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# A Quality Improvement Project on the Utilization of Preoperative Airway Ultrasonography to Predict Difficult Intubations

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# A Quality Improvement Project on the Utilization of Preoperative Airway Ultrasonography to Predict Difficult Intubations

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## Abstract

Common preoperative airway assessments have low sensitivities and specificities for predicting difficult intubations.[1] Computed tomography (CT), magnetic resonance imaging (MRI), X-ray, and ultrasonography or ultrasound exams reliably display upper airway anatomy and can be used to assess difficult airways.[2] Ultrasonography is most favorable because it is easy to use, low cost, does not require ionizing radiation, and provides real-time observation of the upper airway.[2] Despite empirical evidence for the use of preoperative airway ultrasound assessment to predict a difficult versus easy intubation, there is an evidence-to-practice gap. 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 four 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 Ultrasonography, Difficult Intubation, Preoperative Airway Assessment

# A Quality Improvement Project on the Utilization of Preoperative Airway Ultrasonography to Predict Difficult Intubations

## I. Introduction

### Background and Problem Identification

Airway management is a vital skill to keep patients safe in the perioperative period. A secure airway allows providers to adequately oxygenate and ventilate the patient.[3] Patients who are difficult to intubate challenge all anesthesia providers, including certified registered nurse anesthetists (CRNAs), student registered nurse anesthetists (SRNAs), and anesthesiologists. Airway assessments are completed in the preoperative period by anesthesia providers to assess the airway and predict an easy versus difficult intubation.[4]

In the United States, there is no national standard for preoperative airway assessment.[5] Preoperative airway assessments vary depending on the anesthesia provider and institution.[5] Common preoperative airway assessments, such as the modified Mallampati score (MMP), thyromental distance (TMD), interincisor distance, and body mass index (BMI), have low sensitivities and specificities for predicting difficult intubations, especially when only one assessment tool is used.[1] Only one in four patients who is identified to have a difficult airway with the common assessments is found to be difficult to intubate upon direct laryngoscopy (DL).[5] Additionally, 93% of difficult intubations are unanticipated.[5] 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.[6,7,8,9] 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.[4,10]

Computed tomography (CT), magnetic resonance imaging (MRI), X-ray, and ultrasonography or ultrasound exams reliably display upper airway anatomy and can be used to assess difficult airways.[2] Ultrasound, X-ray, and CT have similar diagnosing abilities and are more efficacious than the traditional assessment of MMP score.[2] Ultrasonography is more favorable because it is easy to use, low cost, does not require ionizing radiation, and provides real-time observation of the upper airway.[2] Preoperative airway ultrasound assessments are able to adequately predict difficult intubations.[11] Ultrasound measurements do not correlate with common airway assessments, including the MMP score, TMD, and interincisor distance, highlighting the limitation of the traditional airway assessments.[11]

**Scope of the Problem**

Over 14.4 million operating room procedures were completed in the United States in 2018.[12] Patients require intubation during the perioperative period for a variety of reasons, including patient comorbidities, patient condition, surgical procedure, and anesthetic depth requiring airway management. A responsibility of anesthesia providers is to secure and maintain patients' airways. When an anesthesia provider anticipates a difficult intubation, more equipment and resources are utilized, such as a Glidescope or flexible fiberoptic bronchoscope. A prospective study completed on 499 patients in 2019 found that 9.4% of patients undergoing elective procedures were difficult to intubate.[9] Current preoperative airway assessment tools, including the MMP score, TMD, interincisor distance, and BMI, are limited and inconsistent in distinguishing between easy and difficult intubations.[2] This affects all anesthesia providers who work in procedural or surgical areas and utilize common preoperative airway assessment tools to predict an easy versus difficult intubation.

**Consequences of the Problem**

Poor airway management can lead to devastating consequences for the patients and anesthesia providers involved.[3] Preoperative airway planning, including appropriate equipment specific to each patient based on the preoperative airway assessment, is important to decrease the risks associated with management of a difficult airway.[2] The failure to recognize a patient has a difficult airway can lead to increased morbidity and mortality.[2] Additional equipment will likely not be easily accessible at the bedside due to lack of provider prediction of and preparation for a difficult airway. Patients may be subject to inadequate ventilation and esophageal intubation if a difficult airway is not recognized before DL.[3] Failure to secure a patient's airway and provide adequate oxygenation and ventilation can be life threatening, even if it is for a short amount of time.[3] Patients with unanticipated difficult airways are at a higher risk for brain damage and death.[2] Other consequences of difficult airways include airway injury, aspiration, hypoxia, ventilation failure, bronchoconstriction, and arrhythmia.[2] Difficult and failed intubations are major contributors to liability for anesthesia providers.[13]

**Knowledge Gaps**

Ultrasonography of the airway is an effective tool to predict difficult intubations.[3] It is noninvasive, safe, and well tolerated by patients.[3] Ultrasound is a high-frequency, inaudible sound wave that penetrates different types of body tissues to different degrees.[3] The sound is reflected back to the ultrasound transducer and reproduced visually on a grayscale to produce optimal images.[3] In the real time mode, parts of the body under the transducer are displayed on the screen as they are being scanned.[3] An airway ultrasound assessment can be completed by placing the ultrasound probe under the floor of the mouth.[14] A sagittal view of the oropharyngeal and laryngeal structures, including the tongue and hyoid bone can be seen.[14] However, caudal

displacement of the larynx may obstruct the view of the hyoid bone.[14] Airway ultrasound exams can also identify structures including the epiglottis, vocal cords, tongue base, cricothyroid membrane, and thyrohyoid and hyomental distances.[3] Measurements can then be taken of appropriate airway structures.

There are several ultrasound findings that predict a patient is difficult to intubate. The inability to visualize the hyoid bone on ultrasound has high sensitivity and specificity for difficult intubations.[4] Thicker tongues and larger tongue thickness to thyromental distance ratios predict difficult intubations.[10] In a prospective, observational, double-blinded cohort trial completed on 1,043 surgical patients, the tongue thickness, invisibility of hyoid bone, and anterior neck soft tissue thickness from the skin to thyrohyoid membrane and hyoid bone were measured with ultrasound.[4] Anterior neck soft tissue thickness from skin to epiglottis (DSE) was the most accurate in predicting a difficult airway.[4] However, all parameters were statistically significant between the easy to intubate and difficult to intubate groups.[4] A tongue thickness greater than 5.8 cm, anterior neck soft tissue thickness from the skin to hyoid bone greater than 1.4 cm, and DSE at the thyrohyoid membrane greater than 2.4 cm were the cut off measurements for predicting a difficult intubation.[4] Petrisor and colleagues (2018) completed a diagnostic pilot study on 25 morbidly obese patients. Preoperative airway ultrasound was utilized to measure the hyomental distance, or distance between the hyoid bone and tip of the chin, in the neutral, ramped, and maximally hyperextended positions.[6] The maximally hyperextended to neutral hyomental distance ratio was found to be the most predictive measurement for a difficult airway in obese patients.[6] However, there was also a significant difference in the hyomental distance in

the ramped and maximally hyperextended positions and the ramped to neutral ratio between the easy intubation and difficult intubation groups.[6]

**Proposal Solution**

Despite empirical evidence for the use of preoperative airway ultrasound assessment to predict a difficult versus easy intubation, there is an evidence-to-practice gap. 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. Thirty-two medical residents participated in a point of care ultrasound course to learn indications for ultrasound, how to use ultrasound, interpretation of images, and diagnosis based on ultrasound findings.[15] The course utilized a pretest, didactic portion, hands-on course work, image review, and posttest.[15] After completion of the course, the residents had significantly increased knowledge scores and performed well in practical scenarios to assess image acquisition, interpretation, and integration into medical decision making.[15] A learning module to educate anesthesia providers on the use of ultrasound for preoperative airway assessment can be modeled after this ultrasound course. The quality improvement project will instruct anesthesia providers to identify airway landmarks, such as the hyoid bone, measure tongue thickness, anterior neck thickness, and hyomental distance. By the end of module, anesthesia providers will have the ultrasound skills necessary to identify and measure airway anatomy and integrate the findings to predict easy versus difficult intubations.

# II. Literature Review

## Literature Review Methodology

### Eligibility Criteria

This literature review was completed to identify the airway ultrasound parameters that differentiate a difficult from an easy intubation. Studies were included if they met inclusion criteria. Peer-reviewed primary research studies completed on adult humans 18 years of age or older in the last five years were included to address the practice question. Only studies completed preoperatively on patients requiring general surgery were included. Studies were excluded if they were duplicated in different databases, opinions, editorials, completed on children, more than five years old, or did not compare easy and difficult intubation patient groups. For the purposes of this appraisal, only primary research studies were included, and literature reviews, systematic reviews, and meta-analysis studies were excluded.

### Information Sources and Search Strategy

To complete the literature search, Cumulative Index to Nursing & Allied Health Literature (CINAHL) database and PubMed were systematically searched via Florida International University library services. Key words and phrases used in the searches include "airway ultrasonography," "airway ultrasound," "difficult airway," "difficult intubation," "difficult laryngoscopy," "preoperative," and "preoperative airway assessment." The Boolean search mode was utilized to expand the results by combining more than one phrase such as "airway ultrasound AND difficult airway" and "airway ultrasonography OR ultrasound." The initial search resulted in 298 studies. CINAHL produced 80 studies while PubMed provided 218. After removing duplicates, studies were excluded if the titles and abstracts did not meet inclusion criteria. For example, studies were excluded if they did not compare difficult to easy intubations

utilizing airway ultrasound parameters, were completed before 2016, or not primary research studies. The comprehensive search resulted in eight studies that followed the inclusion and exclusion criteria and were included in this literature review.

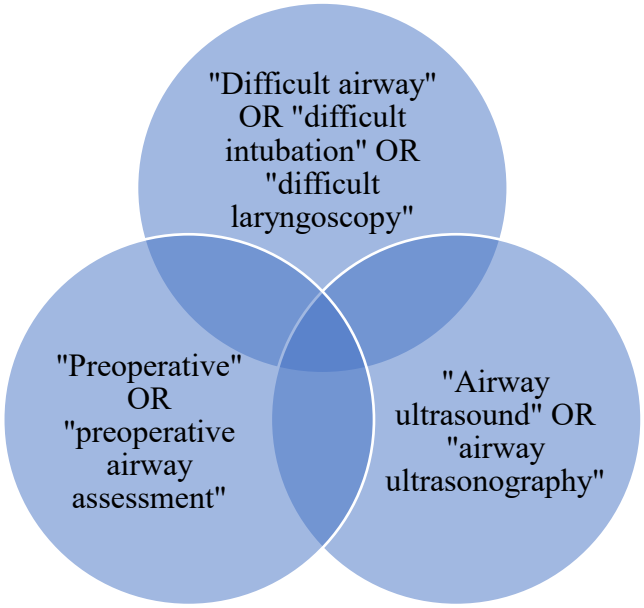


Diagram 1. Search Keywords and Phrases

**Literature Review Results**

Study Characteristics

All eight studies included in this literature review are prospective observational studies. Each study compared preoperative airway ultrasound parameters of adult patients requiring general anesthesia who were difficult and easy to intubate. Among the studies, five different airway ultrasound parameters were evaluated, including visibility of the hyoid bone, tongue thickness, hyomental distance, angle between the glottis and epiglottis, and anterior neck thickness. Agarwal and colleagues focused on the visibility of the hyoid bone, tongue thickness, and anterior neck thickness.[4] Yao and Wang evaluated tongue thickness.[10] Yadav and authors also evaluated tongue thickness in addition to anterior neck thickness.[7] Falcetta et al[1] and Pinto et al both focused primarily on anterior neck thickness.[8] Petrisor et al evaluated the hyomental

distance. [6] Abraham et al measured several airway parameters, such as the hyoid bone, thyrohyoid distance, hyomental distance, distance from base of tongue to hyoid bone, thickness of submental region, distance from epiglottis to hyoid bone, and vocal cords.[3] Wang et al measured the angle between the glottis and epiglottis.[9]

Individual Study Results

In 2021, Agarwal and colleagues completed a prospective, observational, double-blinded cohort trial on 1,043 patients. All of the patients were between the ages of 18-60, classified as American Society of Anesthesiologists (ASA) physical status I–III, and required intubation for general anesthesia.[4] Patients were excluded if they had an airway anatomical anomaly, trauma, tumor, history of difficult airway, or suspected difficult airway.[4] A patient was identified to have a suspected difficult airway if they had a modified MMP score of 3 or 4, TMD less than 6.5 cm, or interincisor distance less than 3 cm.[4] The patients' tongue thickness, visibility of hyoid bone, and anterior neck soft tissue thickness from the skin to thyrohyoid membrane and hyoid bone were assessed with airway ultrasound preoperatively.[4] A curved ultrasound probe was inserted under the patient's tongue intra-orally to assess for the hyoid bone.[4] The tongue thickness, anterior neck thickness from skin to hyoid bone, and DSE at the thyrohyoid membrane were measured with the patient supine and the neck extended using a submandibular curvilinear ultrasound probe.[4] After induction, an experienced investigator with at least five years of experience intubating who was blinded to the preoperative assessment performed DL and classified the patient as difficult or easy to intubate.[4] A patient was classified as difficult to intubate if conventional laryngoscopy required more than two attempts, lasted more than 10 minutes, or required an alternative technique for intubation.[4] Time was measured from the first laryngoscopy attempt to confirmation of intubation with a capnography waveform.[4] The study

resulted in 985 patients classified as easy to intubate with CL grade views of 1 or 2, and 58 were difficult to intubate with CL grade views of 2, 3, or 4.[4] All four of the measurements had statistically significant differences between the easy and difficult intubation groups.[4] A tongue thickness greater than 5.8 cm, anterior neck soft tissue thickness from the skin to hyoid bone greater than 1.4 cm, and DSE at the thyrohyoid membrane greater than 2.4 cm were the cut off measurements for predicting a difficult intubation.[4] Invisibility of the hyoid bone correlated with a difficult intubation.[4] Skin to hyoid bone distance was the most accurate, but individual parameters had limited validity.[4] A model that combined all four parameters was the best at diagnosing difficult intubations.[4] Study limitations include lack of account for functional components of airway ultrasound such as head position and degree of neck extension.[4] The authors recommend that future studies focus on designing a scoring system based on ultrasound parameters to predict difficult airways.[4]

In 2019, Yadav et al completed an observational analytical study on 310 adult surgical patients using ultrasound to measure tongue thickness and skin to hyoid bone and thyrohyoid membrane distances.[7] The patients were between the ages of 18 and 70, had an ASA physical status of I or II, and were scheduled for an elective procedure that required general anesthesia with tracheal intubation.[7] Patients were excluded if they had facial fractures, cervical spine instability, poor submandibular space compliance, or required rapid sequence intubation (RSI).[7] During the preoperative assessment at the bedside, clinical tests were recorded, including the MMP, TMD, sternomental distance, and interincisor gap.[7] The patient was then positioned supine with the head and neck in a neutral position, and a linear high-frequency ultrasound probe was used to measure the distance from the skin to hyoid bone and skin to thyrohyoid membrane.[7] The thyrohyoid membrane was measured at the anterior border of the epiglottis midway between

hyoid and thyroid cartilage, classifying it as DSE.[7] A curvilinear probe was used to measure tongue thickness.[7] Both anterior neck thickness measurements were then taken with the patient in the sniffing position.[7] After induction, an anesthesiologist blinded to the preoperative airway assessment results performed DL.[7] A CL grade 1 or 2 was classified as an easy laryngoscopy, while a grade view of 3 or 4 was classified as a difficult laryngoscopy.[7] The authors found that the tongue thickness and anterior neck thickness, measured as skin to hyoid bone distance and DSE in a neutral and sniffing position, were significantly larger in the difficult intubation group.[7] The cut off values to predict a difficult airway for skin to hyoid bone in neutral and sniffing and DSE in neutral and sniffing were 0.66 cm and 0.77 cm, 2.03 cm and 1.9 cm respectively.[7] The median tongue thickness in the difficult laryngoscopy group was 6.1 cm.[7] Additionally the airway ultrasound measurements were more sensitive and specific to detecting a difficult intubation than the bedside clinical tests.[7] The study limitations include all of the patients were from southern India so the results can't be generalized to other populations, the experience of the anesthesia provider performing the DL impacts the CL view obtained, and the amount of pressure on the ultrasound probe can alter the measurements.[7] The cut off measurements differ from those found by Agarwal et al.[4] This discrepancy can be attributed to the limitations of both studies, specifically difference in provider technique and experience and patient population. Yadav et al recommend that the ultrasound measurements included in this study be used in combination with other bedside clinical tests to best predict difficult laryngoscopy.[7] Additionally, they did not include obese or pregnant patients who are increased risk for difficult intubations so recommend that future studies focus on these populations.[7]

Yao and Wang completed a prospective observational study in 2017 on 2,254 patients requiring tracheal intubation for general anesthesia. All patients included were between the ages

of 18 and 90 with no previous difficult intubations, had an ASA physical status of I-III, and did not have subglottic stenosis or airway anatomical deformity, trauma, or tumor.[10] Preoperatively, a low-frequency convex array probe was placed in the median sagittal plane under the chin with the patient supine and neck extended.[10] The tongue thickness was measured at the maximal vertical dimension of the tongue surface to the submental skin.[10] In addition to the airway ultrasound, the MMP, TMD, and interincisor distance was recorded for all patients.[10] After induction, an anesthesiologist blinded to the preoperative airway assessments with at least five years of experience performed the DL.[10] Similar to the study completed by Agarwal et al in 2021, a difficult intubation was classified as insertion of the endotracheal tube using conventional laryngoscopy that required more than two attempts, lasted over 10 min, or required an alternative technique.[10] Tongue thickness greater than 6.1 cm correlated with an increased incidence of difficult intubation.[10] This result is similar to the findings from both the study completed by Yadav et al that found the mean tongue thickness was 6.1 cm in the difficult to intubate group[7] and the one by Agarwal et al that found tongue thickness greater than 5.8 cm correlated with difficult intubations.[4] Some of the limitations to Yao and Wang's study include participants only of Han Chinese patients, inability to randomly select patients, an no use of a validity study, such as MRI or CT.[10] The authors recommend that preoperative tongue ultrasound measurement be used as an independent predictor for difficult intubations and because it does not require patients to perform a task, airway ultrasound can be easily used on unconscious patients.[10]

In 2018, Falcetta et al completed a prospective observation single-blinded study that analyzed the correlation between ultrasound anterior cervical soft tissue thickness and CL grade view on DL. Patients with a CL grade view of 1 or 2a were identified as easy intubations, and

those with a grade view between 2b and 4 were identified as difficult.[1] Three hundred and one patients 18 years of age or older scheduled for an elective surgery requiring general anesthesia and tracheal intubation were included.[1] Patients were excluded if they required RSI, were pregnant, or had a previous difficult intubation, limited cervical spine mobility, interincisor distance less than 3 cm, TMD less than 6 cm, or maxillofacial anomalies.[1] A linear ultrasound probe in transverse plane was used with the patient supine and head in neutral position to measure anterior cervical soft tissue thickness at two levels, the thyrohyoid membrane (pre-epiglottic space) and the vocal cords (laryngeal inlet).[1] Median DSE greater than 2.54 cm and pre-epiglottic area greater than 5.04 $cm^2$ at the thyrohyoid membrane highly correlated to a difficult intubation.[1] There was no correlation between difficult intubations and anterior neck thickness at the level of the vocal cord.[1] Selection bias was created by excluding patients who were considered difficult intubations based on clinical predictability.[1] The authors recommend future studies to evaluate patients who are predicted to be a difficult intubation based on clinical factors and use multivariate statistical analysis to compare ultrasound measurements with standard clinical screening tests of a difficult airway.[1]

Pinto and colleagues completed a prospective double-blinded study to evaluate the predictive ability of DSE for difficult intubations.[8] The authors included 74 adult patients who required endotracheal intubation for a scheduled procedure.[8] All of the participants had an ASA class of I-III and were excluded if they were pregnant, morbidly obese, or had a tracheostomy, facial or cervical fractures, cervical tumors, or maxillofacial abnormalities.[8] Preoperatively, the authors recorded the MMP, interincisor distance, TMD, and neck circumference of the participants.[8] Similar to Falcetta et al,[1] Yadav et al,[7] and Agarwal et al,[4] Pinto and colleagues used ultrasonography to measure the DSE at the thyrohyoid membrane.[8] Patients were placed

supine with their head and neck in a neutral position.[8] A linear ultrasound probe was placed in the transverse position to measure the DSE.[8] After induction, patients were classified as a difficult or easy laryngoscopy based on their CL grade; a CL grade view of 1 or 2 was assigned to the easy intubation group, and a grade view of 3 or 4 was difficult.[8] Pinto et al found that a DSE of 2.75 cm or greater predicts a difficult airway.[8] Falcetta et al had a similar conclusion, stating that DSE greater than 2.54 cm correlated with a difficult intubation.[1] Agarwal and authors found that the DSE at the thyrohyoid membrane greater than 2.4 cm correlated with a difficult intubation.[4] Yadav and colleagues also measured this airway parameter and found an even smaller cutoff value.[7] DSE greater than 2.03 cm in the neutral position or greater than 1.9 cm in the sniffing position predicted a difficult intubation.[7] Additionally, Pinto and authors found that DSE combined with the MMP score improves the predictive power of current preoperative airway assessments.[8] The study limitations include all data was collected in one hospital and morbidly obese and pregnant patients were excluded.[8] The authors recommend ultrasound DSE be used to predict difficult intubations and state the incorporation of MMP and DSE into a decision tree algorithm is useful.[8]

In 2018 Petrisor et al completed a diagnostic accuracy study on 25 morbidly obese patients to determine the predictive ability of preoperative airway ultrasound. The patients included in the study had BMI greater than 40, needed to be intubated for general surgery, and did not have a planned RSI or videolaryngoscope intubation.[6] Preoperatively, a curvilinear ultrasound transducer was used in the midsagittal longitudinal position to measure the hyomental distance in the neutral, ramped, and maximum hyperextended positions.[6] Induction was performed with the patient in the ramped position, and an experienced anesthesiologist with between 7 and 30 years of experienced performed the direct laryngoscopy.[6] Similar to Pinto et

al[8] and Yadav et al[7] the patients were categorized into two groups, those with grade views of 1 or 2 and those with a grade view of 3 or 4, the easy and difficult airway groups respectively.[6] The maximally hyperextended to neutral hyomental distance ratio less than or equal to 1.23 was found to be the most predictive measurement for a difficult airway in obese patients.[6] There was also a significant difference in the hyomental distance in the ramped and maximally hyperextended positions and the ramped to neutral ratio between the easy and difficult intubation groups with cut off values less than or equal to 4.97 cm, 5.5 cm, and 1.12 respectively.[6] There was no difference found in the neutral position.[6] The authors recommend using the maximum hyperextended to neutral position ratio to predict a difficult direct laryngoscopy in obese patients.[6] This study addresses the recommendations and limitations of several of the studies included in this literature review by solely assessing the use of preoperative airway ultrasound assessments in morbidly obese patients to predict difficult intubations.[6]

Abraham et al completed a prospective clinical study on 137 patients scheduled for surgery requiring general anesthesia and endotracheal intubation.[3] Before induction, the patients were positioned supine with the head in a neutral position.[3] A radiologist used a curved array ultrasound probe to measure several airway parameters, such as the hyoid bone, thyrohyoid distance, hyomental distance, distance from base of tongue to hyoid bone, thickness of submental region, distance from epiglottis to hyoid bone, and vocal cords.[3] An anesthesiologist with more than 15 years of experience performed induction and DL and then placed each patient in the difficult or easy laryngoscopy groups.[3] Patients with CL grade view of 2-4 were classified as difficult to intubate.[3] Unlike most other studies included in this literature review that used the CL grade view to distinguish easy from difficult airways, Abraham et al included a grade view of 2 in the difficult group.[3] Falcetta et al included grade 2b in the difficult group but 2a in the easy

group.[1] Some of the patients in the difficult airway group had bilateral temporomandibular joint ankylosis, obstructive sleep apnea syndrome, carcinoma of the tongue, post-reconstruction of mandibular defect following resection, bilateral condylar fracture, or zygomatic maxillary complex fracture.[3] Abraham and authors concluded that a hyomental distance 1.09 cm or less predicts a difficult intubation.[3] Petrisor et al did not find a significant difference in the hyomental distance in the neutral position, however that study was performed only on morbidly obese patients.[6] Abraham and authors did not specify if or how many obese and morbidly obese patients were included in their conclusions.[3] Additionally, there were no significant differences in age, submental thickness, epiglottis to hyoid bone distance, skin pad thickness to thyroid cartilage, or thyrohyoid distance between the difficult and easy to intubate groups.[3]

Wang et al completed a prospective, self-controlled, assessor blinded, observational study utilizing preoperative airway ultrasound assessments on 499 patients undergoing general anesthesia for elective procedures that required endotracheal intubation.[9] Patients were excluded if they had maxillofacial deformities or fractures, limited mouth opening, restricted neck movement, or loose teeth.[9] Preoperatively, a linear array probe was used to identify and measure airway structures with the patient supine, the head elevated 10 cm on a soft pillow, and the neck extended to mimic the body position during intubation.[9] One anesthesiologist measured tongue base thickness and width, the angle between the epiglottis and glottis, the thyrohyoid membrane, and lateral pharyngeal wall thickness.[9] The angle between the epiglottis and glottis was measured between the long axis of epiglottis and the vertical line through the anterior commissure of the glottis.[9] After DL performed by another anesthesiologist, the CL grade view was recorded.[9] Similar to Pinto et al,[8] Petrisor et al,[6] and Yadav et al,[7] a grade 3 and 4 was classified as a difficult airway.[9] An angle between the epiglottis and glottis less than 50 degrees was predictive

of a difficult airway.[9] This was the only independent variable measured that had a statistically significant difference between the easy and difficult groups.[9] The authors noted that tongue base and lateral pharyngeal wall thickness do not correlate with a difficult intubation but may be related to difficult mask ventilation, however further research is needed.[9]

| Author(s) and Year | Research Design | Sample Size, Characteristics | Exclusion Criteria | Intervention(s) | Parameter(s) | Difficult Airway Classification | Results |
|---|---|---|---|---|---|---|---|
| **Agarwal et al (2021)** | Prospective, observational, double-blinded cohort trial<br><br>Level III | 1,043 patients 18-60 years old, ASA I–III, requiring intubation for general anesthesia | Airway anatomical anomaly, trauma, tumor, history of difficult airway, or suspected difficult airway. | A curved ultrasound probe was inserted under the patient's tongue intra-orally to assess for the hyoid bone. The tongue thickness and anterior neck thickness from skin to hyoid bone and DSE were measured using a submandibular curvilinear ultrasound probe. | Invisibility of hyoid bone<br><br>Tongue thickness<br><br>Anterior neck thickness (skin to hyoid bone and DSE) | More than two attempts, lasted more than 10 minutes, or required an alternative technique for intubation | A tongue thickness > 5.8 cm, anterior neck soft tissue thickness from the skin to hyoid bone > 1.4 cm, and DSE > 2.4 cm predicted a difficult intubation. Invisibility of the hyoid bone correlated with a difficult intubation. Skin to hyoid bone distance was the most accurate. A model that combined all four parameters was the best at diagnosing difficult intubations. |
| **Yadav et al (2019)** | Prospective, observational, analytical study<br><br>Level III | 310 patients 18-70 years old, ASA I or II, scheduled for an elective procedure that required intubation for general anesthesia | Facial fractures, cervical spine instability, poor submandibular space compliance, or required RSI | A linear high-frequency ultrasound probe was used to measure the distance from the skin to hyoid bone and DSE. A curvilinear probe was used to measure tongue thickness. Both anterior neck thickness measurements were then taken with the patient supine/head neutral and in the sniffing position. | Tongue thickness<br><br>Anterior neck thickness (skin to hyoid bone and DSE) | CL grade view 3-4 | The cut off values to predict a difficult airway for skin to hyoid bone in neutral and sniffing and DSE in neutral and sniffing were 0.66 cm and 0.77cm, 2.03 cm, and 1.9 cm respectively. The median tongue thickness in the difficult laryngoscopy group was 6.1 cm. |

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| **Yao and Wang (2017)** | Prospective observational study<br><br>Level III | 2,254 patients 18-90 years old, ASA I-III, requiring tracheal intubation for general anesthesia | Previous difficult intubations, subglottic stenosis, or airway anatomical deformity, trauma, or tumor. | A low-frequency convex array probe was placed in the median sagittal plane under the chin with the patient supine and neck extended. The tongue thickness was measured at the maximal vertical dimension of the tongue surface to the submental skin. | Tongue thickness | More than two attempts, lasted more than 10 minutes, or required an alternative technique for intubation | Tongue thickness > 6.1 cm correlated with an increased incidence of difficult intubation. Preoperative tongue ultrasound measurement can be used as an independent predictor for difficult intubations. |
| **Falcetta et al (2018)** | Prospective observation single-blinded study<br><br>Level III | 301 patients ≥18 years old scheduled for an elective surgery requiring general anesthesia and tracheal intubation | Required RSI, pregnant, previous difficult intubation, limited cervical spine mobility, interincisor distance < 3 cm, TMD< 6 cm, or maxillofacial anomalies. | A linear ultrasound probe in transverse plane was used with the patient supine and head in neutral position to measure anterior cervical soft tissue thickness at two levels, the thyrohyoid membrane (pre-epiglottic space) and the vocal cords (laryngeal inlet). | Anterior neck thickness (DSE and pre-epiglottic area) | CL grade view between 2b and 4 | Median DSE > 2.54 cm and pre-epiglottic area > 5.04 $cm^2$ at the thyrohyoid membrane highly correlated to a difficult intubation. There was no correlation between difficult intubations and anterior neck thickness at the level of the vocal cord. |
| **Pinto et al (2016)** | Prospective double-blinded study<br><br>Level III | 74 adult patients who required endotracheal intubation for a scheduled | Pregnant, morbidly obese, tracheostomy, facial or cervical | A linear ultrasound probe was placed in the transverse position to measure the DSE with the patient supine and their head and | Anterior neck thickness (DSE) | CL grade view 3-4 | DSE ≥ 2.75 cm predicts a difficult airway.<br>DSE combined with the MMP score improves the predictive power of current |

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| | | procedure, ASA I-III | fractures, cervical tumors, or maxillofacial abnormalities. | neck in a neutral position. | | | preoperative airway assessments. |
| **Petrisor et al (2018)** | Diagnostic accuracy study<br><br>Level III | 25 morbidly obese patients, BMI > 40, needed intubation for general surgery | Planned RSI or videolaryngoscope intubation. | A curvilinear ultrasound transducer was used in the midsagittal longitudinal position to measure the hyomental distance in the neutral, ramped, and maximum hyperextended positions. | Hyomental distance | CL grade view 3-4 | The maximally hyperextended to neutral hyomental distance ratio ≤ 1.23 was the most predictive measurement for a difficult airway. There was also a significant difference in the hyomental distance in the ramped and maximally hyperextended positions and the ramped to neutral ratio between the easy and difficult intubation groups with cut off values ≤ 4.97 cm, 5.5 cm, and 1.12 respectively. There was no difference found in the neutral position. |
| **Abraham et al (2018)** | Prospective clinical study<br><br>Level III | 137 patients scheduled for surgery requiring general anesthesia and endotracheal intubation | Patients not undergoing surgery | Supine with the head in a neutral position a curved array ultrasound probe was used to measure several airway parameters | Hyomental distance | CL grade view of 2-4 | Hyomental distance ≤ 1.09 cm predicts a difficult intubation. No significant differences in age, submental thickness, epiglottis to hyoid bone distance, skin pad thickness to thyroid cartilage, or thyrohyoid distance. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Wang et al (2019)** | Prospective, self-controlled, assessor blinded, observational study<br><br>Level III | 499 patients undergoing general anesthesia for elective procedures that required endotracheal intubation. | Maxillofacial deformities or fractures, limited mouth opening, restricted neck movement, or loose teeth. | A linear array probe was used to identify and measure airway structures with the patient supine, the head elevated 10 cm, and the neck extended. The angle between the epiglottis and glottis was measured between the long axis of epiglottis and the vertical line through the anterior commissure of the glottis. | Angle between the epiglottis and glottis<br><br>Tongue thickness and width<br><br>Thyrohyoid membrane<br><br>Lateral pharyngeal wall thickness | CL grade view 3-4 | An angle between the epiglottis and glottis < 50 degrees was predictive of a difficult airway. This was the only independent variable measured that had a statistically significant difference between the easy and difficult groups. |

### Literature Review Discussion

In summary, the literature resulted in eight articles that discussed five different airway ultrasound parameters to differentiate difficult and easy airways preoperatively with more reliability than common preoperative airway assessments. Tongue thickness and anterior neck thickness were the two parameters with the most evidence. Three studies found statistically significant differences in tongue thickness between easy and difficult intubation groups, and four found these differences in anterior neck thickness. The results from this literature review will help inform a quality improvement project for anesthesia providers on the utilization of preoperative airway ultrasonography to predict difficult intubations by identifying the hyoid bone and measuring anterior neck thickness, tongue thickness, and hyomental distance. The quality improvement project is expected to increase anesthesia provider knowledge in ultrasound airway anatomy, skill, and predictive ability to effectively differentiate an easy from difficult airway.

## 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.[6,7,8,9] 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.[4,10]

### 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.[4]

### Ultrasound

Ultrasound is a high-frequency, inaudible sound wave that penetrates different types of body tissues to different degrees.[3] The sound is reflected back to the ultrasound transducer and reproduced visually on a grayscale to produce optimal images.[3] In the real time mode, parts of the body under the transducer are displayed on the screen as they are being scanned.[3]

## 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 differentiating easy versus difficult airway parameters. At Memorial Regional Hospital, ultrasonography is not utilized during the preoperative airway assessment. Neck circumference, BMI, and common airway assessments, such as the MMP, TMD, and interincisor distance, are used to predict difficult intubations. Each provider interprets the data from the assessments individually. Utilization of additional equipment and resources, including the Glidescope and flexible fiberoptic bronchoscope, is based on provider interpretation and prediction of a difficult intubation.

### Goals and Outcomes

SMART goals are specific, measurable, achievable, realistic, and timely.[16] A list of SMART objectives was identified to close the gap between the current state of preoperative airway assessments at Memorial Regional Hospital 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 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 educational module 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 CRNA at Memorial Regional Hospital 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, preoperative airway assessments, and consequences of unanticipated 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.

## VI. SWOT

A SWOT analysis evaluates the strengths, weaknesses, opportunities, and threats of a program, project, or organization.[16] The analysis addresses internal and external attributes and threats.[16] A SWOT assessment was completed on the site, Memorial Regional Hospital anesthesia department, where the preoperative airway ultrasound assessment educational module will be implemented.

### Strengths

Memorial Regional Hospital has a large anesthesia department consisting of anesthesiologists, certified registered nurse anesthetists (CRNAs), and anesthesiologist assistants (AAs). There are many students that rotate through the department, including student registered nurse anesthetists (SRNA) and AA students. The anesthesia providers are therefore familiar with participating in DNP scholarly projects. The anesthesia providers at Memorial Regional Hospital frequently care for critically ill patients that would be negatively impacted by a prolonged or failed intubation. This educational module will educate the anesthesia providers on a more effective technique to predict difficult intubations.

### Weaknesses

At Memorial Regional Hospital, anesthesia providers do not utilize ultrasonography for preoperative airway assessments. Additionally, CRNAs and AAs do not often perform procedures that require ultrasonography skills, such as central lines, arterial lines, peripheral blocks, and preoperative gastric ultrasounds. Therefore, CRNAs and AAs may not be as

comfortable using ultrasound resulting in a steeper learning curve when learning to use ultrasound for preoperative airway assessments.

**Opportunities**

Anesthesia providers do not utilize preoperative airway ultrasound assessments at Memorial Regional Hospital, so there is an opportunity to fill the educational gap and educate the providers on an evidence-based technique for preoperative airway assessments. 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. Also, the anesthesia department can use this educational module to educate future newly hired anesthesia providers on preoperative airway ultrasound assessments.

**Threats**

As with any educational module, there may be resistance among providers to participate or fully engage in the evidence-based practice change. Anesthesia providers may be unwilling to learn a new skill and change their practice if they feel their preoperative airway assessments have been efficacious. Many SRNAs from Florida International University (FIU) will be implementing their educational modules around the same time which may decrease provider participation and effort. During work hours, anesthesia providers are busy and do not have time to participate in educational modules. Participation may not be possible until after work which may decrease participation.

## VII. Theoretical Framework

The Theory of Synergy Model is used to guide the creation of the evidence-based educational module. The Synergy Model was developed based on several assumptions, including

that nurses work to optimize patient and health care system outcomes.[17] The theory describes nursing characteristics, such as clinical judgement, advocacy, clinical inquiry, and facilitator of learning.[17] The principal investigator of this quality improvement project demonstrates many of these qualities by evaluating current practice and facilitating learning for members of the healthcare team.[17] Anesthesia providers that participate in the educational module and change practice by including airway ultrasonography in preoperative assessments will demonstrate clinical inquiry, clinical judgement, and patient advocacy.[17]

## VIII. Methodology

### Setting and Participants

This DNP project will take place at Memorial Regional Hospital. This hospital is in Hollywood, FL. The participants will be the CRNAs.

### Description of Approach and Project Procedures

The educational module will consist of a pretest, PowerPoint presentation, and posttest. Each anesthesia provider at Memorial Regional Hospital 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 at Memorial Regional Hospital 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

Anesthesia providers at Memorial Regional Hospital do not utilize preoperative airway ultrasound assessments. By the end of the educational module, participants will have the ultrasound skills necessary to identify and measure airway anatomy and integrate the findings to predict easy versus difficult intubations. The implementation of the skills learned in the educational module can increase predictive ability of preoperative airway assessments**,** anesthesia provider airway ultrasound skill and anatomy knowledge, and utilization of

preoperative airway ultrasound assessments. The anesthesia department at Memorial Regional Hospital will have the opportunity to use this educational module to educate future newly hired anesthesia providers on preoperative airway ultrasound assessments.

## 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 | 4 (100.00%) |
| **Age** | |
| 25-34 | 2 (50.00%) |
| 35-44 | 0 (0.00%) |
| 45-54 | 2 (50.00%) |
| 55-64 | 0 (0.00%) |
| 65+ | 0 (0.00%) |
| **Gender** | |
| Male | 1 (25.00%) |
| Female | 3 (75.00%) |
| **Ethnicity** | |
| African American | 2 (50.00%) |
| Caucasian | 1 (25.00%) |
| Asian | 0 (0.00%) |
| Hispanic | 1 (25.00%) |
| Other | 0 (0.00%) |
| **Medical Profession** | |
| CRNA | 4 (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 | 1 (25.00%) |

| | |
|---|---|
| Doctoral Degree | 3 (75.00%) |
| Other | 0 (0.00%) |
| Bachelor's degree | 0 (0.00%) |

| **Experience** | |
|---|---|
| Less than 1 year | 1 (25.00%) |
| 1 to 5 years | 1 (25.00%) |
| 6 to 10 years | 0 (0.00%) |
| More than 10 years | 2 (50.00%) |

There were 4 participants in the pre-test demographics, and all completed the study. Most of the participants were female (n=3, 75.00%) compared to male (n=1, 25.00%). There was a range of ethnicities represented, including African American (n=2, 50.00%), Caucasian (n=1, 25.00%), and Hispanic (n=1, 25.00%). All 4 participants are CRNAs. The participants were questioned about the length of time practicing. The practice period ranged from less than one year (n=1, 25.00%), 1 to 5 years (n=1, 25.00%), and more than 10 years (n=2, 50.00%).

**Pre-Test Difficult Airway Knowledge**

Prior to the educational module, none of the participants (0.00%) were aware that 93% of difficult intubations are unanticipated. Only one participant (25.00%) knew that common preoperative airway assessments, such as the modified Mallampati score (MMP), thyromental distance (TMD), interincisor distance, and body mass index (BMI) do not have high sensitivities and specificities for predicting difficult intubations. When asked to select the two Cormack-Lehane (CL) classifications that correspond to a difficult intubation, one participant only selected one answer. Five of the seven answers chosen (71.43%) were correct while two (28.58%) were incorrect.

**Pre-Test Airway Ultrasonography Knowledge**

Prior to the educational module, half of the participants (n=2, 50.00%) knew that airway ultrasonography is more favorable than CT and X-ray because ultrasonography provides real-

time observation of the upper airway, intubation with traditional laryngoscopy that requires more than 2 attempts is considered difficult, and an airway ultrasound assessment can be completed by placing the ultrasound probe under the floor of the mouth in the mid-sagittal plane. The majority of participants (n=3, 75.00%) knew that caudal displacement of the larynx may obstruct the view of the hyoid bone on airway ultrasound exams. Half of the participants (n=2, 50.00%) knew that airway ultrasound exams can identify the epiglottis, vocal cords, cricothyroid membrane, and hyomental membrane. Most participants (75.00%) correctly stated that increased tongue thickness on airway ultrasound doesn't predict an easy intubation and invisibility of the hyoid bone on airway ultrasound predicts a difficult intubation. When asked to select two distances that are assessed with airway ultrasonography to identify anterior neck thickness, one participant only selected one answer choice. The majority of answers (n=5, 71.43%) were correct. Only one participant (25.00%) correctly identified that hyomental distance that predicts a difficult intubation. Additionally, one participant (25.00%) correctly identified the angle between the glottis and epiglottis is predictive of a difficult intubation.

**Pre-Test Utilization of Airway Ultrasonography**

Willingness to use airway ultrasonography in practice prior to the educational module was low. Three participants (75.00%) were somewhat unlikely and one (25.00%) was extremely unlikely to use airway ultrasonography during preoperative airway assessments. When asked how likely they were to utilize airway ultrasonography to identify a difficult airway versus the standard Mallampati assessment, one (25.00%) responded extremely unlikely, two (50.00%) responded somewhat unlikely, and one (25.00%) responded somewhat likely.

**Post-Test Difficult Airway Knowledge**

After the educational module, anesthesia provider knowledge on difficult airways improved. Half of the participants (n=2, 50.00%) were aware that 93% of difficult intubations are unanticipated and knew that common preoperative airway assessments, such as the modified Mallampati score (MMP), thyromental distance (TMD), interincisor distance, and body mass index (BMI) do not have high sensitivities and specificities for predicting difficult intubations. When asked to select the two Cormack-Lehane (CL) classifications that correspond to a difficult intubation, one participant only selected one answer. Six of the seven answers chosen (85.71%) were correct while one (14.29%) was incorrect. There was an improvement 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 difficult intubations are unanticipated? | 0.00% | 50.00% |
| Common preoperative airway assessments, such as the modified Mallampati score (MMP), thyromental distance (TMD), interincisor distance, and body mass index (BMI) have high sensitivities and specificities for predicting difficult intubations. (True or False) | 25.00% | 50.00% |
| A difficult intubation corresponds with a Cormack-Lehane (CL) classification of: (Select 2) | 71.43% | 85.71% |

**Post-Test Airway Ultrasonography Knowledge**

Anesthesia provider knowledge on airway ultrasonography after the educational module improved. Most of the participants (n=3, 75.00%) knew that airway ultrasonography is more favorable than CT and X-ray because ultrasonography provides real-time observation of the

upper airway. Half of the participants (n=2, 50.00%) said intubation with traditional laryngoscopy that requires more than 2 attempts is considered difficult. Less participants answered that question correctly in the post-test compared to the pre-test. All the participants (n=4, 100.00%) answered correctly that an airway ultrasound assessment can be completed by placing the ultrasound probe under the floor of the mouth in the mid-sagittal plane. All the participants (n=4, 100.00%) also knew that caudal displacement of the larynx may obstruct the view of the hyoid bone on airway ultrasound exams. Most of the participants (n=3, 75.00%) knew that airway ultrasound exams can identify the epiglottis, vocal cords, cricothyroid membrane, and hyomental membrane. Most participants (75.00%) correctly stated that increased tongue thickness on airway ultrasound doesn't predict an easy intubation. Less participants (n=2, 50.00%) correctly stated that invisibility of the hyoid bone on airway ultrasound predicts a difficult intubation. When asked to select two distances that are assessed with airway ultrasonography to identify anterior neck thickness, one participant only selected one answer choice. The majority of answers (n=6, 85.72%) were correct. Two participants (50.00%) correctly identified that hyomental distance that predicts a difficult intubation. Most participants (n=3, 75.00%) correctly identified the angle between the glottis and epiglottis is predictive of a difficult intubation. Table 3 shows the differences in responses from the pre- to post-test.

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

| **Question** | **Correct in Pretest** | **Correct in Posttest** |
|---|---|---|
| The anesthesia provider knows that airway ultrasonography is more favorable than CT and X-ray because airway ultrasonography is? | 50.00% | 75.00% |
| Intubation with traditional laryngoscopy that requires more than how many attempts is considered difficult airway? | 50.00% | 50.00% |

| | | |
|---|---|---|
| An airway ultrasound assessment can be completed by placing the ultrasound probe under the floor of the mouth in the mid-sagittal plane. (True or False) | 50.00% | 100.00% |
| On airway ultrasound exams, caudal displacement of the larynx may obstruct the view of which structure? | 75.00% | 100.00% |
| Airway ultrasound exams can identify which of the following structures? | 50.00% | 75.00% |
| Increased tongue thickness on airway ultrasound predicts an easy intubation. (True or False) | 75.00% | 75.00% |
| Which one of the following statements is true? | 75.00% | 50.00% |
| Which of the following distances are assessed with airway ultrasonography to identify anterior neck thickness? (Select 2) | 71.43% | 85.72% |
| Which of the following hyomental distances predicts a difficult intubation? | 25.00% | 50.00% |
| What angle between the glottis and epiglottis is predictive of a difficult intubation? | 25.00% | 75.00% |

**Post-Test Utilization of Airway Ultrasonography**

Regarding willingness to use airway ultrasonography in practice after the educational module, one participant (25.00%) was somewhat unlikely, two (50.00%) were somewhat likely, and one (25.00%) was extremely likely to use airway ultrasonography during preoperative airway assessments. When asked how likely they were to utilize airway ultrasonography to identify a difficult airway versus the standard Mallampati assessment, one (25.00%) responded somewhat unlikely, two (50.00%) responded somewhat likely, and one (25.00%) responded extremely likely. 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 |
|---|---|---|
| How likely are you to use airway ultrasonography during preoperative airway assessments? | | |
| Extremely Unlikely | 25.00% | 00.00% |
| Somewhat Unlikely | 75.00% | 25.00% |
| Somewhat Likely | 0.00% | 50.00% |
| Extremely Likely | 0.00% | 25.00% |
| How likely are you to utilize airway ultrasonography to identify a difficult airway versus the standard Mallampati assessment? | | |
| Extremely Unlikely | 25.00% | 00.00% |
| Somewhat Unlikely | 50.00% | 25.00% |
| Somewhat Likely | 25.00% | 50.00% |
| Extremely Likely | 0.00% | 25.00% |

## X. Discussion

### Limitations

There were a few limitations to this project. For one, there was a small sample size. Thirty-seven anesthesia providers from Memorial Regional were invited to participate, but only 4 completed the educational module. Reminder emails were sent at least once to every provider that didn't respond within a couple weeks. Additionally, the delivery method was limited 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 difficult airway knowledge (100%) and most of the survey question on airway ultrasonography knowledge (70%). There was also increased likeliness that the participants would utilize airway ultrasonography during preoperative airway assessments and to identify a difficult airway versus the standard Mallampati assessment.

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 after the educational module is completed.

# Appendix

## Appendix A: IRB Exemption Approval

**Date:** April 27, 2022

**Protocol Title:** "A Quality Improvement Project on the Utilization of Preoperative Airway Ultrasonography to Predict Difficult Intubations"

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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-22-0177 **IRB Exemption Date:** 04/27/22
**TOPAZ Reference #:** 111495

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

Envision
PHYSICIAN SERVICES

February 2nd, 2022

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

Dr. Miller,

Thank you for inviting Memorial Regional to participate in the Doctor of Nursing Practice (DNP) project conducted by Stephanie Tewes entitled "A Quality Improvement Project on the Utilization of Preoperative Airway Ultrasonography to Predict Difficult Intubations" in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthetist Practice at Florida International University. I have warranted Ms. Tewes' 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 the utilization of Preoperative Airway Ultrasonography to Predict Difficult Intubations.

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: Stephanie Tewes and Ann B. Miller. We expect that Stephanie Tewes will not interfere with normal hospital performance, behave in a professional manner and follow standards of care.

Prior to the implementation of this educational project, the Florida International University Institutional Review Board will evaluate and approve the procedures to conduct this project. Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. We support the participation of our Anesthesiology providers in this project and look forward to working with you.

Suzanne Hale 3/8/2021

Suzanne Hale, MSN, CRNA, ARNP
Advanced Practice Provider Director, Broward and Dade
Chief, Memorial Regional Hospital
Envision Physician Services
954-265-2044

## Appendix C: Pretest and Posttest Questionnaire

## INTRODUCTION

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 differentiating easy versus difficult airway parameters.

Please answer the questions below to the best of your ability. The first questions address demographic information. The following questions measure knowledge on preoperative airway ultrasound use in either multiple choice or true/false format.

**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 Doctoral (DNP, DNAP, EdD, PhD, MD, DO) Other _____

**Anesthesia Provider Experience:** Less than 1 year 1 to 5 6 to 10 more than 10 years

**QUESTIONNAIRE**

1. What percentage of difficult intubations are unanticipated?
    a. 18%
    b. 47%
    c. 75%
    d. 93%
2. Common preoperative airway assessments, such as the modified Mallampati score (MMP), thyromental distance (TMD), interincisor distance, and body mass index (BMI)

have high sensitivities and specificities for predicting difficult intubations. **(True or False)**

a. True

b. False

3. A difficult intubation corresponds with a Cormack-Lehane (CL) classification of: **(Select 2)**

    a. Grade 1

    b. Grade 2

    c. Grade 3

    d. Grade 4

4. The anesthesia provider knows that airway ultrasonography is more favorable than CT and X-ray because airway ultrasonography is?

    a. Difficult to utilize

    b. Time consuming

    c. Provides real-time observation of the upper airway

    d. Requires ionizing radiation

5. Intubation with traditional laryngoscopy that requires more than how many attempts is considered difficult airway?

    a. 1

    b. 2

    c. 3

    d. 4

6. An airway ultrasound assessment can be completed by placing the ultrasound probe under the floor of the mouth in the mid-sagittal plane. **(True or False)**
    a. True
    b. False
7. On airway ultrasound exams, caudal displacement of the larynx may obstruct the view of which structure?
    a. Hyoid bone
    b. Tongue
    c. Epiglottis
    d. Mentum
8. Airway ultrasound exams can identify which of the following structures?
    a. Epiglottis
    b. Vocal cords
    c. Cricothyroid membrane
    d. Hyomental distance
    e. All of the above
9. Increased tongue thickness on airway ultrasound predicts an easy intubation. **(True or False)**
    a. True
    b. False
10. Which one of the following statements is true?
    a. Invisibility of the hyoid bone on airway ultrasound predicts a difficult intubation.
    b. Invisibility of the hyoid bone on airway ultrasound predicts an easy intubation.

c. The hyoid bone is never visible on airway ultrasound.

d. The hyoid bone is always visible on airway ultrasound.

11. Which of the following distances are assessed with airway ultrasonography to identify anterior neck thickness? **(Select 2)**

    a. Skin to epiglottis

    b. Skin to esophagus

    c. Skin to base of cervical spine

    d. Skin to hyoid bone

12. Which of the following hyomental distances predicts a difficult intubation?

    a. > 2 cm

    b. ≤ 1.09 cm

    c. ≤ 1.54 cm

    d. ≥ 1.17 cm

13. What angle between the glottis and epiglottis is predictive of a difficult intubation?

    a. < 75 degrees

    b. > 75 degrees

    c. < 50 degrees

    d. > 50 degrees

14. How likely are you to use airway ultrasonography during preoperative airway assessments?

    a. Most likely

    b. Somewhat likely

    c. Somewhat unlikely

d. Most unlikely

15. How likely are you to utilize airway ultrasonography to identify a difficult airway versus the standard Mallampati assessment?

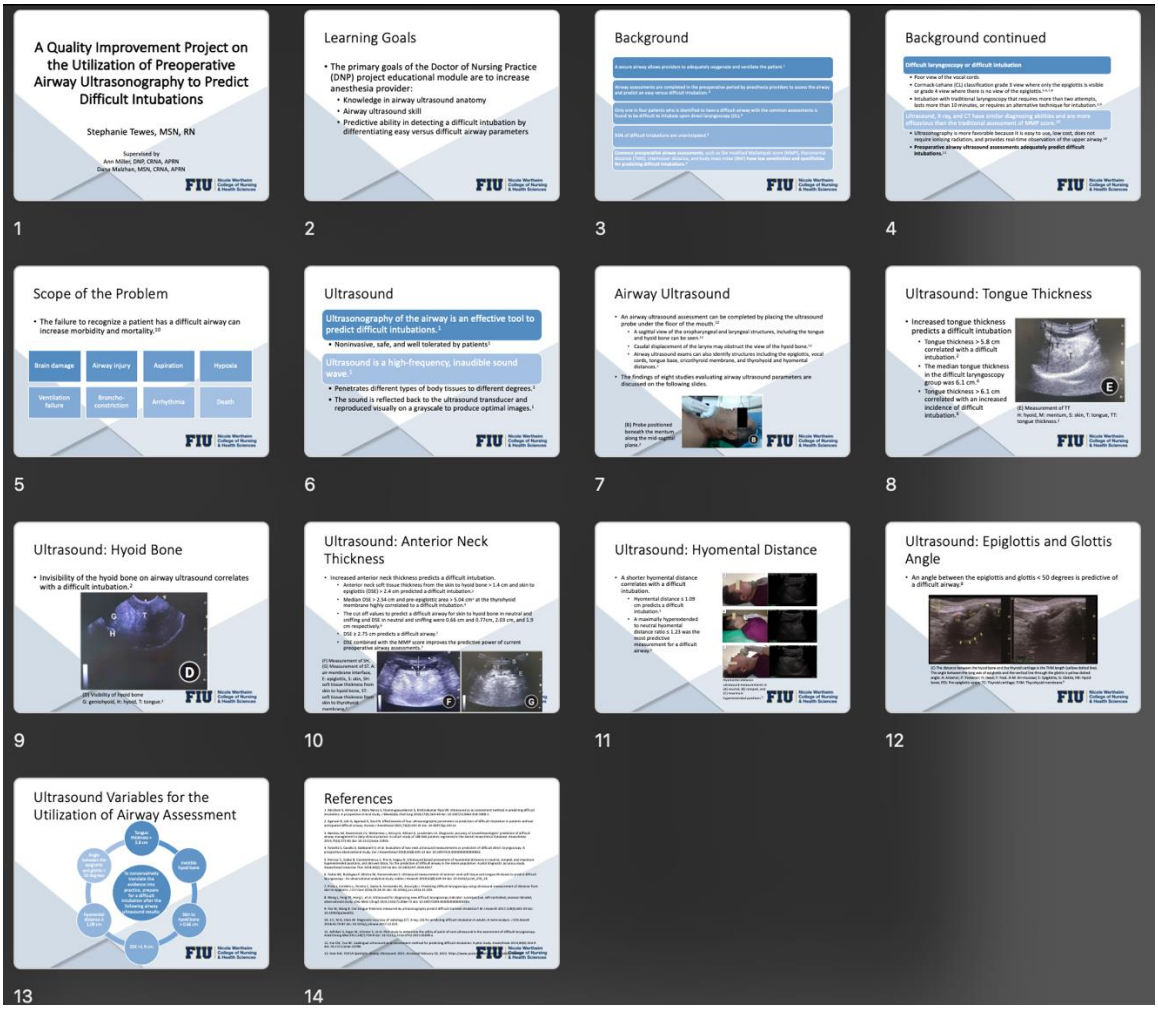
    a. Most likely

    b. Somewhat likely

    c. Somewhat unlikely

    d. Most unlikely

## Appendix D: Educational Module



## References

1. Falcetta S, Cavallo S, Gabbanelli V, et al. Evaluation of two neck ultrasound measurements as predictors of difficult direct laryngoscopy: A prospective observational study. *Eur J Anaesthesiol* 2018;35(8):605-12 doi: 10.1097/EJA.0000000000000832.

2. Ji C, Ni Q, Chen W. Diagnostic accuracy of radiology (CT, X-ray, US) for predicting difficult intubation in adults: A meta-analysis. *J Clin Anesth* 2018;45:79-87 doi: 10.1016/j.jclinane.2017.12.023.

3. Abraham S, Himarani J, Mary Nancy S, Shanmugasundaram S, Krishnakumar Raja VB. Ultrasound as an assessment method in predicting difficult intubation: A prospective clinical study. *J Maxillofac Oral Surg* 2018;17(4):563-69 doi: 10.1007/s12663-018-1088-1.

4. Agarwal R, Jain G, Agarwal A, Govil N. Effectiveness of four ultrasonographic parameters as predictors of difficult intubation in patients without anticipated difficult airway. *Korean J Anesthesiol* 2021;74(2):134-41 doi: 10.4097/kja.20114.

5. Nørskov AK, Rosenstock CV, Wetterslev J, Astrup G, Afshari A, Lundstrøm LH. Diagnostic accuracy of anaesthesiologists' prediction of difficult airway management in daily clinical practice: A cohort study of 188 064 patients registered in the Danish Anaesthesia Database. *Anaesthesia* 2015;70(3):272-81 doi: 10.1111/anae.12955.

6. Petrisor C, Szabo R, Constantinescu C, Prie A, Hagau N. Ultrasound-based assessment of hyomental distances in neutral, ramped, and maximum hyperextended positions, and derived ratios, for the prediction of difficult airway in the obese population: A pilot diagnostic accuracy study. *Anaesthesiol Intensive Ther* 2018;50(2):110-16 doi: 10.5603/AIT.2018.0017.

7. Yadav NK, Rudingwa P, Mishra SK, Pannerselvam S. Ultrasound measurement of anterior neck soft tissue and tongue thickness to predict difficult laryngoscopy - An observational analytical study. *Indian J Anaesth* 2019;63(8):629-34 doi: 10.4103/ija.IJA_270_19.

8. Pinto J, Cordeiro L, Pereira C, Gama R, Fernandes HL, Assunção J. Predicting difficult laryngoscopy using ultrasound measurement of distance from skin to epiglottis. *J Crit Care* 2016;33:26-31 doi: 10.1016/j.jcrc.2016.01.029.

9. Wang L, Feng YK, Hong L, et al. Ultrasound for diagnosing new difficult laryngoscopy indicator: a prospective, self-controlled, assessor blinded, observational study. *Chin Med J (Engl)* 2019;132(17):2066-72 doi: 10.1097/CM9.0000000000000393.

10. Yao W, Wang B. Can tongue thickness measured by ultrasonography predict difficult tracheal intubation? *Br J Anaesth* 2017;118(4):601-09 doi: 10.1093/bja/aex051.

11. Adhikari S, Zeger W, Schmier C, et al. Pilot study to determine the utility of point-of-care ultrasound in the assessment of difficult laryngoscopy. *Acad Emerg Med* 2011;18(7):754-8 doi: 10.1111/j.1553-2712.2011.01099.x.

12. McDermott KW, Liang LL. Overview of Operating Room Procedures During Inpatient Stays in U.S. Hospitals, 2018: Agency for Healthcare Research and Quality, 2021.

13. Joffe AM, Aziz MF, Posner KL, Duggan LV, Mincer SL, Domino KB. Management of difficult tracheal intubation: A closed claims analysis. *Anesthesiology* 2019;131(4):818-29 doi: 10.1097/ALN.0000000000002815.

14. Hui CM, Tsui BC. Sublingual ultrasound as an assessment method for predicting difficult intubation: A pilot study. *Anaesthesia* 2014;69(4):314-9 doi: 10.1111/anae.12598.

15. Schnobrich DJ, Olson AP, Broccard A, Duran-Nelson A. Feasibility and acceptability of a structured curriculum in teaching procedural and basic diagnostic ultrasound skills to

internal medicine residents. *J Grad Med Educ* 2013;5(3):493-7 doi: 10.4300/JGME-D-12-00214.1.

16. Moran K, Burson R, Conrad D. *The Doctor of Nursing Practice Scholarly Project: A Framework for Success Thel*. 2nd ed, 2017.
17. Peterson SJ, Bredow TS. *Middle range theories : application to nursing research and practice Thel*. Fourth edition. ed. Philadelphia: Wolters Kluwer, 2017.