior neck soft-tissue thickness at the level of the vocal cords (ANS-VC), ANS tissue thickness at the level of the hyoid (ANS-hyoid), and the ratio of depth of pre-epiglottis space to distance from epiglottis to midpoint of the distance between vocal cords (Pre-E/E-VC).[5] The primary investigator obtained the measurements and was not involved in tracheal intubation. All patients underwent Mallampati scoring using class I through IV, with class III and IV being predictors for difficult laryngoscopy. Airway assessment using ultrasound was conducted using a high frequency linear probe with the patient in sniffing position.[5] The ANS tissue thickness was measured as the distance from the skin to the anterior part of the trachea at the hyoid level. ANS-VC was measured as the distance from skin to anterior commissure of true vocal cords. Yadav et al concluded a cutoff value of ANS-VC greater than 0.23 was a predictor of difficult laryngoscopy.

Yadav et al used three specific ultrasound parameters mentioned above and correlated the results to the Cormack-Lehane (CL) grade given during direct laryngoscopy for induction. Patients were induced with Propofol and Vecuronium after being preoxygenated with 100% oxygen for 3 minutes.[5] Laryngoscopy was performed by an anesthesiologist with over 10 years of experience who was blinded to the results of the preoperative ultrasound measurements. The incidence of DI was 10% indicating that 20 patients were a difficult laryngoscopy.

Results indicate that ANS-VC as well as the ratio of PES/epiglottis to vocal cord (EVC) were significantly higher in the group of patients having difficult laryngoscopy. The ANS-VC

had the highest sensitivity (87.50%) among all other predictors of difficult airway in this trial. The cut off values to predict a difficult airway for skin to hyoid bone in neutral and sniffing and skin to thyrohyoid membrane in neutral and sniffing were 0.66 and 0.77, 2.03 and 1.9 cm respectively.[5] The authors found that Mallampati score greater than 3 is the second most sensitive tool after ANS-VC, with a sensitivity of 74.15.[5] The *P* value of Mallampati score was 0.0051, while the *P* value of ANS-VC was 0.0001. There was a strong positive linear correlation observed between ANS-VC and a difficult airway, with the area under the curve (AUC) being 0.887.[5] The authors continue to state that Mallampati scoring is inadequate as a single test to predict DI, but when combined with ultrasound parameters it may increase the early detection of a potential DI.[5] Limitations include the skill and technique of the provider operating the ultrasound machine to delineate artifacts that may skew results, along with individual variability in the CL grading during direct laryngoscopy.

Reddy and colleagues also compared ultrasound measured anterior neck soft tissue thickness at the level of the hyoid bone and at the level of the vocal cords, and how these measurements would help in predicting a difficult intubation. The group found that several bedside physical airway assessments exams such as Mallampati and thyromental distance are fast and available, but have a high inter-observer variability, and may be difficult to apply in emergency and critical care settings where patients may be uncooperative or unable to follow directions.[12] It has been hypothesized and proven that increased anterior neck soft tissue thickness could potentially impair the forward motion of the pharyngeal structures, and therefore pose a threat to anesthesia providers in the operating room during direct laryngoscopy.[12] Reddy et al conducted a prospective observational study consisting of 100 patients undergoing elective surgery under general anesthesia requiring an endotracheal tube. Inclusion criteria included

patients above 18 years of age without any known unusual airway pathology. Exclusion criteria included patients requiring rapid sequence induction (RSI), patients with cervical spine pathology, patients scheduled for fiberoptic intubation, uncooperative patients, and pregnant patients.[12] First, all patients had a Mallampati scoring completed along with a measurement of thyromental distance. Then, ultrasound measurements were completed first with the patient in sniffing position using a SonoSite MicroMaxx linear array probe to measure the anterior neck soft tissue thickness at the level of the hyoid, and the vocal cords. After measurements were recorded, patients underwent standard induction and direct laryngoscopy was performed by an anesthesiologist with more than 10 years of experience. He was blinded to the preoperative airway assessment findings.

Results of the prospective observational study conducted by Reddy et al show that 39% of the patients were a Cormack-Lehane grade 1, and 47% of the patients were a Cormack-Lehane grade 2, classifying them as easy intubation. 14% of the patients examined were a Cormack-Lehane grade 3, classifying them as difficult intubation.[12] Reddy et al found that 13% of the study population, or 13 patients, required more than one attempt to successfully achieve endotracheal intubation, or required additional equipment such as the glidescope to achieve intubation.[12] Of the 13 patients, 46.2% or 6 patients had a measured ANS-VC greater than 0.23cm, 23.1% or 3 patients had a Mallampati class greater than III, and 15.3% or two patients had thyromental distance less than 6.5cm.[12] The team found that ANS-VC greater than 0.23 cm was associated with difficult intubation.[12] Mallampati score greater than III had a sensitivity of 71.6, while ANS-VC greater than 0.23cm had a sensitivity of 85.7%, indicating that this measurement is more sensitive in predicting DI when compared to traditional airway assessment exams.[12] Reddy et al found that ANS-hyoid was not a useful indicator of DI in the study

population. Limitations include a small sample size of only 100 patients of the same background which was Asian origin. The study had only 6 patients who were obese as defined by a BMI greater than 30 kg/m^2 which the team stated could have limited the results.[12]

Author(s) and Year	Research Design	Sample Size, Characteristics	Exclusion Criteria	Intervention(s)	Parameter(s) Measured via Ultrasound	Parameter(s) Measured via Traditional Method	Results
Agarwal et al (2021)	Prospective, observational, double-blinded cohort trial Level III	1,043 patients ages 18-60 years old, ASA I-III, requiring endotracheal intubation for general anesthesia.	Airway trauma, airway tumor, abnormal anatomical anomaly of the airway, history of difficult airway, or suspected difficult airway.	Anterior neck thickness from skin to hyoid bone and distance from skin to epiglottis were measured using a submandibular curvilinear ultrasound probe.	Anterior neck thickness from skin to hyoid bone, distance from skin to epiglottis.	Mallampati score	Anterior neck soft tissue thickness from skin to hyoid bone greater than 1.4 cm, and distance from skin to epiglottis greater than 2.4 cm predicted a difficult intubation. Higher number of patients with Mallampati score of 2 in the DI group indicating it is not accurate as a stand-alone test.

Abdelhady et al (2020)	Prospective, single blind, randomized clinical study Level III	80 patients total, ASA physical status I-III, ages 18 to 60 years old, undergoing endotracheal intubation for surgery that was indicated under general anesthesia with a body mass index (BMI) less than 40 kg/m^2	Patient refusal, patients who were unable to provide consent, patients with pre-existing airway malformations, cervical tumors or goiters, history of DI, pregnant patients, patients with tracheostomy tubes, and patients with maxillofacial abnormalities.	Measured ultrasonographic distance from skin to epiglottis (US-DSE) using a linear probe on patients in the supine position ensuring neutral head and neck position. The epiglottis was identified at the thyrohyoid membrane, and the posterior and anterior boarders were identified on ultrasound. The distance in centimeters was measured from the skin surface to the middle axis of the highest part of the epiglottis through the thyrohyoid membrane.	Ultrasound-measured distance from skin to epiglottis (DSE) at the level of the thyrohyoid membrane.	Mallampati score and thyromental distance.	US-DSE greater than 1.85 cm reliably predicts DI during preoperative assessment in patients without any unanticipated difficult airway. DSE was a better indicator in predicting DI compared to any of the pre-intubation screening tests such as Mallampati score and thyromental distance. Mallampati score had a *P* value of 0.044, while US-DSE had a *P* value of 0.002.

Adhikari et al (2011)	Prospective, observational, analytical study Level III	51 patients ages 19 years and older, undergoing elective surgery under general anesthesia requiring endotracheal intubation.	Patient with facial abnormalities such as facial fractures, maxillofacial abnormalities, tumors, and cervical spine fractures. Patients were also excluded if they have had a tracheostomy or were unable to provide written consent.	Ultrasound measured airway parameters were completed using a linear array transducer having the patient in a supine position with head and neck in a neutral position. The anterior neck soft tissue thickness was measured from the skin at five different levels in short axis view. At each level, three separate measurements including central axis, 10 mm to the left, and 10 mm to the right were obtained.[11] The three measurements were then	Ultrasound measured anterior neck soft tissue thickness at the hyoid bone and thyrohyoid membrane.	Mallampati score, thyromental distance, interincisor gap.	Ultrasound measured anterior neck soft tissue thickness was greater in the difficult laryngoscopy group in comparison to the easy laryngoscopy group at the level of the hyoid bone compared to the thyrohyoid membrane. The group found that anterior neck soft tissue thickness cutoff value of 2.8 cm measured at the thyrohyoid membrane can be used to detect difficult laryngoscopy better than

				averaged to find the soft tissue thickness.			Mallampati score of 3 or 4.
Yadav et al (2019)	Prospective, observational, analytical study Level III	Sample size of 200 patients ages 18 years and older requiring general anesthesia and endotracheal intubation scheduled for elective surgery.	Patients who required rapid sequence intubation (RSI), patients with abnormal cervical spine pathology, patients scheduled for fiberoptic intubation, uncooperative patients, and pregnant patients.	Airway assessment using ultrasound was conducted using a high frequency linear probe with the patient in sniffing position. The ANS tissue thickness was measured as the distance from the skin to the anterior part of the trachea at the hyoid level. ANS-VC was measured as the distance from skin to anterior commissure of true vocal cords.	Ultrasound measured anterior neck soft-tissue thickness at the level of the vocal cords (ANS-VC), ANS tissue thickness at the level of the hyoid (ANS-hyoid), and the ratio of depth of preepiglottis space to distance from epiglottis to midpoint of the distance between vocal cords (Pre-E/E-VC).	Mallampati scoring, thyromental distance (TMD), and hyomental distance ratio (HMDR).	Results indicate that ANS-VC as well as the ratio of PES/epiglottis to vocal cord (EVC) were significantly higher in the group of patients having difficult laryngoscopy. Yadav and colleagues concluded a cutoff value of ANS-VC greater than 0.23 was a predictor of difficult laryngoscopy. The ANS-VC had the highest sensitivity

							(87.50%) among all other predictors of difficult airway. The cut off values to predict a difficult airway for skin to hyoid bone in neutral and sniffing and skin to thyrohyoid membrane in neutral and sniffing were 0.66 and 0.77, 2.03 and 1.9 cm. The authors found that Mallampati score greater than 3 is the second most sensitive tool after ANS-VC, with a sensitivity of 74.15. The *P* value of

							Mallampati score was 0.0051, while the *P* value of ANS-VC was 0.0001. There was a strong positive linear correlation observed between ANS-VC and a difficult airway, with the area under the curve (AUC) being 0.887.
Reddy et al (2016)	Prospective, observational, analytical study Level III	100 patients, ages 18 and older without any known unusual airway pathology, undergoing elective surgery under general anesthesia requiring an endotracheal tube.	Patients requiring rapid sequence induction (RSI), patients with cervical spine pathology, patients scheduled for fiberoptic intubation, uncooperative patients, and	Ultrasound measurements were completed first with the patient in sniffing position using a SonoSite MicroMaxx linear array probe to measure the anterior neck soft tissue thickness at the	Ultrasound measured anterior neck soft tissue thickness at the level of the hyoid bone and at the level of the vocal cords.	Mallampati score and thyromental distance (TMD).	13% of the study population, or 13 patients, required more than one attempt to successfully achieve endotracheal intubation, or required additional equipment such as the

			pregnant patients.	level of the hyoid, and the vocal cords.			glidescope to achieve intubation. Of the 13 patients, 46.2% or 6 patients had a measured ANS-VC greater than 0.23cm, 23.1% or 3 patients had a Mallampati class greater than III, and 15.3% or two patients had thyromental distance less than 6.5cm. ANS-VC greater than 0.23 cm was associated with difficult intubation. Mallampati score greater than III had a sensitivity of 71.6, while ANS-VC greater than

							0.23cm had a sensitivity of 85.7%, indicating that this measurement is more sensitive in predicting DI when compared to traditional airway assessment exams.

Literature Review Discussion

After completing this literature review, the evidence demonstrates that ultrasound measured parameters are more accurate at predicting unexpected difficult airways in comparison to traditional airway assessment exams including Mallampati score and thyromental distance. Abdelhady et al, Adhikari et al, and Agarwal et al concluded through their prospective observational studies that ultrasound measured anterior neck soft tissue thickness at either the hyoid bone or the thyrohyoid membrane and found that both parameters were better at predicting difficult intubation compared to Mallampati score. Yadav et al and Reddy et al both concluded that ultrasound measured anterior neck soft tissue thickness at the level of the vocal cords was more sensitive at predicting difficult intubation when compared to Mallampati score and thyromental distance. All five studies produced level III evidence and were prospective, observational studies conducted within the last ten years. As ultrasound is becoming more prevalent throughout hospitals and surgery centers worldwide, the evidence is clear that traditional airway assessment exams are not as reliable at predicting unexpected difficult airways.

III. Definition of Terms

Difficult Intubation or Laryngoscopy

Difficult laryngoscopy or difficult intubation is classified as a poor view of the vocal cords and corresponds with a Cormack-Lehane (CL) classification grade 3 view where only the epiglottis is visible or grade 4 view where there is no view of the epiglottis.[2,20] A difficult intubation can also be classified as intubation with traditional laryngoscopy that requires more than two attempts, lasts more than 10 minutes, or requires an alternative technique for intubation.[2,20]

Preoperative

Preoperative refers to the period before a surgical procedure.

Airway Assessment

Airway assessments are completed in the preoperative period by anesthesia providers to assess the airway and predict an easy versus difficult intubation.[2]

Ultrasound

Ultrasound is a high-frequency, inaudible sound wave that penetrates different types of body tissues to different degrees.[17] The sound is reflected back to the ultrasound transducer and reproduced visually on a grayscale to produce optimal images.[19] In the real time mode, parts of the body under the transducer are displayed on the screen as they are being scanned.[17,19]

IV. Primary DNP Project Goal

The primary goal of the Doctor of Nursing Practice (DNP) project educational module is to increase anesthesia provider knowledge in airway ultrasound anatomy, skill, and predictive ability in detecting a difficult intubation by identifying specific parameters that correlate to easy versus difficult intubation. Standardizing the method in which providers classify airways preoperatively including point of care ultrasonography in real time in comparison to the traditional methods of airway assessment including Mallampati score, visual inspection, and thyromental distance could help decrease the incidence of unpredicted difficult intubations. Although Mallampati is one of the most commonly used clinical tools to predict a difficult laryngoscopy, the scoring is based on patient compliance and patient body position, which can significantly impact the accuracy of difficult airway prediction.[5]

Goals and Outcomes

SMART goals are specific, measurable, achievable, realistic, and timely.[22] A list of SMART objectives was identified to attempt to close to gap between the current preoperative airway assessments and the goals of the educational module. All the goals are specific to anesthesia providers, have realistic expectations, and will be measured in the posttest after completion of the educational module.

1. Increase anesthesia provider airway ultrasound anatomy knowledge after completion of the education module.
2. Increase anesthesia provider airway ultrasound skill after completion of the education module.
3. Increase anesthesia provider ability to differentiate easy versus difficult airway parameters with airway ultrasound after completion of the education module.
4. Increase anesthesia provider ability to predict a difficult intubation with airway ultrasound after completion of the education module.
5. Increase anesthesia provider perception and attitude toward utilization of preoperative airway ultrasound assessments as standard of care for preoperative airway assessment after completion of the education module.
6. Increase anesthesia provider willingness to utilize airway ultrasound in their preoperative assessments after completion of the education module.

V. Program Structure

The development of an educational module explaining the use of airway ultrasound in the preoperative setting compared to traditional methods of airway assessment currently being utilized will require a collaborative, multidisciplinary team effort. The educational module

presented to Florida International University (FIU) CRNA Alumni will consist of a pretest, PowerPoint presentation, and posttest. The principal investigator will develop the education module with guidance from the DNP scholarly advisor and clinical expert. Each FIU CRNA Alumni will take the pretest before viewing the PowerPoint presentation and complete a posttest after the presentation. A computer, tablet, or smartphone will be required to participate in the educational module. The presentation will include background information about ultrasonography, current standard of practice for preoperative airway assessments, and a tutorial on how to conduct an airway assessment. The module will then discuss different parameters that will help anesthesia providers detect a potential difficult airway. The posttest will evaluate the overall effectiveness of the PowerPoint presentation.

VI. SWOT

The strengths, weaknesses, opportunities, and threats (SWOT) analysis assessment tool will be used to evaluate the internal and external characteristics and threats to the educational module's development. A SWOT analysis is useful to generate material for the project leader to consider for solutions and direction for the project.[23] A SWOT assessment was completed at FIU Department of Nurse Anesthesiology regarding the FIU CRNA Alumni currently practicing throughout the country.

Strengths

Utilizing airway ultrasound in the preoperative period can aid clinicians in predicting a difficult intubation and assist anesthesia providers to prepare and utilize other airway options.

It is important for anesthesia providers to have a basic comprehension of ultrasound physics, how to select the proper transducer for the area of the body to be viewed, patient body habitus and how that may interfere with the image, probe orientation, and generalized understanding of basic airway anatomy.[19] An online educational module would ensure providers are well equipped to use the ultrasound to anticipate difficult airways in the clinical setting.

Model/simulation training has gained interest as an effective method for education in the medical field. Ramsingh and colleagues conducted a single-center, prospective, blinded trial consisting of twenty anesthesia residents of various years in training who underwent a training module using ultrasonography.[21] Residents were split into groups in which some received a 90-minute didactic lecture on the use of ultrasound, and the others received a 90-minute lecture in a simulation center that consisted of hands-on learning on mannequins. The study concluded that residents who received the more interactive type of training not only demonstrated improved image acquisition ability but also showed improved content retention as shown by the post-lecture model examination and multiple-choice examination.[21] This indicates that a hands-on training module provided to anesthesia providers will facilitate a greater depth of knowledge of airway ultrasound and encourage providers to make this practice a standard of care in operating rooms and outpatient centers across the country.

Ultrasonography has many benefits for use including reliability, portability, ability to be used at the bedside, radiation-free, cheap, fast, and accurate; it is therefore the best choice for airway assessment.[1] Ultrasonography is a fast, reliable, diagnostic tool used to assist anesthesia providers in assessing the airway and can help prevent intraoperative complications that follow a difficult intubation. Standardization of airway ultrasound in the preoperative setting in both

hospitals and outpatient surgical centers could lead to decreased incidence of unexpected and unanticipated difficult intubation.

Weaknesses

Weaknesses as defined by Zaccagnini and White are areas for improvement, and does the group have the resources to strengthen these areas that are identified as weak areas.[23] An internal problem that is identified, that is keeping with the literature, is inadequate preoperative airway assessment leading to unanticipated difficult intubations in the operating room. Failed and difficult tracheal intubation (DTI) is associated with hypertension as defined by a systolic blood pressure of 200 mmHg or greater, oxygen desaturation as defined by pulse oximeter less than 90%, damage to teeth, admission to the intensive care unit (ICU), and increased complications at extubation.[14] Difficult tracheal intubations are also associated with life threatening arrhythmias, bronchospasm, postoperative laryngospasm, airway trauma, anesthesia awareness, 'can't intubate can't ventilate' (CICV) scenarios, and hypoxia causing brain damage, cardiac arrest, and death. Dental injury is also more common in the airway management of difficult to intubate patients.[16] Currently, many providers are not using the ultrasound as standard of care for preoperative airway assessment.

Opportunities

The implementation of a standardized airway assessment conducted via ultrasound in the preoperative period provides opportunities for multiple disciplinaries to learn from this valuable tool. Providers in the emergency department and intensive care unit have adapted to using point of care ultrasound (POCUS) to complete an initial physical assessment on patients arriving to

the hospital secondary to trauma or illness. The educational module on airway ultrasonography as a means to predict and prevent unanticipated difficult intubation has the opportunity to be utilized in multiple settings and distributed to medical students, medical and surgical residents, physician assistants in the emergency room and intensive care unit, as well as physicians throughout the hospital.

The implementation of airway ultrasonography skills learned in the educational module can increase predictive ability of preoperative airway assessments**,** airway ultrasound skill, anatomy knowledge, and utilization of preoperative airway ultrasound assessments. An educational module on the importance of ultrasound for airway assessment compared to traditional methods of airway assessment can be nation-wide, and the practice change that could occur has the potential to positively impact many patients, as ultrasound has been proven to have a positive correlation to predicting difficult airways.

Threats

Threats include obstacles to the project, business, or organization.[23] Some potential threats to implementing airway ultrasound for preoperative assessment include provider preferences, disrupting workflow by adding a different assessment tool, negative feelings from anesthesia providers regarding ultrasonography, and lack of interest in practice change and adapting a new skill. An American Society of Anesthesiologists' Closed Claims Project (ASACCP) analysis of difficult airway management cases indicated that when a difficult tracheal intubation was anticipated, almost 70% of anesthesia providers continued with routine general anesthesia and paralysis, not adapting or changing their practice based on their assessment, and 60% progressed to a can't intubate can't ventilate scenario.[14] Poor outcomes

were significantly more common in these cases than in cases managed differently upon the assessment of a difficult airway.[14]

Since the implementation of a new preoperative airway assessment is dependent on anesthesia provider participation, surgeons and preoperative nurses must also feel that this type of assessment is necessary in order to encourage a new protocol that may be different from current preoperative management. Anesthesia providers must feel compelled to conduct an airway assessment with ultrasound to prevent unanticipated difficult intubation and inform patients and families in the preoperative period why this type of assessment is necessary. With an accurate and reliable airway assessment conducted using ultrasound, patients must be informed that this type of assessment will help prevent unanticipated difficult airways that could lead to hypoxia, brain injury, respiratory failure, and organ dysfunction.

VII. Theoretical Framework

The theoretical framework for this project is based on Parse's Human Becoming School Thought. Rosemarie Parse's theory views humans as unitary and the human-universe process as irreducible and dynamic. Health is an ever-changing state, based on human beings' choices, values, and priorities.[23] Providers operating within this theoretical framework use defined goals and treatment regimens to effect change within their work environment. The goal of this DNP project focusing on utilizing ultrasound compared to traditional methods of preoperative airway assessment is to highlight how providers can improve patient care and prevent injury in the operating room. Parse's philosophy stating that research and practice focus on the discerning patterns and improving quality of life, align with the mission statement of this project.[23] Interpersonal influences are social norms that can either help or hurt the uptake of a new project

or skill. Examples of interpersonal influences that may be present throughout the course of the DNP project include providers feelings regarding changing the traditional methods of airway assessment, staff resentment to having to learn a new skill, and time. At the end of the educational module, anesthesia providers will have a better grasp on how to incorporate more modern methods of airway assessment into current practice to promote translation of research into the clinical arena.

VIII. Methodology

Setting and Participants

This DNP project will take place virtually, with participants being any CRNA who is an alumni of the FIU CRNA Program based in Miami, FL.

Description of Approach and Project Procedures

The educational module will consist of a pretest, PowerPoint presentation, and posttest. Each FIU CRNA Alumni will take the pretest before the viewing the PowerPoint presentation and complete a posttest after the presentation. A computer, tablet, or smartphone will be required to participate in the educational module. The presentation will include background information about ultrasonography, preoperative airway assessments, and dangers of difficult intubations. The module will then demonstrate proper airway ultrasound technique, airway ultrasound anatomy, and parameters to differentiate easy versus difficult airways. Several images will be utilized to improve recognition of airway structures. The posttest will evaluate the overall effectiveness of the PowerPoint presentation.

Protection of Human Subjects

After the project is approved by the Institutional Review Board (IRB), all the CRNAs who are alumni of the FIU CRNA program will receive the educational module via email. Participation will be voluntary, and the participants can withdraw at any time. CRNAs that participate will benefit from learning a new skill, preoperative airway ultrasound assessment. There will be no risk to the participants.

Data Collection

The outcome variables will be the differences between pretest and posttest answers. Other collected data will include gender, age, and education background. The participants will also be asked to provide feedback regarding the ease of use of the educational module, attitudes about preoperative airway ultrasound, and willingness to incorporate it into practice.

Data Management and Analysis Plan

The data will be stored in a password protected database. The primary investigator and two DNP project supervisors will have access to the collected data. No identifiable data will be collected or stored. The mean score for each pretest answer will be compared to the mean posttest answer.

Future Implications

Standardization of preoperative airway assessment including the use of ultrasound has proven to reduce the amount of unanticipated difficult intubations encountered in the operating room. An educational intervention teaching anesthesia provider on how to conduct a thorough

airway assessment with ultrasound will benefit not only the patients undergoing general anesthesia for surgical procedures throughout the different operating room settings, but also limit the use of difficult airway supplies to those only found to have positive results on airway ultrasound. Anesthesia providers would be prepared for a difficult intubation prior to induction which would the staff to ensure access to the glidescope machine, fiberoptic bronchoscope, and adequate staff members available to assist with intubation. This DNP project will provide FIU CRNA alumni with the tools necessary to prevent unanticipated difficult intubations in the future and improve patient care.

IX. Results

Pre-Test Demographics

The pre-test demographics are shown in Table 1, shown below.

Table 1. *Pre-Test Participant Demographics*

Demographic	**n (%)**
Total Participants	3 (100.00%)
Age	
20-30	0 (0.00%)
31-40	1 (33.3%)
41-50	2 (66.66%)
51-60	0 (0.00%)
60+	0 (0.00%)
Gender	
Male	1 (33.33%)
Female	2 (66.66%)
Ethnicity	
African American	0 (0.00%)
Caucasian	0 (0.00%)

Asian	0 (0.00%)
Hispanic	3 (100.00%)
Other	0 (0.00%)

Medical Profession	
CRNA	3 (100.00%)
AA	0 (0.00%)
Anesthesiologist	0 (0.00%)
Other	0 (0.00%)

Highest Education	
Bachelor's degree	0 (0.00%)
Master's degree	0 (0.00%)
Doctoral Degree	3 (100.00%)
Other	0 (0.00%)
Bachelor's degree	0 (0.00%)

Experience	
1 to 2 years	1 (33.33%)
2 to 5 years	1 (33.33%)
5 to 10 years	0 (0.00%)
More than 10 years	1 (33.33%)

There were 3 participants in the pre-test demographics, and all completed the study. Most of the participants were female (n=2, 66.66%) compared to male (n=1, 33.33%). There was a limited range of ethnicities represented, as all three participants are Hispanic (n=3, 100%). All 3 participants are CRNAs with their doctorate degree. The participants were questioned about the length of time practicing. The practice period ranged 1 to 2 years (n=1, 33.33%), 2 to 5 years (n=1, 33.33%), and more than 10 years (n=1, 33.33%).

Pre-Test Difficult Airway Knowledge

Prior to the educational module, one participant (33.33%) knew that 30% of anesthesia-related deaths result from failures of airway management. Only one participant (33.33%) knew that 85% of anesthesia-related injuries result in death or brain damage. When asked which traditional method of airway assessment is based upon visualization of anatomical oropharyngeal

structures and relates them to a difficult intubation, two participants (66.66%) recognized this as the Mallampati scoring system. Only one participant (33.33%) knew that increased anterior neck soft tissue thickness impairs forward mobility of pharyngeal structures and can lead to a difficult laryngoscopy.

Pre-Test Airway Ultrasonography Knowledge

Prior to the educational module, two of the participants (66.66%) knew that ultrasonography is fairly easy to use and does not require ionizing radiation. Two thirds of the participants (66.66%) correctly selected a linear probe for vascular imaging, central line placement, and airway assessment. Before starting airway ultrasonography, two participants (66.66%) correctly would place their patient in the supine position. Only one participant (33.33%) chose to place their patient in lithotomy position. When starting airway ultrasound examination, majority of the participants (66.66%) correctly placed the probe above the sternal notch. Two participants (66.66%) determined that the tracheal rings appear hypoechoic in a linear formation on the ultrasound machine. When asked to select the inability to visualize which structure on ultrasound has a high sensitivity and specificity for difficult intubation, none of the participants (n=0, 0.00%) selected the hyoid bone as the correct answer. Most participants (n=2, 66.66%) incorrectly chose the tracheal rings as their answer. When asked to select two ultrasound parameters that have been linked directly to an increased incidence of difficult intubation, majority of the participants (66.66%) correctly chose anterior neck soft tissue thickness at the level of the vocal cords. Two thirds of the participants (66.66%) knew that on average it takes 10 minutes for a provider to obtain ultrasound measurements of the airway. Before the educational module, most participants (66.66%) selected that preoperative airway

ultrasonography can be used in many different settings including the endoscopy suite, main operating room, and cardiovascular suite.

Pre-Test Utilization of Airway Ultrasonography

Willingness to use airway ultrasonography in practice prior to the educational module was low. Two participants (66.66%) were neutral and one (33.33%) was somewhat likely to use airway ultrasonography in the preoperative setting to assess the airway as standard of care. When asked about participants attitude in utilizing ultrasound for airway assessment, two participants (66.66%) had a positive attitude, while only one participant (33.33%) remained neutral.

Post-Test Difficult Airway Knowledge

After the educational module, anesthesia provider knowledge on ultrasonography techniques and parameters to identify difficult airways improved. Most of the participants (n=2, 66.66%) knew that 30% of anesthesia-related deaths result from failures of airway management, and that 85% of anesthesia related injuries result in death or brain damage. After the presentation, most participants (n=2, 66.66%) knew that the Mallampati scoring system is a traditional method of airway assessment that is based upon visualization of anatomical oropharyngeal structures and relates them to a potential difficult intubation. After the educational intervention, all the participants (n=3, 100%) knew that increased anterior neck soft tissue thickness impairs forward mobility of pharyngeal structures and leads to difficult laryngoscopy. There was an improvement in knowledge on all questions. Table 2 shows the differences in responses from the pre- to post-test.

Table 2. *Difference in Pre- and Post-Test (Difficult Airway Knowledge)*

Question	**Correct in Pretest**	**Correct in Posttest**
What percentage of anesthesia-related deaths result from failures of airway management?	33.33%	66.66%

Eighty five percent of anesthesia related injuries result in:	33.33%	66.66%
Which traditional method of airway assessment is based upon visualization of anatomical oropharyngeal structures and relates them to a difficult intubation?	66.66%	66.66%
What factor impairs forward mobility of pharyngeal structures and leads to difficult laryngoscopy?	33.33%	100.00%

Post-Test Airway Ultrasonography Knowledge

Anesthesia provider knowledge on airway ultrasonography after the educational module improved knowledge. Most of the participants (n=2, 66.66%) knew that ultrasound is fairly easy to use and does not require ionizing radiation. Two participants (66.66%) correctly selected the linear probe to complete an airway assessment. All participants (n=3, 100%) placed their patient in supine position prior to starting airway ultrasonography. All of the participants (n=3, 100%) placed the ultrasound probe above the sternal notch prior to starting airway ultrasonography. After the educational module, all participants (n=3, 100%) knew that the tracheal rings appear hypoechoic in a linear formation on the ultrasound machine, and the inability to visualize the hyoid bone on ultrasound has high sensitivity and specificity for difficult intubation. Most participants (n=2, 66.66%) correctly selected the two parameters that have been linked directly to an increased incidence of difficult intubation, including distance from skin to epiglottis at the level of the hyoid bone, and anterior soft neck tissue thickness at the level of the vocal cords. All participants (n=3, 100%) knew that the average time it takes for a provider to obtain ultrasound measurements of the airway is 10 minutes. After the educational module, most participants (n=2,

66.66%) knew that preoperative airway ultrasonography can be used in most care areas including the endoscopy suite, the main operating room, and the cardiovascular suite.

Table 3. *Difference in Pre- and Post-Test (Airway Ultrasonography Knowledge)*

Question	**Correct in Pretest**	**Correct in Posttest**
Ultrasonography is fairly easy to use and requires ionizing radiation. True or false:	66.66%	66.66%
Of the three main ultrasound probes used in practice, which probe is ideal for vascular imaging, central line placement, and airway assessment?	66.66%	66.66%
Before starting airway ultrasonography examination, what position should the patient be in?	66.66%	100.00%
When beginning airway ultrasound examination, the ultrasound probe is placed on what anatomical structure?	66.66%	100.00%
After rotating the ultrasound probe 90 degrees at the level of the thyroid, the structures that appear hypoechoic in a linear formation are identified as what important structure?	66.66%	100.00%
The inability to visualize what anatomical structure on ultrasound has high sensitivity and specificity for difficult intubation?	0.00%	100.00%
Which two ultrasound measured parameters have been linked directly to an increased incidence of difficult intubation? (Select 2)	66.66%	66.66%
The average time it takes for a provider to obtain ultrasound measurements of the airway is approximately:	66.66%	100.00%
Preoperative airway ultrasonography can be used in what settings?	66.66%	66.66%

Post-Test Utilization of Airway Ultrasonography

Regarding willingness to use airway ultrasonography in practice after the educational module, one participant (33.33%) was neutral, and two participants (66.66%) were very likely to use airway ultrasonography as standard of care for preoperative airway assessment. When asked about participant attitude in utilizing ultrasound in the preoperative setting, two participants (66.66%) felt very positive towards using ultrasound, while one participant (33.33%) remained neutral. Table 4 shows the differences in responses from the pre- to post-test.

Table 4. *Difference in Pre- and Post-Test (Utilization of Airway Ultrasonography)*

Question	**Pretest**	**Posttest**
What is your attitude in utilizing airway ultrasound in the preoperative setting to assess the airway as standard of care?		
Very positive	0.00%	66.66%
Positive	66.66%	0.00%
Neutral	33.33%	0.00%
Negative	0.00%	33.33%
Very negative	0.00%	0.00%
How likely are you to utilize ultrasonography for airway assessment?		
Very likely	0.00%	66.66%
Somewhat likely	66.66%	0.00%
Neutral	33.33%	33.33%
Somewhat unlikely	0.00%	0.00%
Very unlikely	0.00%	0.00%

X. Discussion

Limitations

There were a few limitations to this project. For one, there was a small sample size. Sixty FIU CRNA alumni were invited to participate, but only three completed the educational module.

Reminder emails were sent at least once to every provider that did not response within a few weeks. Additionally, the delivery method was limited to two weeks since the project was asynchronous and done entirely online.

Conclusion

Overall, there was an increased number of correct responses in the posttest compared to the pretest. There was improvement in all the survey questions on airway ultrasound and identifying specific structures (100%) and remained the same on general ultrasound information (44.44%). There was also increased likeliness that the participants would utilize airway ultrasonography during preoperative airway assessments and to identify a potential difficult airway versus the current standard airway assessments including Mallampati score and thyromental distance.

Based on the results of this quality improvement project, an educational module on airway assessment utilizing ultrasound parameters compared to no ultrasound parameters increases knowledge in ultrasound airway anatomy, skill, and predictive ability in detecting a difficult versus easy intubation. This quality improvement project will impact how the participants practice anesthesia and the patients receiving care. Specifically, it will influence preoperative airway assessment strategies. The data showed that the educational module increased anesthesia providers' knowledge and attitude toward implementing ultrasonography into preoperative airway assessments. Future research is needed to increase the sample size and focus on the implementation of airway ultrasonography in the preoperative setting after the educational module is completed.

Appendix

Appendix A: IRB Exemption Approval

FIU | FLORIDA INTERNATIONAL UNIVERSITY

Office of Research Integrity
Research Compliance, MARC 414

MEMORANDUM

To:	Dr. Ann B. Miller
CC:	Allison Gold
From:	Elizabeth Juhasz, Ph.D., IRB Coordinator
Date:	April 6, 2022
Protocol Title:	**"An Educational Module for the Utilization of Airway Ultrasonography as a Standard of Care for Preoperative Airway Assessment: A Quality Improvement Project"**

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-22-0134	**IRB Exemption Date:**	04/06/22
TOPAZ Reference #:	111520		

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.
3) 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 B: Letter of Support

FIU Department of Nurse Anesthesiology

Nicole Wertheim College of Nursing & Health Sciences

February 2, 2022

Ann Miller DNP, CRNA, APRN Clinical
Associate Professor
Department of Nurse Anesthesiology
Florida International University

Dear Dr. Miller,

I thank you for inquiring about the use of the FIU DNAP alumni list for participation in the Doctor of Nursing Practice (DNP) project conducted by Allison Gold entitled "An Educational Module Explaining the Utilization of Airway Ultrasonography as Standard of Care for Preoperative Airway Assessment: A Quality Improvement Project" in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthetist Practice at Florida International University. I have granted Ms. Gold permission to conduct the project using our providers.

Evidence-based practice's primary aim is to yield the best outcomes for patients by selecting interventions supported by the evidence. This project intends to evaluate if a structured educational training (intervention/program) targeting anesthesia providers will increase knowledge on the use of airway ultrasound as a standard of care for preoperative airway assessment.

We understand that participation in the study is voluntary and carries no overt risk. All Alumni 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: Allison Gold and Dr. Miller.

Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. Allison Gold will behave professionally, follow standards of care. 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
Interim Chair, Department of Nurse Anesthesiology
Associate Professor

Appendix C: Pretest and Posttest Questionnaire

INTRODUCTION

The primary aim of this QI project is to improve the knowledge of CRNAs pertaining to the use of airway ultrasonography in the preoperative period to assist in predicting difficult intubation in order to improve patient outcomes in this population.

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 and perceptions on airway ultrasonography.

PERSONAL INFORMATION

1. **Gender:** Male Female Other_____
2. **Age:** _____
3. **Ethnicity:**

   Hispanic Caucasian African American Asian

   Other_____
4. **Position/Title:** _____
5. **Level of Education:** Associates Bachelors Masters DNP Other_____
6. How many years have you been an anesthesia provider?

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

QUESTIONNAIRE

1. **What percentage of anesthesia-related deaths result from failures of airway management?**
   a. 10%
   b. 30%
   c. 60%
   d. 90%
2. **Eighty five percent of anesthesia related injuries result in:**
   a. Nausea and vomiting
   b. Chipped or broken teeth

c. Cervical instability

d. Death or brain damage

3. **Which traditional method of airway assessment is based upon visualization of anatomical oropharyngeal structures and relates them to a difficult intubation?**

    a. Thyromental distance

    b. Neck circumference

    c. Mallampati Scoring System

    d. Tongue size

4. **What factor impairs forward mobility of pharyngeal structures and leads to difficult laryngoscopy?**

    a. Increased anterior neck soft tissue thickness

    b. Elongated epiglottis

    c. Narrow vocal cords

    d. Small thyromental distance

5. **Ultrasonography is fairly easy to use and requires ionizing radiation. True or False:**

    a. True

    b. False

6. **Of the three main ultrasound probes used in practice, which probe is ideal for vascular imaging, central line placement, and airway assessment?**

    a. Curvilinear

    b. Linear

    c. Phased array

7. **Before starting airway ultrasonography examination, what position should the patient be placed in?**
    a. Left lateral
    b. Trendelenburg
    c. Supine
    d. Lithotomy
8. **When beginning airway ultrasound examination, the ultrasound probe is placed on what anatomical structure?**
    a. Above the sternal notch
    b. Below the clavicle
    c. Above the sternocleidomastoid muscle
    d. Below the trapezius muscle
9. **After rotating the ultrasound probe 90 degrees at the level of the thyroid, the structures that appear hypoechoic in a linear formation are identified as what important structures?**
    a. Vocal cords
    b. Tracheal rings
    c. Thyroid cartilage
    d. Parathyroid gland
10. **The inability to visualize what anatomical structure on ultrasound has high sensitivity and specificity for difficult intubations?**
    a. Epiglottis
    b. Tracheal rings

c. Hyoid bone

d. Thyroid cartilage

11. Which two ultrasound measured parameters have been linked directly to an increased incidence of difficult intubation? (Select 2)

a. Distance from skin to epiglottis at the level of the hyoid bone

b. Vocal cord thickness bilaterally

c. Distance between tracheal rings

d. Anterior soft neck tissue thickness at the level of the vocal cords

12. The average time it takes for a provider to obtain ultrasound measurements of the airway is approximately:

a. 5 minutes

b. 10 minutes

c. 15 minutes

d. 30 minutes

13. Preoperative airway ultrasonography can be used in what settings?

a. Endoscopy suite

b. Main operating room

c. Cardiovascular suite

d. All of the above

14. What is your attitude in utilizing ultrasound in the preoperative setting to assess the airway as standard of care?

a. Very positive

b. Positive

c. Neutral

d. Negative

e. Very negative

15. How likely are you to utilize ultrasonography for airway assessment?

a. Very likely

b. Somewhat likely

c. Neutral

d. Somewhat unlikely

e. Very unlikely

Appendix D: Educational Module

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