Assessing Certified Registered Nurse Anesthetists' Perceptions of the Adequacy of a Quick-Reference Guide for Evaluating Airways of Patients with Obesity: A Quality Improvement Project

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Notes from the Author

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Abstract

Obesity is a growing health concern and increases the risk of a difficult airway. Recent evidence indicates a combination of airway assessment techniques may be most effective in predicting difficult airways in patients with obesity, but determining which combination to use is difficult. The purpose of this project was to assess the perceptions of adequacy of the quick-reference guide format as a useful tool for CRNA practice when assessing the airways of patients with obesity. A literature review was conducted to identify the airway assessment techniques that are most accurate in predicting difficult airways in patients with obesity. Then, a quick-reference guide was created to present these techniques together. Ten CRNAs were asked to complete a pre-implementation survey, use the quick-reference guide for two weeks, and complete a post-implementation survey. Comparison between the pre- and post-implementation surveys showed that perceptions of usefulness of the STOP-Bang score, Mallampati score, and thyromental distance increased during the project. Perceptions of usefulness of neck circumference and thyromental distance to neck circumference ratio changed little. Overall perceptions of usefulness of the quick-reference guide were moderate. The results from this project could indicate that a quick-reference guide may act as a helpful addition to the pre-anesthetic assessment. However, this project was conducted for a short period of time with few participants, so further investigation needs to be conducted to better understand what alterations to the quick-reference guide may improve utility.

Keywords: Obesity, CRNAs, quick-reference guide, airway assessment, perceptions

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Section I. Introduction

Background

Obesity, defined as a body mass index (BMI) greater than or equal to 30 kg/m^2, is a growing health problem in the United States (National Institute of Diabetes and Digestive and Kidney Diseases, 2021). The National Health and Nutrition Examination Survey from 2017 to 2018 found that 42.4% of adults in the United States have obesity, and an additional 9.2% of adults have severe obesity. With so many adults in the United States living with obesity, this population now represents a large portion of patients presenting for surgery. In anesthesia, obesity can increase risk in all aspects of care, but one of the most dangerous circumstances that anesthesia providers must prepare for is the increased risk for difficult airways.

The practice guidelines for the American Society of Anesthesiologists (ASA) define a difficult airway as an airway that anesthesia providers have difficulty accessing or maintaining (Apfelbaum et al., 2022). The difficulty can include problems with laryngoscopy, bag mask ventilation, and intubation. Obesity may increase the risk for a difficult airway because of anatomical and physiologic changes such as increased fat deposition in the airway, which can lead to a smaller trachea or airway closure when the airway relaxes (Mehta et al., 2022; Moura et al., 2021). Obesity can also alter respiratory function by increasing oxygen consumption while decreasing lung volumes, which reduces the amount of time available to secure an airway before significant oxygen desaturation occurs (Moura et al., 2021). The risk for a difficult airway ranges between 2-8% in patients without obesity but ranges up to 14% for patients with obesity (Mehta et al., 2022). Because of the increase in risk related to difficult airways for patients with obesity, proper assessment and preparation are essential.

The American Association of Nurse Anesthesiology (AANA, 2019) includes performing focused anesthesia assessments and patient-specific planning of anesthesia care in their standards of care. Additionally, the AANA (2020b) guidelines for scope of anesthesia practice include the ability to comprehensively assess patients for the possibility of anesthesia-related complications as a vital element of practice. To best meet these AANA standards, nurse anesthetists must understand how obesity can affect airway access and how effective airway assessment techniques are at detecting difficult airways. However, many assessment techniques exist, and determining the best predictors for difficult airways in patients with obesity is difficult.

Recent research indicates that a combination of assessment techniques may better predict difficult airways in patients with obesity, and new techniques, such as point-of-care ultrasound, are being investigated for accuracy (Emik et al., 2021; Thota et al., 2022). Practice guidelines from the ASA and AANA reflect these changes. The 2022 ASA practice guidelines recommend the use of multiple airway assessment techniques in all airway assessments to better predict difficult airways (Apfelbaum et al., 2022). The AANA (2020a) has incorporated additional techniques, such as point-of-care ultrasound of airway anatomy, into practice considerations as potentially helpful in identifying difficult airways in patients with obesity. However, the AANA and ASA do not specify which combination of techniques to use. Presentation of the most recent data related to accuracy of airway assessment techniques in patients with obesity can, therefore, help to prepare anesthesia providers to care for this patient population and to further the goal of providing the most evidence-based care. Utilization of a quick-reference guide format for presentation of the most evidence-based techniques could also help to make this information more accessible in the clinical setting and to present techniques together that have been demonstrated to work best in combination.

Organizational Needs Statement

The inability to accurately predict a difficult airway can lead to patient harm. While nurse anesthetists at this medical center do a great job assessing their patients and managing difficult airways, healthcare providers should always strive to improve patient care as new evidence becomes available. The AANA (2019) includes participation in quality improvement and fostering a culture of safety as two standards of anesthesia care. Additionally, The Joint Commission (2023) requires knowledge of current recommendations from professional organizations in their national requirements for assessment of patients before anesthesia.

The ASA recommends the use of multiple assessment techniques but does not specify which techniques might be best at predicting difficult airways in patients with obesity (Apfelbaum et al., 2022). The AANA (2020a) does not have any specific requirements for airway assessment in patients with obesity but does indicate that point-of-care ultrasound may be useful as a developing technique for safe anesthesia practice. To best meet these standards for professional practice, anesthesia providers must have knowledge of the most current evidence related to accuracy of airway assessment techniques in patients with obesity, as well as gain knowledge about developing techniques that may become a standard part of practice in future.

Problem Statement

Obesity (BMI $\geq$ 30 kg/m^2) has increased to over 40%, and morbid obesity (BMI $\geq$ 40 kg/m^2) to more than 9% of the population in the United States (National Institute of Diabetes and Digestive and Kidney Diseases, 2021). Subsequently, there are more patients with obesity presenting for surgery and anesthesia. The increased adiposity in patients with obesity alters anatomy and physiology and places them at higher risk for difficult perioperative airway management (Mehta et al., 2022; Moura et al., 2021). There are a variety of techniques to

properly assess these risks; however, no single source could be found that succinctly incorporated predictive scales for properly identifying and managing potential difficult airways in patients with obesity.

Purpose Statement

The purpose of this Doctor of Nursing Practice (DNP) quality improvement (QI) project is to assess Certified Registered Nurse Anesthetists' (CRNAs') perceptions of adequacy of a newly developed quick-reference guide as a useful tool for their practice as it pertains to assessment of the airway of patients with obesity. Knowledge gained from this pilot project could be used in future quality improvement and policy efforts aimed at improving anesthesia care of patients with obesity.

Section II. Evidence

Description of Search Strategies

The goal of this literature review was to determine the current level of evidence regarding accuracy of common airway assessment techniques in predicting difficult airways in patients with obesity. The literature review was guided by the PICOT question: “What airway assessment techniques in anesthesia help predict difficult airways for patients with obesity?” The major concepts of interest were obesity, airway assessment, and difficult airway.

A search was conducted using PubMed, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Google Scholar. The search strategy *((airway assessment) OR (airway management) OR (preoperative assessment) OR (anesthesia assessment)) AND (obesity OR bariatric) AND ((difficult airway) OR (difficult laryngoscopy) OR (difficult intubation) OR (difficult ventilation))* was used for both PubMed and Google Scholar. Results were limited to publication in the last 5 years (2018-2023) for both, and PubMed was additionally restricted to English language publications. Using this search strategy, PubMed pulled the MeSH terms obesity; bariatrics; anesthesia; airway management; intubation; laryngoscopy; ventilation; and ventilators, mechanical. No MeSH terms were identified for airway, assessment, preoperative, or difficult, but these terms were utilized for best results. In CINAHL, the search strategy *((MH "Obesity") OR (MH "Obesity, Morbid") OR "bariatric") AND ("difficult laryngoscopy" OR "difficult airway" OR "difficult ventilation" OR "difficult intubation") AND ("airway assessment" OR "airway" OR "preoperative assessment" OR "anesthesia assessment" OR (MH "Nurse Anesthetists"))* was used. This search utilized both major headings and keywords because the most relevant phrases such as “airway assessment,” “difficult airway,” “difficult laryngoscopy,” “difficult intubation,” and “difficult ventilation” did not exist as major headings. In addition to

the English language and 5-year (2018-2023) limits, this search was also limited to results that were peer reviewed. See Appendix A for concepts, keywords, MeSH terms, and subject headings. See Appendix B for search strategies and limits.

These search strategies initially identified 136 relevant citations in PubMed, 44 in CINAHL, and 17,200 in Google Scholar. The decision to include or exclude items was made through review of titles and abstracts. Items that referred to airway assessment techniques, techniques to improve laryngeal visualization before a laryngoscopy attempt, or factors that could make airways, intubation, ventilation, or visualization more difficult in adult patients with obesity were included. Articles that focused on pediatric populations or on laryngoscopy, airway management instead of assessment, or treatments for a difficult airway were excluded. Articles that did not investigate airway assessment specifically in patients with obesity were also excluded. For Google Scholar, only the first four pages of results were reviewed. See Appendix B for number of articles found, number of articles kept, and rationale for inclusion or exclusion. After reviewing titles and abstracts, 40 articles in PubMed, 15 articles in CINAHL, and 21 articles in Google Scholar were identified for full-text review.

After full-text review, 21 articles were identified as containing relevant evidence for the project. The articles were entered into a literature matrix and classified using Melnyk and Fineout-Overholt's (2019, p.131) key to levels of evidence, with the strongest level of evidence listed as Level I and the weakest as Level VII. Two articles were identified as systematic reviews or meta-analyses (Level I), 17 articles were identified as uncontrolled cohort studies (Level V), one article was identified as a descriptive or qualitative study (Level VI), and one article was identified as expert opinion (Level VII). See Appendix C for details about each article and for a note about classification using Melnyk and Fineout-Overholt's key.

Selected Literature Synthesis

Multiple airway assessment techniques have been investigated for their sensitivities in predicting difficult airways in patients with obesity. Generally, airway assessment techniques are based on physiological characteristics. Therefore, to get the most accurate predictions of difficult airways, anesthesia providers need to know the strengths of the relationships between physiological characteristics and difficult airways. This literature synthesis examines the current evidence for common airway assessment techniques and for the relationships between physiological characteristics and difficult airways in patients with obesity. This synthesis also includes current evidence for airway assessment techniques that may help practice in the future.

Definition of Difficult Airway

Because the definition of "difficult airway" varies between studies, comparing study results and determining the best airway assessment methods for predicting difficult airways in patients with obesity is complicated. Difficult airway can be defined by many things including difficult mask ventilation (DMV), difficult intubation (DI), or difficult laryngoscopy (DL; Apfelbaum et al., 2022). All three of these definitions have been used in the different studies discussed, and several studies used multiple definitions. In this literature synthesis, only Hung et al. (2023) looked at DMV alone, while only Roth et al. (2019) investigated factors that influence DMV, DI, and DL. Six research teams defined difficult airway by DI (Mehta et al., 2022; Pradeep et al., 2023; Schnittker et al., 2020; Sharma et al., 2023; Siaw et al., 2018; Siriussawakul et al., 2018). Six additional research teams defined difficult airway by DL (Ahmed et al., 2021; Çelik et al., 2021; Corrente et al., 2020; Moura et al., 2021; Siddiqui et al., 2022; Wu et al., 2022). Three research teams defined difficult airway by both DMV and DI (Moon et al., 2019; Sinha et al., 2020; Thota et al., 2022). One research team defined difficult airway by both DMV

and DL (Özdilek et al., 2018). Finally, three research teams used number of attempts to intubation to define difficult airway (Emik et al., 2021; Mahmoud et al., 2021; Saasouh et al., 2018). Even these groupings are not exact, however, because measurement of DMV, DI, and DL varied by study. To allow for comparison of results, any definition of difficult airway was considered in this literature synthesis.

Difficult Mask Ventilation

Out of all aspects that can be used to define a difficult airway, it may be most important to differentiate the factors that increase risk for DMV. DI and DL are both important, but DMV can result in the inability to ventilate the patient if DI is also a factor. Six studies researched the relationships between physiological characteristics and DMV (Hung et al., 2023; Moon et al., 2019; Özdilek et al., 2018; Roth et al., 2019; Sinha et al., 2020; Thota et al., 2022).

Hung et al. (2023), Moon et al. (2019), Roth et al. (2019), and Thota et al. (2022) found that a Mallampati score of III or IV increased risk for DMV. However, only one of these studies found that a high Mallampati score acted as a predictor of DMV (Roth et al., 2019). Hung et al. (2023) found in their systematic review that, while 13 factors had relationships with DMV, the three best predictive factors for DMV were history of neck radiation, increased neck circumference, and presence of obstructive sleep apnea (OSA). Moon et al. (2019) additionally found that OSA presence was predictive for DMV along with male sex and a BMI greater than or equal to 40 kg/m^2. Roth et al. (2019) found that the upper lip bite test and Mallampati score could be used as predictors for DMV, but they would not predict many events because of lack of specificity. Finally, Thota et al. (2022) also noted a relationship between an increased BMI, male sex, older age, and history of OSA with DMV, but found that only an increased neck circumference could be considered predictive.

Of the two additional studies that investigated the relationship between physical characteristics and DMV, Özdilek et al. (2018) determined that no factors independently predicted DMV in women, but inadequate mouth-opening and inadequate neck flexion could predict DMV in men. Sinha et al. (2020) found that an increased BMI paired with an increased neck circumference could predict about half of DMV cases. The results from these studies demonstrate the amount of variability found in which factors might predict DMV, and many of the studies were the only studies to report on the efficacy of some physical characteristics in predicting DMV. Of these results, presence of OSA, an increased neck circumference, and a higher Mallampati score appear to have the most evidence for their relationships to DMV, but their predictive value varies (Hung et al., 2023; Moon et al., 2019; Roth et al., 2019; Sinha et al., 2020; Thota et al., 2022). Because of the variability in results, it may be most important to keep in mind that these factors can increase risk for DMV and to prepare accordingly.

Body Mass Index and Obesity

Obesity, while generally regarded as a risk factor for difficult airways, does not act as the most reliable predictive physical characteristic. In this literature review, twelve articles were identified that included investigation into whether obesity correlated with difficult airways. Six research teams found in uncontrolled cohort studies that obesity correlated with difficult airways (Çelik et al., 2021; Mehta et al., 2022; Pradeep et al., 2023; Saasouh et al., 2018; Schnittker et al., 2020; Sinha et al., 2020). However, five additional teams found in one systematic review and four uncontrolled cohort studies that obesity did not correlate with or predict difficult airways reliably (Ahmed et al., 2021; Emik et al., 2021; Hung et al., 2023; Mahmoud et al., 2021; Özdilek et al., 2018). Additionally, as discussed before, Moon et al. (2019) determined in their uncontrolled cohort study that obesity could be used as a predictor for DMV, but not DI.

Of the six studies that identified a correlation, Saasouh et al. (2018) found that the risk for a difficult airway increased linearly with BMI until 30 kg/m^2. However, once a BMI of 30 kg/m^2 was reached, risk did not further increase. This study's results differ from the results determined by Çelik et al. (2021), who found that a BMI greater than 46 kg/m^2 was correlated with difficult airways, and from Sinha et al. (2020), who found a BMI cutoff value of greater than or equal to 45 kg/m^2 was associated with difficult airways. Mehta et al. (2022), Pradeep et al. (2023), and Schnittker et al. (2020) all additionally found that BMI was associated with difficult airways but did not specify a BMI cutoff value. However, Ahmed et al. (2021), Emik et al. (2021), Hung et al. (2023), Mahmoud et al. (2021), and Özdilek et al. (2018) did not find that obesity or BMI correlated with or predicted difficult airways. The study by Hung et al. (2023) also had the highest level of evidence out of the twelve articles, as it was a systematic review.

These studies demonstrate the issue with utilizing obesity or BMI as predictors for difficult airways; the results from seven studies indicated that obesity had some relationship to difficult airways, but the results from five studies indicated that either no correlation existed, or the relationship was not strong enough to be considered predictive. Mehta et al. (2022) and Thota et al. (2022) discussed in their articles that obesity and BMI may not function as the best predictors of difficult airways because of variability in patient physiology even within the same BMI groupings. The better predictors relate to physiology of the patient. Some of the most assessed physical characteristics are discussed below.

Neck Circumference

Neck circumference has been heavily researched, and nine studies were identified in this literature review where researchers found a relationship between increased neck circumferences and difficult airways. Hung et al. (2023) found in their systematic review that larger neck

circumferences increased risk for difficult airways four-fold. The researchers in an additional eight uncontrolled cohort studies found that an increased neck circumference alone was associated with difficult airways in patients with obesity (Ahmed et al., 2021; Çelik et al., 2021; Emik et al., 2021; Moura et al., 2021; Pradeep et al., 2023; Sinha et al., 2020; Thota et al., 2022; Wu et al., 2022). Only one study, an uncontrolled cohort study of 120 patients, found that neck circumference did not have a statistically significant relationship to difficult airways and was not predictive for difficult airways in patients with obesity (Özdilek et al., 2018).

However, even with nine studies supporting the relationship between increased neck circumferences and difficult airways, using neck circumference to assess risk for difficult airways in patients can be complicated by lack of consensus in cutoff values. Among the study results that indicated a relationship between increased neck circumferences and difficult airways, many of the research teams did not report cutoff values for determining difficult airway risk, and no agreement was found in those that did. Hung et al. (2023) determined that a neck circumference above 40 cm was associated with increased risk for a difficult airway. Emik et al. (2021) determined a neck circumference above 41.5 cm increased risk. Sinha et al. (2020) found that a neck circumference above 44.5 cm was the most significant predictive factor for difficult airways. Wu et al. (2022) determined a neck circumference above 49.1 cm was an independently predictive factor for difficult airways. Finally, Çelik et al. (2021) determined a neck circumference above 50 cm increased risk for a difficult airway by 8.32 times. No single cutoff value for predicting risk for a difficult airway was found in this literature synthesis.

STOP BANG Score and Obstructive Sleep Apnea

Despite the inconsistency in evidence for cutoff values for determining risk for difficult airways in patients with obesity, neck circumference is used in some airway assessment

measures. Neck circumference greater than 40 cm is generally accepted in anesthesia practice as a risk factor for difficult airways and is an element of the STOP BANG score used to predict whether a patient has OSA (Mahmoud et al., 2021). Of note, 40 cm was the cutoff value determined by Hung et al. (2023), and this was the study that had the highest level of evidence. Assessment techniques like the STOP BANG score can also benefit anesthesia practice by combining factors that have correlations to difficult airways in a single assessment, potentially increasing sensitivity and more accurately identifying difficult airways.

For example, the STOP BANG score uses multiple factors to identify patients with possible undiagnosed OSA (Mahmoud et al., 2021). OSA has its own correlations to difficult airways, as noted in the discussion of predictive factors for DMV. Hung et al. (2023) found in their systematic review that OSA increases risk for DMV 3.6-fold. Siaw et al. (2018) also found in a literature review that 14.5% of patients with OSA had difficult intubation in comparison to 7.7% of patients who did not have OSA, and Mahmoud et al. (2021) found in their uncontrolled cohort study that a high STOP BANG score indicative of OSA was an independent predictor of difficult airways. Additionally, Sinha et al. (2020) found in their uncontrolled cohort study that BMI combined with neck circumference had a 55% predictive value for difficult airways. The authors noted that these two factors are already components of the STOP BANG score and suggested that STOP BANG use could improve prediction accuracy, although further research needs to be done. These studies indicate that STOP BANG may be a helpful assessment tool in predicting difficult airways in patients with obesity.

Thyromental Distance

Thyromental distance (TMD) has also been investigated as an independent predictor of difficult airways in patients with obesity. Only two uncontrolled cohort studies by Çelik et al.

(2021) and Thota et al. (2022) determined that a small TMD could be used as a predictor for difficult airways in patients with obesity. Çelik et al. (2021) found that a TMD less than or equal to 6.5 cm increased the risk for a difficult intubation by approximately 40 times. Thota et al. (2022) found that a TMD less than 6 cm could be used as an independent predictor of DI but had to be combined with the Mallampati score to predict DMV. However, Ahmed et al. (2021), Hung et al. (2023), Moura et al. (2021), and Pradeep et al. (2023) determined in their studies that TMD had a relationship with difficult airways in patients with obesity, but the relationship was not necessarily strong enough for TMD to act as an independently predictive factor. Finally, Mahmoud et al. (2021), Mehta et al. (2022), Özdilek et al. (2018), and Wu et al. (2022) found that short TMDs could not act as predictors of difficult airways because there was not a significant relationship between obesity and short TMDs.

While most of the discussed articles indicate that TMD alone may not be the best predictor of difficult airways in patients with obesity, two studies found that the ratio between neck circumference and TMD could act as a strong predictor of difficult airways in patients with obesity (Ahmed et al., 2021; Pradeep et al., 2023). Use of the ratio between neck circumference and TMD may also help to alleviate issues related to the fact that a single cutoff value for neck circumference has not been established, but it does require that a cutoff for the ratio be determined. In this case, Ahmed et al. (2021) determined in their uncontrolled cohort study that a ratio above 7.9 had a good predictive value for difficult laryngoscopy. However, Pradeep et al. (2023) determined that a neck circumference to TMD ratio of greater than 5.05 cm was predictive for difficult airways with 94.7% sensitivity in patients with obesity. Again, no single best cutoff value was identified in this literature review.

TMD is also a component of the EL.GA score system, to which Corrente et al. (2020) added a neck circumference cutoff of greater than 42.5 cm to attempt to better predict difficult airways. The EL.GA score system awards points based on mouth opening, TMD, Mallampati score, neck movement, jaw thrust, BMI, and history of difficult intubation. The research team found that the addition of neck circumference increased predictive value, from 0.14 to 0.69, in moderately obese patients. However, this was the only study to discuss use of the EL.GA score system, and the small sample size and retrospective observational design mean that the results may not be generalizable. Inclusion of this study in this literature synthesis serves to demonstrate that research into novel techniques is being done to try and determine assessments that best predict difficult airways in patients with obesity. This study also included many of the commonly used airway assessment techniques in one scoring system, and the results demonstrated that a combination technique did improve prediction accuracy with the correct combination.

Mallampati Score

Researchers have also heavily examined the accuracy of the Mallampati score in predicting difficult airways in patients with obesity. The researchers for two systematic reviews and nine uncontrolled cohort studies found that a higher Mallampati score of III-IV does have a relationship with difficult airways in patients with obesity (Ahmed et al., 2021; Çelik et al., 2021; Emik et al., 2021; Hung et al., 2023; Mahmoud et al., 2021; Moon et al., 2019; Moura et al., 2021; Özdilek et al., 2018; Pradeep et al., 2023; Roth et al., 2019; Thota et al., 2022). However, the predictive power of the Mallampati score used alone varied by study. Some results from some studies, like those from the uncontrolled cohort study completed by Moura et al. (2021), indicated that the Mallampati score had a correlation with difficult airways, but the research team did not determine predictive strength. The results from other studies, like those

from the systematic review completed by Roth et al. (2019), showed that the Mallampati score was the strongest predictor for difficult intubation of those studied and identified six out of every eleven difficult airway events. Additionally, Çelik et al. (2021) determined that a Mallampati score of III or IV increased risk for a difficult airway by approximately 16 times.

However, much like other physiologic measurements, the strength of the Mallampati score in predicting difficult airways in patients with obesity may increase when used as part of a combination assessment. Four studies found that the Mallampati score combined with one or more other measures increased predictive power. Emik et al. (2021) found that the Mallampati score combined with either neck, chest, or waist circumference measures was predictive for difficult airways. Siriussawakul et al. (2018) also identified Mallampati score as a good predictor of difficult airways in a literature review and attempted to design a new airway assessment equation to help predict difficult airways. The equation also included BMI and neck circumference to TMD ratio and was moderately effective at predicting difficult airways. Siddiqui et al. (2022) combined the Mallampati score with the Wilson score and found that sensitivity increased from 72% to 75%, with accuracy in predicting difficult airways at 98.5% for patients with obesity and 95.4% for patients with morbid obesity. Finally, Sharma et al. (2023) expressed in their expert opinion that a combination of the 3-3-2 rule, which can be used to help remember assessment of mouth opening, hyomental distance, and thyrohyoid distance, with the Mallampati score could enhance prediction of difficult airways. The variability in which assessment methods were combined with the Mallampati score to better predict difficult airways in patients with obesity again made the determination of one best method difficult.

Ultrasound Techniques

Another goal of this DNP project was to present data on assessment techniques which may become part of standard practice in the future. Most notably, two research teams investigated the usefulness of ultrasound in assessing for difficult airways in patients with obesity (Moura et al., 2021; Wu et al., 2022). The AANA (2020a) recently included the use of ultrasound in airway assessments in their practice considerations because it may help to predict difficult airways in patients with difficult-to-palpate anatomy. Of the two studies that investigated usefulness of ultrasound in airway assessments, Moura et al. (2021) found that ultrasound of the distance from the skin to the epiglottis could predict 66% of cases of difficult airway. Wu et al. (2022) found that ultrasound of tongue thickness combined with neck circumference could predict difficult airways. Although these methods differ, use of ultrasound is a simple technique that could help to increase patient safety. However, these techniques require more research to determine cutoff values and increase generalizability. These techniques also require special training and devices, which can hinder implementation of ultrasound assessments until they become more standardized because of the increased cost involved.

Conclusion

This literature synthesis demonstrates that many different airway assessment techniques exist. Because of variability in the definition of difficult airway, comparison of study results can be complicated. This literature synthesis considered DMV, DI, DL, and an increased number of attempts to intubation as difficult airways and compared results accordingly, although distinctions were made where some physiological characteristics only had a relationship with or predicted one difficult airway definition. A distinction was made for assessments that may best predict DMV because of the importance in being able to ventilate patients even if intubation

cannot be achieved. However, because of lack of consensus between study results into the best predictors for DMV, it may be best to consider any of the associated factors found in this synthesis on an individual basis to help prepare for a DMV scenario.

As far as predictive factors, obesity and BMI do not function as the best predictors of difficult airways because of variability in patient physiology, although they should be considered as possible risk factors (Mehta et al., 2022; Thota et al., 2022). Nine studies determined that an increased neck circumference alone was predictive for difficult airways, although differences in cutoff values can complicate use in clinical practice (Ahmed et al., 2021; Çelik et al., 2021; Emik et al., 2021; Hung et al., 2023; Moura et al., 2021; Pradeep et al., 2023; Sinha et al., 2020; Thota et al., 2022; Wu et al., 2022). Standard application of a neck circumference cutoff of greater than or equal to 40 cm in the STOP BANG score has the potential to accurately predict difficult airways in patients with obesity, and results found in this literature review are promising for the predictive power of the STOP BANG score and OSA for difficult airways, but more research needs to be done for greater confidence in predictive value (Mahmoud et al., 2021; Siaw et al., 2018; Sinha et al., 2020). TMD alone may not act as the best predictor of difficult airways, but the ratio between neck circumference and TMD may better predict difficult airways; again, more research is required to increase confidence in predictive value and determine a cutoff value (Ahmed et al., 2021; Pradeep et al., 2023). Finally, the Mallampati score was demonstrated to have a relationship to difficult airways in 11 studies (Ahmed et al., 2021; Çelik et al., 2021; Emik et al., 2021; Hung et al., 2023; Mahmoud et al., 2021; Moon et al., 2019; Moura et al., 2021; Özdilek et al., 2018; Pradeep et al., 2023; Roth et al., 2019; Thota et al., 2022). However, the research teams often indicated that combination of the Mallampati score with additional assessments could help to improve predictive value.

One of the common themes identified in this literature review was that a combination of assessment methods may work best to predict difficult airways. However, many different combinations were researched. The best evidence for a combination score found in this literature review was for the STOP BANG score (Mahmoud et al., 2021; Siaw et al., 2018; Sinha et al., 2020). Additionally, Sharma et al. (2023) discussed the 3-3-2 rule in their expert opinion but presented the technique with no real evidence to support its use. Most of the usefulness for the 3-3-2 rule may come from the ease of remembering it and its inclusion as part of the pneumonic LEMON, which encourages providers to look externally, evaluate the 3-3-2 rule, do a Mallampati score, look for airway obstruction or OSA, and evaluate neck mobility. In one way or another, all these factors were demonstrated to have a relationship to difficult airways in this literature review, which demonstrates that LEMON has the potential to be a great predictor of difficult airways in patients with obesity. However, its validity and sensitivity have not been evaluated in practice.

Determining a single best combination of assessments from this literature review was not possible. For this reason, all these assessment methods were chosen for inclusion on a quick-reference guide. An additional section about “ramping” patients was included on the quick-reference guide because, although not an airway assessment method, ramping can increase the odds of successful airway management. If the potential for a difficult airway is identified using the quick-reference guide, ramping patients may help diminish the odds of failed airway access. No previous attempts at a quick-reference guide were found during the literature review, meaning that the efficacy of presenting the most effective tools from the literature in a quick-reference guide could not be determined. However, because of the novel approach of combining these assessment techniques on a quick-reference guide, results from this study have the potential

to guide future quality improvement measures by providing more evidence as to the helpfulness of these assessment measures used in combination.

Project Framework

This project utilized the plan-do-study-act (PDSA) cycle from the Institute for Health Improvement's (IHI) model for improvement (Langley et al., 2009). The PDSA cycle is a framework for implementing, evaluating, and improving interventions within healthcare in the spirit of quality improvement. In this project, a single PDSA cycle was completed to plan the quick-reference guide, implement use of the reference guide, evaluate feedback about its usefulness to clinical practice, and suggest changes to the quick-reference guide that may be more useful in future quality improvement projects. This model is beneficial because it acts as an additional and simplified framework for quality improvement instead of replacing other methods that may already be in place in healthcare facilities. It is a good choice for this project because it can be used quickly to analyze results and has been developed for testing changes even in very small projects.

Ethical Considerations and Protection of Human Subjects

The target population for this intervention was CRNAs who work with patients with obesity. There was some potential that participating in the project, including use of the quick-reference guide, could minimally disrupt usual practice for CRNA participants. However, the effect was anticipated to be minimal as the intervention aligned with accepted care standards, including many currently used assessments. Although this quick-reference guide included some airway assessment techniques that may not usually be a part of everyday airway assessment, patient care should not have been altered by use of the quick-reference guide because it included techniques that work best in this population. No patients were a part of the target population, and

no personal data or identifying information were collected. Additionally, development of a quick-reference guide could potentially benefit the entire population of CRNAs that work with patients with obesity because dissemination of the quick-reference guide could help to improve practice, make practice safer, or meet the goals of continuing education and quality improvement set out by the AANA (2019) standards.

Several steps were involved in preparing for this project and moving through the approval process. First, CITI modules from https://about.citiprogram.org/ for Responsible Conduct of Research and All Biomedical Investigators and Key Personnel were completed. Then, a screening process from the College of Nursing and the University Medical Center Institutional Review Board (UMCIRB) was completed to evaluate whether this project qualified as quality improvement or research. Because the project was determined to be a quality improvement project, it was exempt from full IRB approval.

Finally, UMCIRB approval and approval from the partnering organization's research office was sought after the quick-reference guide and project were fully developed and ready to implement. With these two organizations, permission was received through a site contact person, and a form was signed. See Appendix D to view the initial quality improvement screening tool and the final approval form for project implementation from the local facility.

Section III. Project Design

Project Setting

This project took place in the main operating rooms of a 974-bed Level I trauma center in eastern North Carolina. The major medical center has 24 main operating rooms. The existing relationship between the CRNAs at the medical center and the College of Nursing helped facilitate implementation of this DNP project. The medical center also performs a high volume of cases, serving as a potential facilitator for frequent use of the quick-reference guide. However, the fast-paced environment could also have acted as a barrier to implementation by limiting the amount of time the CRNAs had to use the quick-reference guide.

Project Population

The target population for this project was the CRNAs working in the main operating rooms at the medical center. Ten CRNAs were recruited by the clinical contact person to participate in the quality improvement project. Facilitators to implementing this project with this population included CRNAs familiar with the CRNA program at ECU and being willing to help.

Population-level barriers to implementation included that use of the quick-reference guide could alter CRNA usual practice and slow their workdays. The quick-reference guide was a new tool for the CRNAs, which could have slowed assessments while they learned how to use it. The slowed assessment times may have made them less likely to use the quick-reference guide. Many of the CRNAs at this medical center also have years of experience assessing airways and may not have been willing to change established practice routines that have been working safely. The nature of CRNA work also made dissemination of laminated copies difficult; CRNAs work individually in operating rooms, and finding a common time between cases to locate those involved and discuss the project was difficult. Additionally, the student

registered nurse anesthetist (SRNA) implementing the project was only present in the main operating rooms for two days during the project implementation period. Some of the CRNAs involved were not working on the two days that the SRNA was present.

Project Team

The team lead for this project was one primary SRNA. The team further consisted of three additional SRNAs, a project chair, a site contact person, a clinical contact person, the CRNA program director, and the DNP course director. The SRNAs and the project chair developed the project and implementation materials. The site contact person signed the agreement for data to be collected at the surgical site. The clinical contact person helped recruit participants and facilitated communication between the SRNA team lead and the CRNA participants. The CRNA program director oversaw the entire project and provided the opportunity to disseminate findings to meet the requirements for the DNP degree. Finally, the DNP course director helped provide a timeline and outline for the DNP project by developing a structured course to guide students through the process. The DNP course director also provided feedback on the content and sources included in the literature review to ensure accuracy and completeness.

Initial planning of the project took place between the team lead SRNA, the three additional SRNAs, and the project chair. The four SRNAs developed the quick-reference guide, the pre- and post-implementation surveys, and the educational PowerPoint as a group. Guidance was provided by the project chair, who acted as a mentor by assisting with topic development and corresponding problem and purpose statements. The project chair also gave feedback about how to revise implementation materials. Once planning was complete, project implementation was completed individually.

The team lead SRNA used the developed quick-reference guide, pre- and post-implementation surveys, and educational PowerPoint to implement the DNP project at their assigned implementation site. Each student was assigned a separate implementation site with a different CRNA target population. Communication between the CRNAs at the assigned site and the team lead SRNA was facilitated by the clinical contact faculty member. All data from the pre- and post-implementation surveys were collected through Qualtrics and analyzed individually. Literature reviews and papers were also written individually.

Methods and Measurement

The purpose of this DNP project was to assess CRNAs' perceptions of the adequacy of a newly developed quick-reference guide as a tool for airway assessment in patients with obesity. The knowledge gained from this project could be used in future quality improvement efforts aimed at improving anesthesia care in patients with obesity. A single PDSA cycle was used as the framework.

The *plan* phase of the cycle involved a literature review and synthesis of relevant evidence. Knowledge gained from the literature review was used to create a quick-reference guide and an educational PowerPoint about which airway assessment techniques best predict difficult airways in patients with obesity. Before project implementation, pre- and post-implementation surveys were also created as a method of evaluating the CRNAs' perceptions of the quick-reference guide. Questions on the surveys were as similar as possible to allow for data analysis between the pre- and post-implementation surveys. The questions were a mix of ordinal questions, with Likert-type rankings for how much the CRNAs agreed with a statement or used an assessment technique, and free response questions. Emails were also drafted, which contained links to the surveys, a digital copy of the quick-reference guide, and the educational PowerPoint.

In addition to the emailed quick-reference guide, laminated, pocket-sized versions were created for use in the operating room. See Appendix E for the quick-reference guide, Appendix F for the email to participants, Appendix G for the copies of the Qualtrics survey questions, and Appendix H for the copies of the PowerPoint slides.

In the *do* phase of the PDSA cycle, the first drafted email was sent to all CRNA participants. Participants were asked to complete the pre-implementation survey before looking at either the PowerPoint or the quick-reference guide. All results from Qualtrics were gathered confidentially for the pre- and post-implementation surveys. Once the pre-implementation surveys were completed, the participating CRNAs were asked to look over the PowerPoint educational tool, which contained voiceovers to explain the evidence gathered in the literature review about each airway assessment tool on the quick-reference guide. The laminated versions of the quick-reference guides were distributed to the CRNA participants on the first day of clinical at the surgical site, and any questions or concerns about the project were answered. Then, the CRNAs were asked to use the quick-reference guides for two weeks to guide their airway assessments of patients with obesity. After the two-week implementation, participants were asked to complete the post-implementation surveys.

In the *study* phase of the PDSA cycle, the results for the pre- and post-implementation surveys were analyzed in Excel. The results were analyzed for any changes in frequency of use of the assessment techniques on the quick-reference guide and for interest in learning more about new airway assessment techniques. The results were additionally analyzed for what the participants felt worked best and for suggested improvements.

In the *act* phase of the PDSA cycle, the findings from data analysis were used to determine any necessary adjustments to the quick-reference guide. The results were synthesized,

and a poster was created and presented to CRNA students and faculty at the College of Nursing as well as any CRNA participants who chose to attend. Finally, the finished paper and poster were uploaded into ECU's digital repository, The Scholarship.

Section IV. Results and Findings

Results

The purpose of this project was to assess CRNA perceptions of the usefulness of a quick-reference guide developed to assist with assessing airways of patients with obesity. Data were collected using a pre- and post-implementation Qualtrics survey before and after a two-week implementation period. The surveys were designed to collect data on CRNAs' estimates of the percentage of patients with obesity in a typical two-week period and to assess frequency of use before and after project implementation of six airway assessment measures and one method of improving airway visualization. Finally, data were collected on CRNA perceptions about the usefulness of these airway assessment techniques and the quick-reference guide.

Ten CRNA participants were sent identical emails the evening before implementation of the project. The emails introduced participants to the purpose of the project. They also contained copies of the quick-reference guide, the PowerPoint, and a link for completion of the pre-implementation survey. Participants were asked to complete the pre-implementation survey and view the PowerPoint, then use the quick-reference guide for two weeks. Two emails were sent during the two-week implementation to remind participants that the project was ongoing. Then, participants were asked to complete the post-implementation survey at the end of the two-week implementation period, and a reminder post-implementation email was sent a few days later. Finally, participants received an email thanking them for participation and notifying them of when results would be shared. See Appendix E for the quick-reference guide, Appendix F for the emails sent to participants, Appendix G for the pre- and post-implementation survey questions, and Appendix H for the PowerPoint slides.

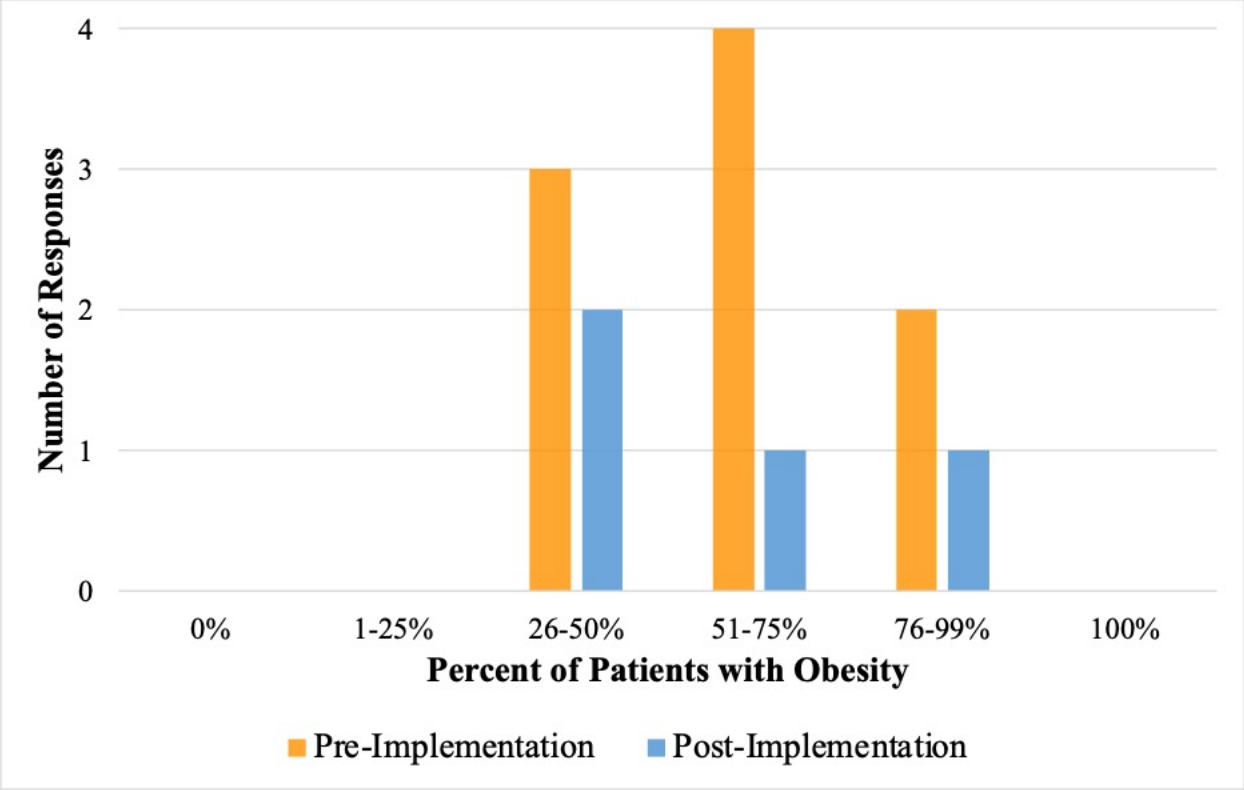
During this period, nine of ten invited participants responded to the pre-implementation survey, and four of those nine responded to the post-implementation survey. Data were extracted from surveys using Qualtrics and were analyzed in Excel.

Data Presentation

Participating CRNAs were asked to estimate what percentage of their patients in a typical two-week period have obesity. Then, they were asked to estimate the percentage of their patients with obesity during the two-week implementation period. Figure 1 shows the percentage of patients with obesity as reported by the CRNAs both pre- and post-implementation.

Figure 1

Percent of Patients with Obesity in a Typical Two-Week Period Versus During Implementation



Note. n = 9 on the pre-implementation survey and n = 4 on the post-implementation survey.

As depicted in Figure 1, three of nine respondents indicated 26-50%, four of nine indicated 51-75%, and two of nine indicated 76-99% of their patients have obesity in a typical two-week period. None of the nine respondents on the pre-implementation survey and none of the four respondents on the post-implementation survey indicated 0%, 1-25%, or 100% of their patients have obesity in a typical two-week period. After implementation, two of four respondents reported 26-50%, one of four reported 51-75%, and one of four reported 76-99% of their patients had obesity in the two-week implementation period.

The CRNAs were also asked to comment on how true they believed two statements to be: that patients with obesity are more difficult to mask ventilate and that patients with obesity are more difficult to intubate. Regarding the statement about mask ventilation, of nine respondents to the pre-implementation survey, none indicated the statement was *entirely false*, one each reported the statement was *somewhat false* or *neither true nor false*, six found the statement *somewhat true*, and one found the statement *entirely true*. On the post-implementation question regarding the same statement that patients with obesity are more difficult to mask ventilate, of the four respondents, none found the statement *entirely false*, one each indicated the statement was *somewhat false* or *neither true nor false*, two found the statement *somewhat true*, and none found the statement *entirely true*.

Regarding the statement that patients with obesity are more difficult to intubate, of nine respondents to the pre-implementation survey, one indicated the statement was *entirely false*, one found the statement *somewhat false*, three found the statement *neither true nor false*, four found the statement *somewhat true*, and none found the statement *entirely true*. On the post-implementation survey, of four respondents, none found the statement *entirely false*, one found

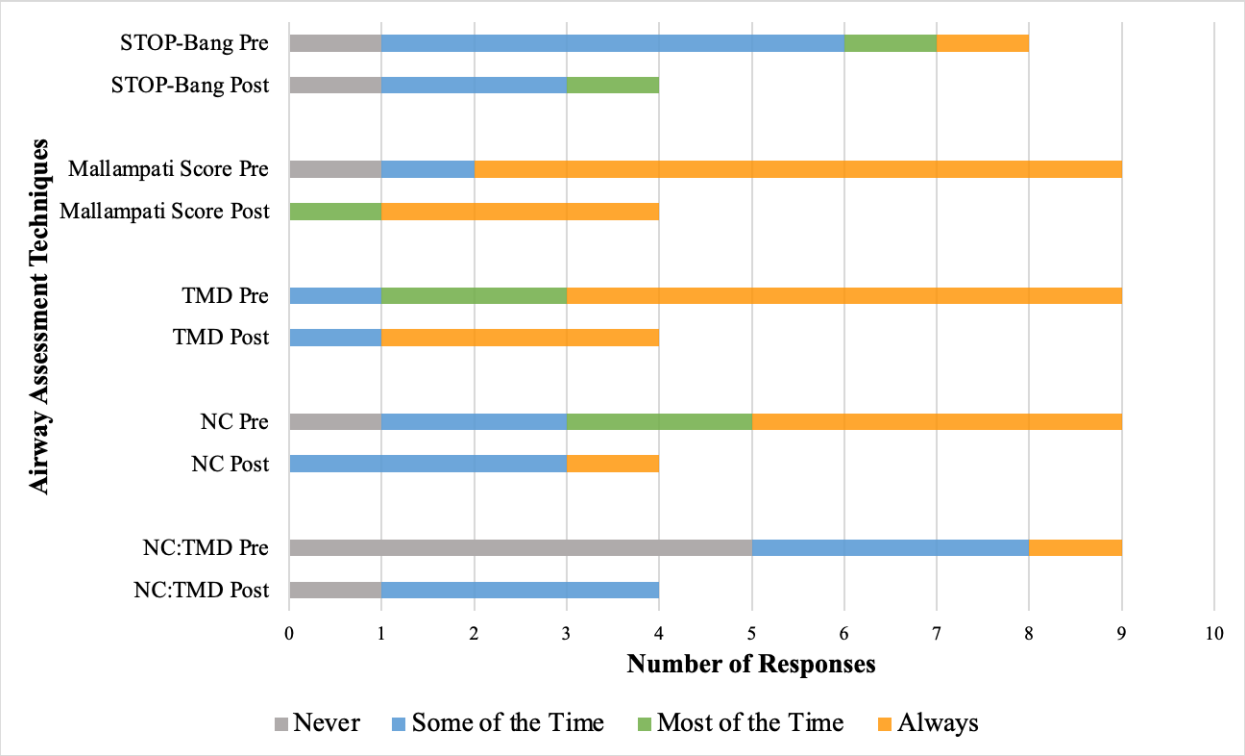
the statement *somewhat false*, one found the statement *neither true nor false*, two found the statement *somewhat true*, and none found the statement *entirely true*.

The pre- and post-implementation surveys also included questions to assess whether any respondents had received training with point-of-care ultrasound (POCUS) for airway assessment and whether CRNAs expressed interest in becoming trained to use ultrasound for airway assessment. None of the nine respondents reported receiving prior training in use of POCUS for assessing airways for patients with obesity, and no respondent indicated they used POCUS to assess airways before project implementation. On the post-implementation survey, one of four respondents indicated no interest in becoming trained to use POCUS to assess patients' airways, while one respondent indicated a moderate interest, and two respondents indicated that they would be very interested. As far as use of POCUS, after implementation, three of four respondents indicated that they did not use POCUS during the implementation period, but one participant indicated that they used POCUS *some of the time*.

The pre- and post-implementation surveys additionally assessed how often CRNA participants used the airway assessment measures included on the quick-reference guide and assessed their perceptions about the utility of these airway assessment measures in predicting difficult airways for patients with obesity. Figure 2 depicts how often the CRNAs reported using the five airway assessment measures included on the quick-reference guide both before and after project implementation.

Figure 2

Frequency of Airway Assessment Measure Use Before and After Quick-Reference Guide Use



Note. n = 9 on the pre-implementation survey and n = 4 on the post-implementation survey. TMD refers to the thyromental distance. NC refers to neck circumference. NC:TMD refers to the ratio between neck circumference and thyromental distance.

Figure 2 shows that, for the STOP-Bang score, one respondent reported *never* using the score in evaluating airways in patients with obesity on both the pre- and post-implementation surveys, and one reported using the score *most of the time* on both the pre- and post-implementation surveys. Most responses indicated that CRNAs used the score *some of the time*; five of nine respondents on the pre-implementation survey and two of four on the post-implementation survey indicated that they used the STOP-Bang score *some of the time*. One of

nine respondents indicated on the pre-implementation survey that they *always* used the STOP-Bang score.

Figure 2 also demonstrates that, for the Mallampati score, most respondents (seven of nine on the pre- and three of four on the post-implementation survey) reported *always* using this assessment technique. Pre-implementation, one respondent each reported using the Mallampati score *never* or *some of the time*. Post-implementation, no respondents reported that they used the assessment technique less than *most of the time*.

For the thyromental distance, data in Figure 2 indicates that most respondents on both the pre- and post-implementation surveys answered that they *always* use this assessment technique. On the pre-implementation survey, one of nine CRNA respondents reported using the technique *some of the time*, and two indicated they use it *most of the time*. After implementation, one of four respondents indicated they used the technique *some of the time*.

For neck circumference, Figure 2 demonstrates that, on the pre-implementation survey, one of nine respondents reported *never* using this technique, two respondents reported use *some of the time*, two respondents reported use *most of the time*, and four respondents reported *always* using this technique. After implementation, three of four respondents indicated they used the technique *some of the time* while one of four respondents indicated they *always* used the technique.

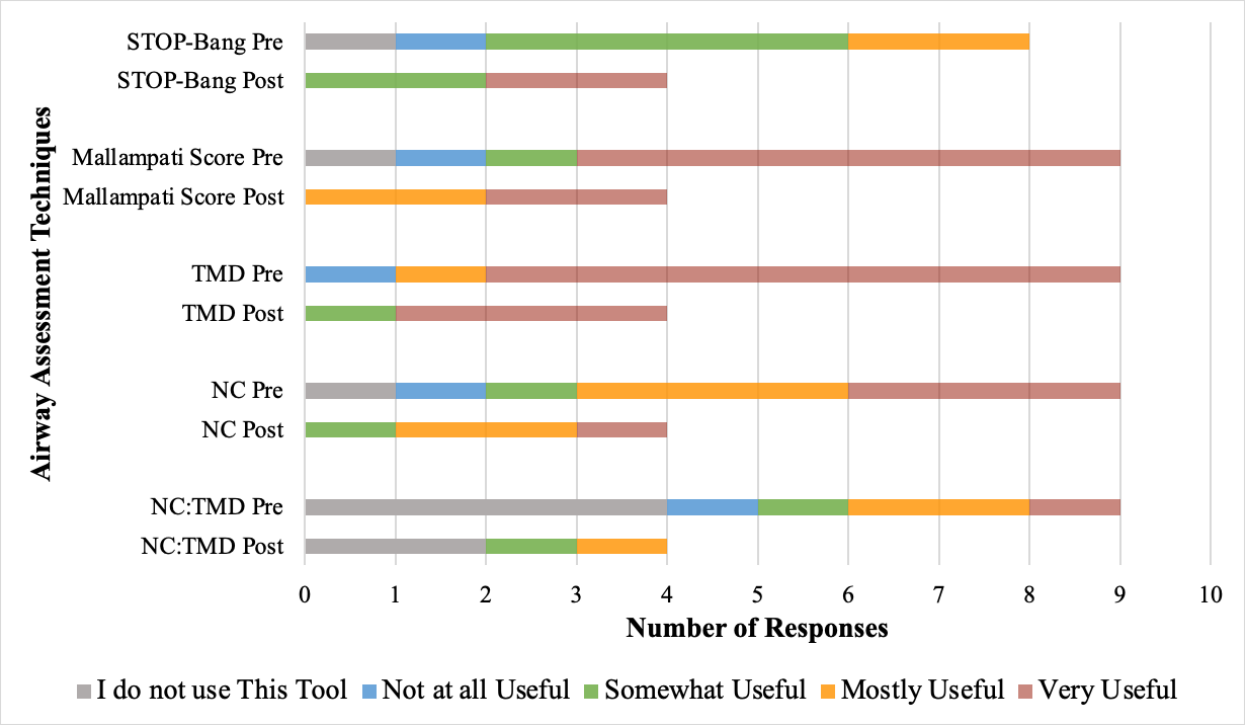
Figure 2 lastly shows that, for the ratio between neck circumference and thyromental distance, five of nine respondents on the pre-implementation survey and one of three respondents on the post-implementation survey indicated they *never* used this assessment technique. Three respondents reported using this technique *some of the time* on both the pre- and post-

implementation surveys. One respondent reported *always* using this technique on the pre-assessment.

Figure 3 depicts CRNA perceptions of the usefulness of each airway assessment measure before and after project implementation.

Figure 3

Perceptions of the Usefulness of Airway Assessment Measures in Predicting Difficult Airways in Patients with Obesity



Note. n = 9 on the pre-implementation survey and n = 4 on the post-implementation survey. TMD refers to the thyromental distance. NC refers to neck circumference. NC:TMD refers to the ratio between neck circumference and thyromental distance.

Figure 3 shows that, for the STOP-Bang score, one of nine respondents to the pre-implementation survey reported *never* using this tool, one reported feeling this tool was *not at all useful* in predicting a difficult airway, four reported this tool is *somewhat useful*, and two reported this tool is *mostly useful*. No respondents to the pre-implementation survey reported that the STOP-Bang is *very useful*. In the post-implementation survey, two of four respondents found this tool *somewhat useful*, and two found this tool *very useful*.

For the Mallampati score's usefulness in predicting a difficult airway, Figure 3 shows that, of nine respondents to the pre-implementation survey, one each indicated that they *do not use this score*, that they find the Mallampati score *not useful*, and that they find the Mallampati score to be *somewhat useful*. Six respondents indicated they believe the Mallampati score to be *very useful*. On the post-implementation survey, two participants indicated that the Mallampati score is *mostly useful,* and two indicated *very useful*.

For thyromental distance's usefulness in predicting a difficult airway, Figure 3 shows that, on the pre-implementation survey, of nine respondents, one each indicated this assessment method is *not at all useful* or *mostly useful*. Seven respondents indicated this assessment method is *very useful*. On the post-implementation survey, one of four respondents indicated this method is *somewhat useful*, and three of four indicated it is *very useful*.

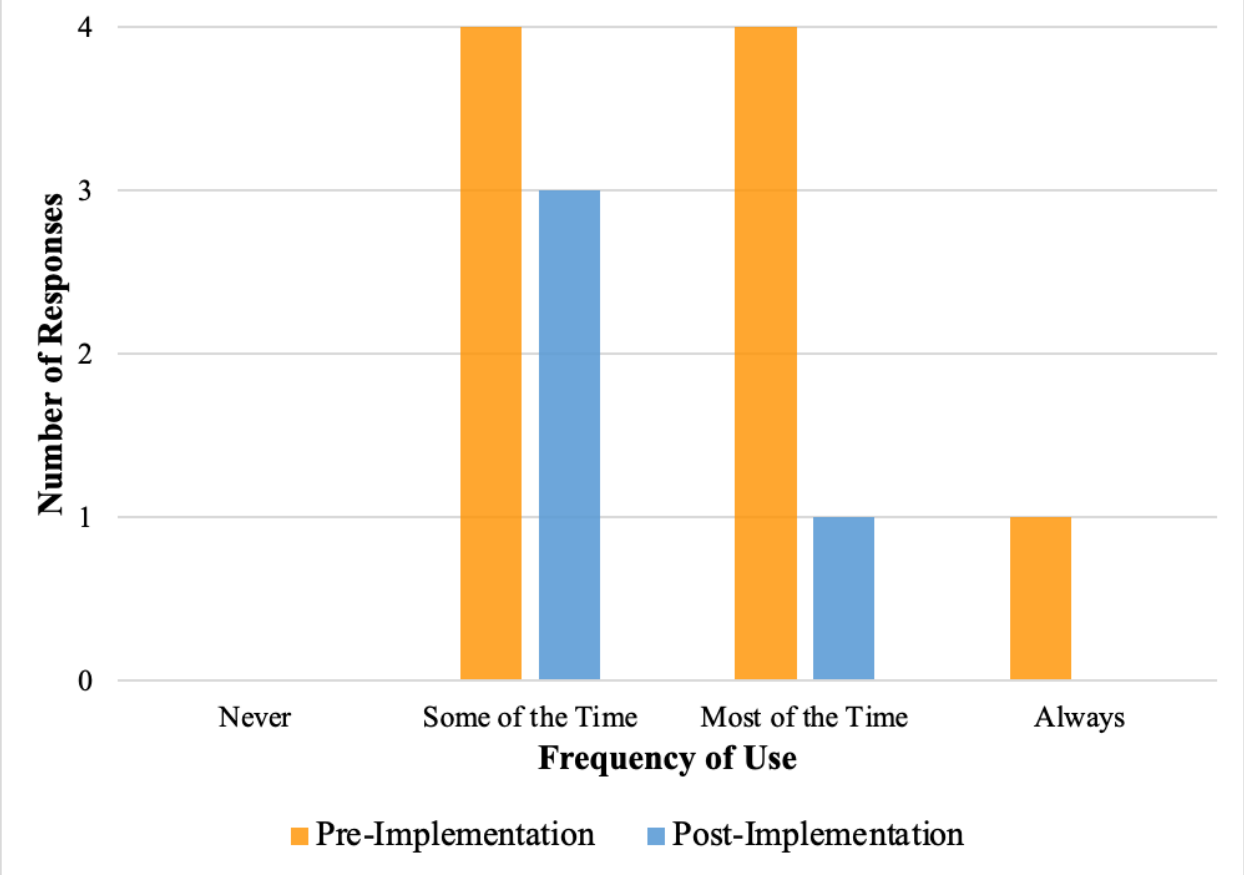
For neck circumference's usefulness in predicting a difficult airway, Figure 3 shows that, on the pre-implementation survey, of nine respondents, one each indicated they *do not use this tool*, they find this tool *not useful*, and they find this tool *somewhat useful*. Three respondents indicated the tool is *mostly useful*, and three indicated the tool is *very useful*. On the post-implementation survey, one of four respondents found the tool *somewhat useful*, two of four respondents found the tool *mostly useful*, and one of four respondents found the tool *very useful*.

Finally, Figure 3 shows that, for the ratio between neck circumference and thyromental distance's usefulness in predicting a difficult airway, on the pre-implementation survey, four of nine respondents indicated they *did not use this tool*, one each found the tool *not at all useful*, *somewhat useful*, or *very useful*, and two found the tool *mostly useful*. On the post-implementation survey, two of four respondents reported they *did not use this tool*, and one each found the tool *somewhat useful* or *mostly useful*.

Figure 4 depicts how often CRNA participants "ramped" patients.

Figure 4

Frequency of Ramping Patients with Obesity Before and After Project Implementation



Note. n = 9 on the pre-implementation survey and n = 4 on the post-implementation survey.

Figure 4 depicts that, on the pre-implementation survey, four of nine participants reported ramping patients to optimize intubating conditions in patients with obesity *some of the time*, four reported ramping *most of the time*, and one reported *always* ramping. On the post-implementation survey, three of four participants reported ramping *some of the time*, and one reported ramping *most of the time*.

The final set of questions on the post-implementation survey evaluated CRNA perceptions of the usefulness of the quick-reference guide and how often they used the quick-reference guide over the two-week implementation period. They were additionally asked what they found to be most useful on the quick-reference guide and what was least useful or could be improved. One of four respondents found the quick-reference guide *somewhat useful*, while one of the four respondents reported it was *mostly useful*. Two of four respondents reported the quick-reference guide was *very useful*. None reported that they *did not use* the quick-reference guide or that they used it *always*. Two of four respondents used the guide *some of the time* while an additional two used it *most of the time*.

In the free response section to determine participants' impressions of which aspects of the quick-reference guide worked well and what could be improved, only one participant commented what worked well on the quick-reference guide, which was "aligning the three axes." Two participants provided comments about what they perceived was least useful about the quick-reference guide. The answers included "STOP-BANG" and "realistically I probably won't ever measure someone's neck."

Analysis

The questions about percentage of patients cared for that had obesity were intended to determine the utility of the quick-reference guide for the CRNAs during the implementation

period in comparison to a typical two-week period. The initial impression of Figure 1 indicates the participants may have cared for fewer patients with obesity during the implementation period, potentially influencing reports of actual and perceptual utility of the quick-reference guide. Alternately, participants may have overestimated how many patients they care for in a typical two-week period that have obesity. The largest number of respondents on the pre-implementation survey estimated that 51-75% of their patients have obesity in a typical two-week period. In comparison, the largest number of respondents on the post-implementation survey, two of four respondents, reported that 26-50% of their patients had obesity during the implementation period. However, the difference between the number of respondents to pre- and post-implementation surveys makes direct comparison difficult. What is most notable from the data is that every CRNA indicated that at least 26% of the patient population that they typically care for has obesity. While this figure may not be exact because the answers were based on estimations, these responses highlight the importance of learning which assessment measures work most reliably for predicting difficult airways in patients with obesity. A better understanding of the accuracy of different airway assessment measures could help to increase safety for a large proportion of patients.

The question assessing how much CRNAs agreed with two statements about mask ventilation and intubation was designed to assess the utility of a quick-reference guide in helping with assessment for patients with obesity. While there was some variability in the answers from CRNAs about the truthfulness of these two statements, the response most highly selected on both the pre- and post-implementation surveys was that CRNAs found both statements *somewhat true*. However, the pre-implementation survey results indicate stronger support for the statement that mask ventilation is more difficult than that intubation is more difficult. On the pre-

implementation survey for the statement about mask ventilation, the majority of CRNAs found the statement *somewhat true*. Only three of nine CRNAs provided a response other than that they found the statement to be *somewhat true*. In comparison, on the pre-implementation survey for the statement about intubation, five CRNAs gave a response other than that they found the statement to be *somewhat true*. Although *somewhat true* did have the largest number of responses compared to other answer choices, the majority of CRNAs indicated they found the statement about intubation to be *entirely false*, *somewhat false*, or *neither true nor false*. For this reason, the data suggest that CRNAs in this quality improvement project consider mask ventilation, but not necessarily intubation, to be more difficult in patients with obesity. Interestingly, this result aligns with current evidence in the literature (Thota et al., 2022).

The instructional PowerPoint introduced some data about POCUS utility in airway assessment for patients with obesity in the interest of continuing education, but it was not included on the quick-reference guide because no training in the use of POCUS was provided. The purpose of POCUS inclusion in the PowerPoint was to provide education on an airway assessment technique that may become more common in the future. The questions about POCUS on the surveys were meant to assess for prior experience with POCUS and to assess for interest in learning more about this assessment technique. No participants indicated that they received training in POCUS for airway assessment or used it to assess airways, but on the post-implementation survey, one of four respondents indicated they used POCUS *some of the time*. It is possible that the one respondent who reported using POCUS some of the time during the implementation period found the technique interesting and wanted to use it based on the information provided in the PowerPoint. Overall, interest in learning more about POCUS was

high, with three of four respondents indicating that they would be *very interested* or *somewhat interested* and only one indicating that they would be *not at all interested*.

The pre- and post-implementation surveys also assessed use and thoughts about usefulness of, the included airway assessments. Again, when comparing results between pre- and post-implementation surveys, direct comparison is complicated by a large difference between sample sizes. However, some comparisons can be made.

For use of the STOP-Bang score to predict difficult airways in patients with obesity, most respondents to the pre-implementation survey and two of four respondents to the post-implementation survey indicated they use this technique *some of the time*. When looking at perceptions about utility in predicting difficult airways in patients with obesity, most respondents on the pre-implementation survey reported feeling that the STOP-Bang is *somewhat useful* or *mostly useful*, but some participants did indicate that they *do not use the tool* or find it to be *not at all useful*. After implementation, all participants reported the STOP-Bang score to be *somewhat useful* or *very useful* in predicting difficult airways in patients with obesity. These results could indicate that use of STOP-Bang and perceptions about its utility increased with use of the quick-reference guide. However, with a 45% response rate on the post-implementation survey and small sample size (n=9), no conclusion about the use of this tool can be made.

For use of the Mallampati score in predicting difficult airways in patients with obesity, most respondents reported this tool is *very useful* and reported *always* using this score. While one person each on the pre-implementation survey reported the Mallampati score was *not at all useful* or that they *do not use this tool* in predicting difficult airways in patients with obesity, and no participants on the post-implementation survey reported that the tool was less than *mostly useful*, the limited sample size on the post-implementation survey (n=4) makes direct comparison

of results challenging. It cannot be known if opinions changed in favor of utility of the tool in predicting difficult airways in patients with obesity or if opinions improved on the post-implementation survey because participants that responded to the pre-implementation survey did not respond to the post-implementation survey.

For use of thyromental distance to predict difficult airways in patients with obesity, most participants indicated they use this tool *always* and find this tool *very useful*. Before implementation, one participant indicated that this tool was *not at all useful* for predicting difficult airways in patients with obesity. No participants reported that this tool was less than *somewhat useful* on the post-implementation survey. These results indicate that participants may have increased their opinions about usefulness of thyromental distance in predicting difficult airways in patients with obesity. However, because of the small sample size (n=9) and disparity between the number of respondents to pre- and post-implementation surveys, no firm conclusion can be drawn.

For use of neck circumference in predicting difficult airways in patients with obesity, utilization of this tool varied in the pre-implementation survey, with no clear majority. In the post-implementation survey, no participants indicated they used the tool *never* or *most of the time*. Thoughts about utility of this tool were also vague. Two participants reported this tool is *mostly useful* in predicting difficult airways in patients with obesity, while two of four participants perceived the tool to be either *somewhat useful* or *very useful*. With the small sample size (n=9) and low response rate to the post-implementation survey (n=4) it is difficult to draw any conclusions.

For use of neck circumference to thyromental distance ratio in predicting difficult airways in patients with obesity, few reported using the tool on either the pre- or post-

implementation surveys. Perceptions about utility of the ratio for predicting difficult airways in patients with obesity were also low. Most respondents on both the pre- and post-implementation surveys indicated they found the tool *not at all useful*. The data may support the conclusion that thoughts about usefulness and use of the thyromental distance to neck circumference ratio in predicting difficult airways in patients with obesity changed very little and remained low. However, once again, the small sample size (n=9) and low response rate to the post-implementation survey makes drawing conclusions difficult.

For ramping to improve visualization during an intubation attempt, the data in Figure 4 appears to indicate that use of ramping decreased after project implementation, but the difference in size between the pre-implementation response group (n=9) and the post-implementation response group (n=4) makes drawing any conclusion difficult.

None of the four respondents on the post-implementation survey indicated they found the quick-reference guide *not at all useful*. This result could indicate that the format of a quick-reference guide could work well to present airway assessment measures together in a way that CRNAs find useful, even if they find differing levels of utility in this presentation method. While no CRNAs indicated they *always* used the quick-reference guide, none indicated they *never* used it either. These results could indicate that the quick-reference guide could act as a helpful addition to the pre-anesthetic assessment. These results also indicate that perceptions about what worked well and what could be improved are based on actual experience using the guide. One participant responded that the depiction of aligning the three axes worked well. Two participants indicated that STOP-Bang and neck circumference measurements were not useful in predicting difficult airways in patients with obesity. Likely, these measures take a longer time to complete pre-operatively, decreasing their utility in the fast-paced operating room environment. However,

reasoning for what worked well and what did not was not given, so any conclusions drawn here are based on speculation.

Section V. Implications

Financial and Nonfinancial Analysis

The quick-reference guide has the potential to be financially beneficial to the medical center and could improve quality of patient care. There was very little cost for implementation, and potential benefits to the organization make up for any cost incurred.

This medical center had several resources that may have added to successful use of the quick-reference guide and could help with successful dissemination of a quick-reference guide for airway assessment implemented by the medical center itself. This medical center has many CRNAs who are dedicated to ensuring safe and quality patient care who are willing to try new evidence-based techniques such as POCUS or a quick-reference guide to improve patient care. This medical center also has computers in every preoperative space and OR, which could make access to an electronic copy of the quick-reference guide easy and increase potential for use.

Comparatively, although there were some barriers to quick-reference guide use, they were minimal. The main barrier was likely the current lack of available tape measures for patient neck circumference assessment. Although it is impossible to say that the use of the neck circumference measure would increase with the availability of tape measures, the lack of tape measures may decrease the use of the neck circumference airway assessment tool. Easy access to resources, with additional education about the accuracy of neck circumference measurement in prediction of difficult airways for patients with obesity, would likely make the use of the tape measure for assessment much more common. At the very least, the neck circumference measure was one of the two measures, together with the Mallampati score, that had the largest number of studies supporting its relationship with prediction of difficult airways in the literature review.

Providing tape measures would be a relatively low-cost solution, as discussed below, and could help to increase use of this assessment method.

Cost of quick-reference guide implementation to the medical center would also be low. Firstly, most participants did not receive laminated copies of the quick-reference guides and instead used the PDF copies sent in the first email. If this approach was used by this medical center, there would be no cost for distributing the quick-reference guides to the CRNAs, as the quick-reference guides could be accessed on the CRNAs' mobile devices or the computers in the preoperative area. Training to use the quick-reference guide was also completed in less than 10 minutes through a voiceover PowerPoint, and this training could be completed at work, minimizing additional training costs to the medical center.

Secondly, the quick-reference guide contains mostly airway assessment measurements that are commonly used. Using the quick-reference guide should minimally disrupt existing CRNA workflow once they are familiar with the tool. No cost should be expected from delayed start times in the operating rooms.

Lastly, the quick-reference guide contains mainly airway assessment measurements that can be used with no additional supplies. The exception is the neck circumference measurement, which would require the purchase of pliable tape measures for CRNA use. However, these tape measures would only be used in airway assessment, meaning that they would only be required in preoperative spaces. Purchasing tape measures and placing one in each of the preoperative spaces at the main operating rooms would not be as expensive as purchasing one for each CRNA to carry around. The cost would also be minor; one site selling medical supplies lists their tape measures at $0.59 per tape measure, and the hospital likely already purchases tape measures for specific units in the hospital and could likely buy tape measures at a discounted price (The

Perfect Measuring Tape Company, 2024). Additionally, once purchased, the tape measures could be reused by cleaning them with the existing wipes that the medical center already provides. Alternatively, the preoperative clinic could implement a protocol of measuring neck circumference for all patients.

In comparison to these costs to implement the use of a quick-reference guide, the costs of patient harm from unidentified difficult airways are much higher. The inability to predict, prepare for, and appropriately manage a difficult airway can lead to patient harm that may result in unanticipated hospital stays, prolonged reliance on mechanical ventilation, or death. The results from this project indicate that perhaps 26% of the patient population cared for by this medical center have obesity. Although this figure is an estimate and may not be completely accurate, if at least a quarter of the patients cared for have the potential for an unidentified difficult airway, this medical center is more at risk for unanticipated high costs related to unidentified difficult airway events. A 2021 study by Moucharite et al. identified that the cost for ICU stays was $14,468 higher, and for inpatient stays was $4,029 higher for stays related to difficult intubations when compared to those that were not. The length of stay for ICU and inpatients were also 2 and 3.8 days longer, respectively. The researchers found that obesity was statistically significantly related to difficult intubations. Implementation of a quick-reference guide that includes the most accurate airway assessment measures for patients with obesity could help to prevent unidentified difficult airway events and save the medical center the costs related to them.

Comparing the potential cost of unidentified difficult airways for the medical center to the cost of disseminating the quick-reference guide and related tools demonstrates a minimal cost but potentially large benefit in determining the most effective assessments for patients with

obesity and providing them in a quick-reference guide format. It is difficult to determine an exact estimate of cost that could be spared by the medical institution because published figures about the number of hospital admissions related to unanticipated difficult airways in patients with obesity could not be found. However, if the medical center secures as good a price on tape measures as at the site listed earlier, the cost for implementing use of the quick reference guide would be approximately $25. In comparison, if even one patient has an unidentified difficult airway event and requires an inpatient stay, the cost to the institution could be about $4,029 or more (Moucharite et al., 2021). In addition to potential benefits to income and a decrease in costs related to difficult airway events, this project could also improve quality of care provided to patients and improve efficiency in airway assessment by standardizing care.

Implications of Project

Recent research indicates that a combination of assessment techniques may better predict difficult airways in patients with obesity, and new techniques, such as point-of-care ultrasound, are being investigated for accuracy (Emik et al., 2021; Thota et al., 2022). The 2022 ASA practice guidelines recommend use of multiple airway assessment techniques in all airway assessments to better predict difficult airways (Apfelbaum et al., 2022). However, the AANA and ASA do not specify which combination of techniques to use. Presentation of the most recent data related to accuracy of airway assessment techniques in patients with obesity can, therefore, help to prepare anesthesia providers to care for this patient population and to further the goal of providing the most collect evidence-based care. Additionally, the AANA (2019) includes participation in quality improvement and fostering a culture of safety as two standards of anesthesia care.

This quality improvement project was intended to evaluate CRNA perceptions of the usefulness of a newly developed quick-reference guide for airway assessment in patients with obesity. Because results from the literature review indicated that no one assessment method could be determined to work best, and recent literature indicates that a combination of techniques may best predict difficult airways, the quick-reference guide was designed to include all the most evidence-based airway assessment techniques identified in the literature review.

The results of this quality improvement project suggest that presentation of these airway assessment measures may be effective in a quick-reference guide format and that most of these may be considered useful by the CRNAs at this medical center, but a much larger quality improvement project would need to be implemented to know for sure. While there was likely a similar proportion of patients with obesity during implementation as during any two-week period, there were too few respondents on the post-implementation survey to make conclusions about changes to opinion about use of airway assessment measures. The exception to this statement is the evaluation of the use of POCUS. The results from this project indicate that no CRNA participants were trained in the use of POCUS but that most respondents to the post-implementation survey expressed some interest in learning how to use POCUS in airway assessment. These results indicate that future quality improvement projects could be implemented to identify the accuracy of POCUS in predicting difficult airways for this patient population and to train CRNAs in the use of POCUS.

Results from this project also indicated that a clear majority of CRNAs considered mask ventilation, but not necessarily intubation, to be more difficult for patients with obesity. This opinion is supported in the literature (Thota et al., 2022). Of note, the literature review for this project included a discussion of the airway assessment measures that work best in predicting

difficult mask ventilation because of the importance of ventilation when intubation cannot be achieved. The literature review suggested that difficult mask ventilation may be the difficult airway issue most associated with obesity. For this reason, the most common factors found to be associated with difficult mask ventilation were included on the quick-reference guide and in the educational PowerPoint. The results from this quality-improvement project suggest that any other developed quick-reference guide would likely benefit from inclusion of a section about difficult mask ventilation predictors in patients with obesity.

When considering individual airway assessment measures included on the quick-reference guide, results of this quality improvement project vary. The literature review indicated that airway assessment measures with best evidence to support them as predictors of difficult airways in patients with obesity included identifying OSA, the Mallampati Score, and neck circumference measurements. Opinions about and use of the STOP-Bang score in this quality improvement project indicated this tool may be helpful, but further investigation is needed. However, the Mallampati score and neck circumference were two of the three most-used tools in this quality improvement project. The Mallampati score was the most used and had the highest responses for opinions about the usefulness of the tool, which aligns with the findings in the literature review that the Mallampati score has the largest individual predictive strength for difficult airways in patients with obesity. The neck circumference measurement also had high levels of evidence in the literature review indicating that a larger neck circumference has a relationship with difficult airways in patients with obesity, and although this measure did have a high level of use on both surveys, the use of this tool could likely be increased if tape measures were provided or if the measurement was completed in the preoperative clinic. Increasing use of this tool would be beneficial for future quality improvement to better determine what tools in

combination may work best to predict difficult airways in patients with obesity. The literature indicates that one tool alone is not sufficient and will not identify many difficult airway events.

In this quality improvement project, the third most-used airway assessment measure was thyromental distance. Participants ranked this tool as *very useful*. In comparison, evidence from the literature review indicated that a decreased thyromental distance is likely related to difficult airways in patients with obesity, but no one cutoff value could be determined, and only a few studies investigated the relationship. These results indicate that quality improvement projects can be vital to identifying assessment measures that may work best in specific patient populations, as experienced CRNAs can identify tools that work best for them and indicate areas where additional research needs to be done.

Finally, the least used tools on the quick-reference guide include the neck circumference to thyromental distance ratio and ramping. There were only a few studies that provided evidence for the ratio found in the literature review, and participants (n=4) for this quality improvement project largely *did not use the tool* and found the tool *not at all useful*, or only found the tool *somewhat useful*. These results could indicate that this tool is too time consuming, or that most practitioners are relying on a visual assessment of neck circumference rather than measuring, so a ratio cannot be obtained. This hypothesis is supported by the free response answers, where one respondent indicated they realistically would not measure a neck circumference. Future quality improvement should be aimed at improving access to supplies for neck circumference measuring to determine if utility of this tool could be increased. Alternately, a quality improvement project could be implemented to create and implement a protocol for neck circumference measurement and thyromental distance to neck circumference ratio calculation at the preoperative clinic. As

for ramping, the number of respondents ramping patients largely did not change during project implementation, and no statistics directly supporting ramping were found in the literature review.

The results from this quality improvement project are important because they can help guide future quality improvement that could improve care for patients with obesity. Identifying airway assessment measures that work best in patients with obesity can help CNRAs prepare for and potentially avoid difficult airway events that can cause patient harm. Avoiding these events not only improves care to patients, but can decrease the cost to patients, CRNAs, and the healthcare organization related to difficult airway events.

Sustainability

If this organization were to implement a larger quality improvement project based on findings from this project, the organization would be able to implement the project with very little financial burden. As discussed, the cost for providing tape measures would be minimal in comparison to the cost of difficult airway events, and even if no difficult airway event occurred during project implementation, the cost of tape measures is very low to a healthcare institution. Additionally, the tape measures would not need to be purchased again, meaning the project could continue indefinitely until enough data were recorded to assess the value to the organization.

Additional quality improvement projects using POCUS might also benefit this patient population. The literature review for this project indicated that different POCUS assessments are being shown to predict difficult airways in this population. A quality improvement project that aimed to provide education to CRNAs about POCUS, train them to use different POCUS techniques, and analyze which techniques could help to identify difficult airways and improve patient care. One possible challenge for this quality improvement project could include the

limited number of ultrasounds in the hospital in combination with the high number of airway assessments occurring concomitantly.

Dissemination Plan

The results from this project were incorporated into a poster presentation delivered to the nurse anesthesia program members, the nurse anesthesia department members, and any project participants who elected to attend. The final version of this paper and the poster are posted in The Scholarship, East Carolina University's digital repository.

Section VI. Conclusion

Limitations

This project had several limitations. Firstly, the sample size (n=9) for the pre-implementation survey alone is too small to allow for generalizability to this healthcare organization. In addition, the very low response rate (n=4) to the post-implementation survey further limits generalizability, but also removes the opportunity to evaluate patterns in changes between the pre- and post-implementation surveys.

Secondly, this project included a variety of airway assessment measures on a quick-reference guide format because no single best airway assessment measure was identified in the literature review. However, data supporting the individual assessment measures varies, and more research needs to be done on all the measures to better identify which work best in this patient population. For this reason, the quick-reference guide cannot be used to determine which measures work best for this population; instead, the results are limited to identifying which measures the CRNAs consider to work best and to evaluating whether a quick-reference guide format is useful for CRNA use in practice.

Recommendations for Future Implementation and/or Additional Study

Future implementation or additional study of the information contained in this quick-reference guide could benefit from some adjustments. Firstly, any additional study of the individual airway assessment measures would be helpful in determining which might work best to include, and which may not. More research needs to be conducted on the effectiveness of specific airway assessment measurements used in combination with each other. Additionally, cutoff values need to be determined through research to make these airway assessment measures more useful and more compelling.

The quick-reference guide format may work well for another organization, but a dissemination plan should be created if hard copies are made. Only two participants received hard copies of the quick-reference guide in this project because no formal dissemination plan was made, meaning that CRNAs had to be located individually when both the SRNA and the CRNA had time to discuss the tool. In the fast-paced operating room environment, and with the lack of schedule overlap, many CRNAs simply were not approached.

The ability to contact CRNAs in person could also help increase response rates and generalizability/lessons learned from the project. It is possible that few CRNAs were invested in the project because they were not directly approached to have the project explained to them. It is also possible that the CRNAs had questions about the project and could not have them answered. Any of these reasons could have led to the much lower response rate for the post-implementation survey, which overall decreased the utility of the project and made conclusions of the results nearly impossible. In future projects, a direct in-person implementation plan would likely work better. To lower costs, hard copies would not necessarily need to be provided, but a meeting time could be planned to allow for CRNAs to come and learn about the project and how to use the airway assessment tool, even if they access it as a PDF on their mobile device.

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Appendices

Appendix A

Literature Search Concept Table

	Concept 1 Obesity	**Concept 2** Airway assessment	**Concept 3** Difficult airway
Keywords	Obesity Bariatric	Airway assessment Anesthesia assessment Preoperative assessment Airway management	Difficult airway Difficult intubation Difficult ventilation Difficult laryngoscopy
PubMed MeSH	"obesity"[MeSH Terms] OR "bariatrics"[MeSH Terms]	"anesthesia"[MeSH Terms] OR "airway management"[MeSH Terms]	"intubation"[MeSH Terms] OR "laryngoscopy"[MeSH Terms] OR "ventilation"[MeSH Terms] OR "ventilators, mechanical"[MeSH Terms]
CINAHL Subject Headings	(MH "Obesity") OR (MH "Obesity, Morbid") OR “bariatric”	"airway assessment" OR "airway" OR "preoperative assessment" OR "anesthesia assessment" OR (MH "Nurse Anesthetists")	"difficult laryngoscopy" OR "difficult airway" OR "difficult ventilation" OR "difficult intubation"
Google Scholar	obesity OR bariatric	“airway assessment” OR “airway management” OR “preoperative assessment” OR “anesthesia assessment”	“difficult airway” OR “difficult laryngoscopy” OR “difficult intubation” OR “difficult ventilation”

Appendix B

Literature Search Log

Search date	Database or search engine	Search strategy	Limits applied	Number of citations found/kept	Rationale for inclusion/exclusion of items
Oct 9, 2023	PubMed	((airway assessment) OR (airway management) OR (preoperative assessment) OR (anesthesia assessment)) AND (obesity OR bariatric) AND ((difficult airway) OR (difficult laryngoscopy) OR (difficult intubation) OR (difficult ventilation)) PubMed interpretation: ((("airway"[All Fields] OR "airway s"[All Fields] OR "airways"[All Fields]) AND ("assess"[All Fields] OR "assessed"[All Fields] OR "assessement"[All Fields] OR "assesses"[All Fields] OR "assessing"[All Fields] OR "assessment"[All Fields] OR "assessment s"[All Fields] OR "assessments"[All Fields])) OR ("airway management"[MeSH Terms] OR ("airway"[All Fields] AND "management"[All Fields]) OR "airway management"[All Fields]) OR (("preoperation"[All Fields] OR "preoperational"[All Fields] OR "preoperations"[All Fields] OR	5 years (2018-2023) English	136/40	This project involves airway assessment of adult populations, so items involving children were eliminated. This project also focuses on assessment of airways, not management, so articles focusing on airway management, laryngoscopy, or treating a difficult airway were also excluded. Any studies that specifically excluded patients with obesity were also ruled out. Included items referred to airway assessment techniques or to techniques to improve laryngeal visualization before a laryngoscopy attempt, such as with the ramp method. Included items focused on adult populations and on parameters that could make airways, intubation,

		"preoperative"[All Fields] OR "preoperatively"[All Fields]) AND ("assess"[All Fields] OR "assessed"[All Fields] OR "assessement"[All Fields] OR "assesses"[All Fields] OR "assessing"[All Fields] OR "assessment"[All Fields] OR "assessment s"[All Fields] OR "assessments"[All Fields])) OR (("anaesthesia"[All Fields] OR "anesthesia"[MeSH Terms] OR "anesthesia"[All Fields] OR "anaesthesias"[All Fields] OR "anesthesias"[All Fields]) AND ("assess"[All Fields] OR "assessed"[All Fields] OR "assessement"[All Fields] OR "assesses"[All Fields] OR "assessing"[All Fields] OR "assessment"[All Fields] OR "assessment s"[All Fields] OR "assessments"[All Fields]))) AND ("obeses"[All Fields] OR "obesity"[MeSH Terms] OR "obesity"[All Fields] OR "obese"[All Fields] OR "obesities"[All Fields] OR "obesity s"[All Fields] OR ("bariatric"[All Fields] OR "bariatrics"[MeSH Terms] OR "bariatrics"[All Fields])) AND ((("difficult"[All Fields] OR "difficults"[All Fields]) AND ("airway"[All Fields] OR "airway s"[All Fields] OR "airways"[All Fields])) OR			ventilations, or visualization more difficult. Decision as to inclusion or exclusion was made from article titles or abstracts.

		(("difficult"[All Fields] OR "difficults"[All Fields]) AND ("laryngoscopy"[MeSH Terms] OR "laryngoscopy"[All Fields] OR "laryngoscopies"[All Fields])) OR (("difficult"[All Fields] OR "difficults"[All Fields]) AND ("intubate"[All Fields] OR "intubated"[All Fields] OR "intubates"[All Fields] OR "intubating"[All Fields] OR "intubation"[MeSH Terms] OR "intubation"[All Fields] OR "intubations"[All Fields] OR "intubator"[All Fields] OR "intubators"[All Fields])) OR (("difficult"[All Fields] OR "difficults"[All Fields]) AND ("ventilated"[All Fields] OR "ventilates"[All Fields] OR "ventilating"[All Fields] OR "ventilation"[MeSH Terms] OR "ventilation"[All Fields] OR "ventilate"[All Fields] OR "ventilations"[All Fields] OR "ventilators"[All Fields] OR "ventilators, mechanical"[MeSH Terms] OR ("ventilators"[All Fields] AND "mechanical"[All Fields]) OR "mechanical ventilators"[All Fields] OR "ventilator"[All Fields] OR "ventilators"[All Fields] OR "ventillation"[All Fields]))			

Oct 9, 2023	CINAHL	((MH "Obesity") OR (MH "Obesity, Morbid") OR "bariatric") AND ("difficult laryngoscopy" OR "difficult airway" OR "difficult ventilation" OR "difficult intubation") AND ("airway assessment" OR "airway" OR "preoperative assessment" OR "anesthesia assessment" OR (MH "Nurse Anesthetists"))	5 years (2018-2023) English Peer Reviewed	44/15	Same rationale used as for PubMed
Sept 21, 2023	Google Scholar	((airway assessment) OR (airway management) OR (preoperative assessment) OR (anesthesia assessment)) AND (obesity OR bariatric) AND ((difficult airway) OR (difficult laryngoscopy) OR (difficult intubation) OR (difficult ventilation))	5 years (2018-2023)	17,200/21 The first four pages of results were reviewed.	Same rationale used as for PubMed

Appendix C

Literature Matrix

Year	Author, Title, Journal	Purpose & Conceptual Framework or Model	Design and Level of Evidence	Setting	Sample	Tool/s and/or Intervention/s	Results
2023	Hung, K.-C., Chuang, M.-H., Kang, F.-C., Chang, Y.-J., Lin, C.-M., Yu, C.-H., Chen, I.-W., & Sun, C.-K. (2023). Prevalence and risk factors of difficult mask ventilation: A systematic review and meta-analysis. *Journal of Clinical Anesthesia*, *90*. https://doi.org/10.1016/j.jclinane.2023.111197	To identify risk factors for and strengths in predicting difficult mask ventilation Framework: None Noted	Systematic review and Meta-analysis Level I	All included studies focused on the operating room	20 studies Published between 2005 and 2022 335,846 patients total	Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines followed for a meta-analysis in: EMBASE MEDLINE Google Scholar Cochrane Library Also performed a search of the cited sources for each relevant article	Investigated 13 risk factors for difficult mask ventilation. Authors noted that included studies varied in reporting of strength of clinical predictors. A note was made that combining data could help to increase sample size and determine power of different assessment measures. Strongest predictive risk factor was neck radiation (5x increased risk), followed by increased neck circumference (4x

							increased risk) and OSA (3.6x increased risk). This analysis did not find independent predictive power of obesity alone for difficult mask ventilation. A neck circumference > 40 cm was found to be the second-best predictor of difficult mask ventilation. The authors discuss that results from prior studies are inconsistent. **Notes:** No standard definition of difficult mask ventilation. The majority of included studies focused on single risk factors/ predictors, not combinations.

2023	Pradeep, S., Bhar Kundu, S., & Nivetha, C. (2023). Evaluation of neck-circumference- thyromental-distance ratio as a predictor of difficult intubation: A prospective, observational study. *Indian Journal of Anaesthesia*, *67*(5), 445–451. https://doi.org/10.4103/ija.ija_631_22	To compare NC/TMD accuracy in predicting difficult airway to neck circumference, thyromental distance, and sternomental distance alone in patients with and without obesity. Framework: None Noted	Prospective observational study Level V	Operating room/ general surgery Calcutta National Medical College and Hospital	100 patients	**Researchers measured:** Neck circumference Thyromental distance Sternomental distance Gap between incisors MMS Body weight Then, anesthesiologists performed laryngoscopy and graded difficulty based on the Intubation Difficulty Scale.	Increased weight and BMI, smaller gaps between incisors, higher MMS, larger neck circumference, larger NC/TMD, and larger thyromental and sternomental distances had significant DI associations. NC/TMD had 94.7% sensitivity in patients with obesity and 100% in patients without obesity. NC/TMD ratio cutoff for patients with obesity 5.05. Thyromental and sternomental distances alone in patients with obesity had decreased sensitivity and could not be considered good predictors.

2023	Sharma, S., Patel, R., Hashmi, M. F., & Friede, R. (2023). 3-3-2 rule. In: *StatPearls*. StatPearls Publishing.	To define the 3-3-2 rule as part of continuing education and to discuss the benefits of the tool in clinical practice and airway assessment. Framework: None Noted	Expert opinion Level VII	None Measure designed to assess any airway	None	None	3: adequate mouth opening is 3 or more fingers between upper and lower teeth in an open mouth 3: a hyomental distance of at least 3 fingers is generally sufficient 2: a thyrohyoid distance of at least two fingers is generally sufficient The 3-3-2 rule combines these 3 factors to predict ease of airway access. Any factor less than these accepted distances places the patient more at risk of DI. The authors recommend combination with the Mallampati score to enhance prediction of DI.

2022	Mehta, A. R., Maldonado, Y., Abdalla, M., Roessler, J., Schmidt, M., Pu, X., Skubas, N. J., & Ruetzler, K. (2022). Association between body mass index and difficult intubation with a double lumen tube: A retrospective cohort study. *Journal of Clinical Anesthesia*, *83*. https://doi.org/10.1016/j.jclinane.2022.110980	To determine the relationship between difficult intubation and BMI. Framework: None Noted	Retrospective cohort study Level V	Operating room at Cleveland Clinic	8641 patients Retrospect-ive review between 2008 and 2021	SAS Studio statistical analysis of predictors for difficult intubation (>1 intubation attempt) Assessed correlation between BMI and DI Assessed correlation between DI and airway abnormality **Airway abnormality:** Reduced neck motion Limited neck extension/flexion Short neck Short thyromental distance Small mouth opening Non-compliant submandibular space Presence of a beard	DI noted as 2-8% in patients without obesity or 14% in patients with obesity in Introduction. Noted that obesity can narrow the trachea or cause airway closure because of adipose tissue in the neck. Found that BMI is a weak predictor of DI for a DLT. Did not find a prediction of DI from airway abnormalities for a DLT. **Notes:** Did not consider single lumen tubes.

2022	Siddiqui, K. M., Hameed, F., & Ali, M. A. (2022). Diagnostic accuracy of combined Mallampati and Wilson score to predict difficult intubation in obese patients: A descriptive cross-sectional study. *Anesthesiology and Pain Medicine*, *11*(6). https://doi.org/10.5812/aapm.118626	To determine if the Mallampati score combined with the Wilson score accurately predict DI in patients with obesity. Framework: None Noted	Descriptive cross-sectional study Level V	Operating room	300 patients	Researchers documented the Mallampati score and Wilson score pre-operatively and then analyzed their significance in comparison to laryngoscopy grades as determined by the Cormack-Lehane class.	14% incidence of DI in study participants Sensitivity of the combined score was comparable (75% versus 72%) between patients with obesity and morbid obesity. The accuracy was 98.5% and 95.4% respectively.
2022	Thota, B., Jan, K. M., Oh, M. W., & Moon, T. S. (2022). Airway management in patients with obesity. *Saudi Journal of Anaesthesia*, *16*(1), 76-81. https://doi.org/10.4103/sja.sja_351_21	To explore the current evidence for risk factors for airway complications in patients with obesity. Framework: None Noted	Literature review – not systematic Level V	Most articles focused on operating room patients	77 articles	PubMed search Published within 10 years of 2021 English No Independent or Dependent Variables **Looked at:** Preop assessment Difficult airway predictors Airway assessment scales Obesity & DI/DMV Intubation	**Risk for Difficult Mask Ventilation (DMV):** BMI, Mallampati score 3-4, snoring/OSA, male sex, older age **Risk for Difficult Intubation (DI):** male sex, greater than 46 years old, Mallampati score 3-4, thyromental distance < 6cm, larger neck circumference **Obesity and DI/DMV:** multiple

						techniques Video laryngoscopy Apneic oxygenation	studies link obesity and DMV but varying results exist for obesity and DI. Some evidence for increased Mallampati scores in patients with obesity. **Predictors for DMV:** Multiple studies have found increased neck circumference to predict DMV. One study found that a combination of Mallampati score and thyromental distance score acted as a comprehensive predictor. **Predictors for DI:** Increased neck circumference **Notes:** The authors only used PubMed for searches. Many studies from other

							sites could be missing. The authors present conflicting results from some studies but do not discuss possible causes. The authors discuss that anatomy differs widely even at the same BMI, which could explain why BMI is not a good predictor. The review is a mix of old and new studies, but some portions rely on old data. Even in sections that have more recent studies, the studies are still generally outside of the 5-year mark and, on occasion, older than 10 years. The review does not discuss if scales have been verified

							for patients with obesity. The authors discuss several combinations of airway assessment tests that may work better than one test alone. However, multiple different methods are identified. No single BEST method is identified, necessitating further research.
2022	Wu, Y.-M., Su, Y.-H., Huang, S.-Y., Wang, C.-W., Shen, S.-C., Chen, J.-T., Lo, P.-H., Cherng, Y.-G., Wu, H.-L., & Tai, Y.-H. (2022). Morphometric and ultrasonographic determinants of difficult laryngoscopy in obese patients: A prospective observational study. *Journal of the Chinese Medical Association*, *85*(5), 571-577. https://doi.org/10.1097/JCMA.0000000000000721	To determine risk factors for difficult laryngoscopy in patients undergoing bariatric surgery Framework: None Noted	Prospective observational study Level V	Medical center/ operating room Taiwan	80 patients BMI 30-35 kg/m^2	Enrolled patients undergoing laparoscopic sleeve gastrectomy from May 2020 – April 2021 **Physical exam for:** Thyromental distance Neck movement MMS Neck circumference Upper lip bite test	No risk classification techniques for lean populations worked for the obese population. Neck circumference (>49.1 cm) was the only independently predictive factor of difficult laryngoscopy.

						Also took ultrasound measures of soft tissue depth of the neck and tongue size	5% difficult laryngoscopy/ intubation. Ultrasound measure of tongue size together with neck circumference best predicted difficult laryngoscopy. **Notes:** All patients were placed in ramped position prior to intubation attempt, which can affect difficulty of laryngoscopy. All patients received cricoid pressure during the laryngoscopy attempt. The authors discuss that the literature contains a lack of consensus on the best approach to airway assessment in patients with obesity. They

							discuss that some of this inconsistency is from the lack of consistent measuring techniques.
2021	Ahmed, A. M., Zaky, M. N., El-Mekawy, N. M., Ollaek, M. A., Sami, W. M., & Mohamed, D. M. (2021). Evaluation of thyromental height test in prediction of difficult airway in obese surgical patients: An observational study. *Indian Journal of Anaesthesia*, *65*(12), 880–885. https://doi.org/10.4103/ija.ija_675_21	To determine if the TMHT predicts difficult airway in patients with obesity. To compare accuracy with neck circumference, MMS, and TMHT/neck circumference ratio Framework: None Noted	Uncontrolled observational cohort study Level V	Operating room/ surgical center	105 patients BMI > 30	One research team member performed the airway assessment tests in the pre-operative area. Results of these tests were compared to the anesthesiologist's Cormack-Lehane grade for the patient. **Measured:** MMS Neck circumference TMHT	Weak predictive value of large neck circumferences. TMHT (83% sensitivity) and MMT predicted difficult laryngoscopy. Neck circumference to TMHT ratio was a strong predictor of difficult laryngoscopy. Increased BMI did not correlate with DI. **Notes:** Patients were in the ramped position for intubation attempts, which can alter difficulty of

							intubation/may not be common practice. The authors note that other studies have investigated the usefulness of TMHT in predicting DI but that there are varying results and few that take into account whether obesity changes the validity of the test. 83% sensitivity - not as high as some other studies, but not the lowest score either.
2021	Çelik, G., Zengin, S. U., Ergün, M. O., & Umuroğlu, T. (2021). Correlation between neck circumference measurement and obesity type with difficult intubation in obese patients undergoing elective surgery. *Journal of Surgery and Medicine*, *5*(9), 912-916. https://doi.org/10.28982/josam.989262	To evaluate measures commonly used to assess airways and to examine associations between ease of airway access and neck circumference in obese patients.	Observational cross-sectional, prospective study Level V	Surgical center	85 patients	**Physical exam and interview for:** Height and weight BMI Age Gender Mallampati score Thyromental distance Neck circumference Cormack-Lehane	Neck circumference greater than 50 cm increased DI risk by 8.323 times. A thyromental distance less than or equal to 6.5 cm increased DI risk 40.475 times.

		Framework: None Noted				Results analyzed in statistical software R Convenience sample: patients recruited with ASA score I-III, over 18 years of age, BMI >35, and eligible for elective surgery at one surgical center	A Mallampati score > 2 increased DI risk 16.129 times. A Cormack-Lehane scale >2 increased DI risk 13.449 times. A significant relationship existed between DI and BMI, neck circumference, thyromental distance, Mallampati score, and Cormack-Lehane. Patients with DI had smaller thyromental distances and increased BMIs, neck circumferences, Mallampati scores, and Cormack-Lehane scales. Cut-off values for risk: BMI greater than 46, neck circumference

							greater than 50 cm, thyromental distance less than or equal to 6.5 cm, Mallampati score greater than 2, and Cormack-Lehane scale greater than 2. **Notes:** Examiners used different laryngoscopes for different patients, which could have acted as a confounding variable. This is the only study listed that found Mallampati score can act as a predictor of difficult intubation/airway by itself. Other studies discuss Mallampati score may have more significance when combined with other measures. This research team

							collected a small sample size, which potentially diminished generalizability.
2021	Emik, E., Gümüs-Özcan, F., Demirgan, S., & Selcan, A. (2021). Evaluation of the correlation between preoperative airway assessment tests, anthropometric measurements, and endotracheal intubation difficulty in obesity class III patients undergoing bariatric surgery. *Medicine*, *100*(36). https://doi.org/10.1097/MD.0000000000027188	To determine cutoff values related to difficult intubation in patients with obesity and to evaluate how well airway assessment tests predict difficult airway. Framework: None Noted	Prospective observational study Level V	Operating room/ surgery center	121 patients Convenience sampling: all patients undergoing selective bariatric surgery at clinic during time of study without exclusion criteria Excluded: history of difficult airway, limited neck movement, history of oral cancer or surgery, cervical injury, and anomalies in	**Physical exam for:** MMS Modified Cormack-Lehane Classification (MCLC) Thyromental distance Sternomental distance Neck/waist/chest circumferences Time/attempts to intubation	Risk for difficult intubation: 41.5 cm neck, 153.5 cm waist, and 147.5 cm chest circumferences or greater. All 3 positively correlated with difficult intubation. High MMS plus one or more increased circumference (neck, chest, or waist) predictive for difficult intubation. Higher BMI not correlated with difficult intubation. Increased MMS associated with obesity and DI.

					facial structure		Thyromental/ sternomental distance not associated with DI. **Notes:** This was one of few studies to use time or number of attempts to intubation to define difficult airway. This variability in definition can complicate comparing this study to others. All patients were obese. No comparison in efficacy of measurements between normal and obese weight. This study did evaluate sensitivity and specificity of waist/chest/neck circumferences and found these measures to be

							moderately sensitive, with low specificity. These measures come with a high risk for false negatives.
2021	Mahmoud, M., Hasanin, A. M., Mostafa, M., Alhamade, F., Abdelhamid, B., & Elsherbeeny, M. (2021). Evaluation of super-obesity and super-super-obesity as risk factors for difficult intubation in patients undergoing bariatric surgery. *Surgery for Obesity and Related Diseases*, *17*(7), 1279-1285. https://doi.org/10.1016/j.soard.2021.03.028	To determine the association between difficult intubation and super-obesity or super-super-obesity Framework: None Noted	Prospective cohort study Level V	University hospital operating room	664 patients Mean BMI 47.1 +/- 7.8 kg/m^2 Super obesity defined as BMI > 50 Super-super-obesity defined as BMI > 60	Recruited patients for the study from a pool of patients scheduled for bariatric surgery Analyzed data in SPSS Assessed intubation difficulty with both: Number of attempts Intubation difficulty scale **Preoperative assessment included:** Weight Height BMI Sex ASA status Beard presence OSA status STOP-BANG score	Neither super obesity nor super-super-obesity increased risk of DI. High STOP-BANG and high Mallampati score only two factors associated with DI. High STOP-BANG, high Mallampati score, and limited neck extension independently predicted DMV. **Notes:** ALL patients were placed in ramped position prior to intubation attempt, which can affect difficulty of laryngoscopy.

						MMS Mouth opening Thyromental distance Neck circumference Neck extension	These researchers used two of the most common difficult intubation scales to allow for comparison to other studies.
2021	Moura, E. C., Filho, A. S., de Oliveira, E. J., Freire, T. T., Leal, P., Gomes, L. M., Servin, E. T., & de Oliveira, C. M. (2021). Comparative study of clinical and ultrasound parameters for defining a difficult airway in patients with obesity. *Obesity Surgery*, *31*, 4118-4124. https://doi.org/10.1007/s11695-021-05528-1	To determine a cut-off point for using ultrasound distance from skin to epiglottis (DSE) to predict difficult airway. To evaluate the association between clinical factors and the ultrasound assessment of difficult airway. Framework: None Noted	Observational prospective study Level V	Operating room/ surgery center	100 patients Convenience sample: patients presenting for video gastroplasty between November 2019-November 2020	Clinical variables were collected through interview and measurement: Sex Weight Height Age MMS Thyromental and sternomental distance Neck circumference Mouth opening Cormack-Lehane scale DSE calculated as an average distance Data analyzed in SPSS The researchers	Mouth opening and DSE had statistical significance for correlation to difficult airway. Neck circumference and DSE were significantly correlated with Cormack-Lehane. A moderate and significant correlation existed between neck circumference and BMI. Mallampati score had a moderate, negative, significant correlation with thyromental and

						investigated how Mallampati score, thyromental distance, cervical perimeter, mouth opening, and skin-epiglottis distance relate to difficult airway as measured by the Cormack-Lehane scale.	sternomental distances. Thyromental and sternomental distances had a moderate, significant correlation with difficult airway. DSE had a weak, negative, significant correlation with neck circumference. DSE greater than 29.3 mm predicted difficult airway. **Notes:** Skin-epiglottis distance had a sensitivity and specificity of approximately 66%, which indicates many cases of difficult airway would not be predicted. Authors discussed

							multiple tests used to assess for difficult airway but did not highlight whether one test predicted better than others.
2020	Corrente, A., Fiore, M., Di Colandrea, S., Aurilio, C., Passavanti, M. B., Pota, V., Sansone, P., Diana, G., Signoriello, G., & Pace, M. C. (2020). A new simple score for prediction of difficult laryngoscopy: The EL.GA+ score. *Anaesthesiol Intensive Ther*, *52*(3), 206-214. https://doi.org/10.5114/ait.2020.97775	To evaluate whether the addition of a neck circumference measure (EL.GA+) to the EL.GA index improves accuracy of prediction of difficult airway in patients with obesity. Framework: None Noted	Retrospective observational study Level V	Operating room at academic hospital Naples	240 patients	Analyzed the records of patients who had undergone anesthesia requiring intubation. Airway assessment measures taken before surgery and analyzed in this study included: Mouth opening Thyromental distance Mallampati score Head and neck movement Body mass Neck circumference	The EL.GA index calculates risk through points awarded based on: Mouth opening Thyromental distance MMS Neck movement Jaw thrust Body mass History of DI Addition of a neck circumference cutoff (>42.5 cm) to create the EL.GA+ resulted in an increased predictive value from 0.14 to 0.69 in moderately obese patients. The EL.GA+ also had higher specificity.

							Notes: The authors discuss many other studies that investigated the usefulness of neck circumference measures in predicting difficult airway. They conclude that no universal neck circumference cutoff measure exists.
2020	Schnittker, R., Marshall, S. D., & Berecki-Gisolf, J. (2020). Patient and surgery factors associated with the incidence of failed and difficult intubation. *Anaesthesia*, *75*(6) , 756–766. https://doi.org/10.1111/anae.14997	To determine number of DIs in Victoria, Australia from 2015-2017 and physiological factors associated with them. Framework: None Noted	Retrospective, uncontrolled cohort study Level V	Operating Room Victoria, Australia	861,533 general anesthesia cases 4092 difficult intubation cases identified	Analyzed a state dataset for DI and related physiological factors using SAS dataset	Incidence of DI increased with ASA status/increasing number of comorbidities. 1.26% chance of DI for patients with obesity compared to 0.47% chance for patients without obesity. The authors discuss that some studies also show an increased risk of DI with obesity while others do not show

							an increased risk of DI with obesity. Increase in ASA status from: ASA I to II 3x risk ASA I to III 5x risk ASA I to IV+ 8x risk Men had a significant higher risk of DI than women. **Notes:** This study was completed only using a dataset for Victoria, Australia. Generalizability may be low. Presence of uncomplicated obesity shifts ASA status from I to II, which from this study may indicate 3x the risk of DI.

2020	Sinha, A., Jayaraman, L., & Punhani, D. (2020). Predictors of difficult airway in the obese are closely related to safe apnea time!. *Journal of Anaesthesiology and Clinical Pharmacology*, *36*(1), 25–30. https://doi.org/10.4103/joacp.JOACP_164_19	To evaluate what physiological factors may increase risk of difficult airway and decrease safe apnea time in patients with obesity. Framework: None Noted	Retrospective correlational study Level V	Operating room	834 patients BMI greater than or equal to 35	Assessed ease of airway access with difficult airway score, which takes ease of mask ventilation, difficult intubation, and number of people required into account A score greater than or equal to 6 was considered difficult.	Found 14.4% of patients (all had obesity) had difficult airway score of 6 or greater. A clinically and statistically significant decrease in safe apnea time was present with a difficult airway score greater than 6 even when measures to prolong safe apnea time as much as possible were used. Higher BMI and higher neck circumference measurements were found to predict a higher difficult airway score. Both a BMI 45 or greater plus neck circumference 44.5 cm or greater together had a 55%

							predictive value for difficult airway. Neck circumference was the most significant predictor. **Notes:** The authors discuss that BMI and neck circumference are both components of the STOPBANG score. They suggest that the STOPBANG score could be a useful method of predicting difficult airway but acknowledge that more research should be conducted.
2019	Moon, T. S., Fox, P. E., Somasundaram, A., Minhajuddin, A., Gonzales, M. X., Pak, T. J., & Ogunnaike, B. (2019). The influence of morbid obesity on difficult intubation and difficult mask ventilation.	To determine how obesity affects intubation and mask ventilation and to explore the associations between physical measurements	Retrospective correlational study Level V	Operating room	37016 patients	Chart review of all operating room tracheal intubations over 6 years (2011-2017) **Inclusion criteria:** Direct	4.3% of morbidly obese patients had DI. 4.2% of patients without morbid obesity had DI.

	Journal of Anesthesia, *33*, 96-102. https://doi.org/10.1007/s00540-018-2592-7	and difficult airway. Framework: None Noted				laryngoscopy, BMI charted, complete intubation charting, age>18, charted ASA and Mallampati Score	DMV 7% in morbidly obese patients versus 2.5% in patients not morbidly obese. Male, age > 46, intact teeth, and high Mallampati score correlated with DI. Morbid obesity not correlated with DI. The authors discuss BMI not a great indicator by itself, but anatomical differences can influence intubation difficulty. **Notes:** Half of intubations by CRNAs, half from residents. This approach leaves room for variability in results because different providers are using the measurement scales. Retrospective - only

							information from medical chart available, not concurrent with actual intubations. This approach means that researchers cannot determine potential extraneous variables or control for them.
2019	Roth, D., Pace, N. L., Lee, A., Hovhannisyan, K., Warenits, A. M., Arrich, J., & Herkner, H. (2019). Bedside tests for predicting difficult airways: An abridged Cochrane diagnostic test accuracy systematic review. *Anaesthesia*, *74*(7), 915-928. https://doi.org/10.1111/anae.14608	To estimate accuracy of common airway assessment measures in predicting difficult airway Framework: None Noted	Systematic review Level I	None	133 studies	Literature search on: Cochrane Central Register of Controlled Trials Cochrane Register of Diagnostic Test Accuracy Studies MEDLINE EMBASE Clarivate Analytics Web of Science CINAHL	Commonly used tests yielded variable sensitivities but high specificities for predicting difficult airway. Highest sensitivity for difficult laryngoscopy = upper lip bite test (identifies 7/10) Highest sensitivity for DI = MMS (identifies 6/11) The authors noted that predictors for difficult mask ventilation lacked

							specificity and that the upper lip bite test and MMS still did not predict many events. The combination of inability to predict a difficult mask and false negatives from these two tests could lead to a situation where ventilation could not be provided.
2018	Özdilek, A., Beyoglu, C. A., Erbabacan, Ş. E., Ekici, B., Altındaş, F., Vehid, S., & Köksal, G. M. (2018). Correlation of neck circumference with difficult mask ventilation and difficult laryngoscopy in morbidly obese patients: An observational study. *Obesity Surgery*, *28*, 2860–2867. https://doi.org/10.1007/s11695-018-3263-3	To determine whether neck circumference and other physical measurements correlate with difficult airway Framework: None Noted	Observational cross-sectional study Level V	Operating room/ general surgery	120 patients BMI 40 or above ASA III score	**Physical exam for:** Neck circumference BMI Mallampati score Neck movements Breast/thorax/waist/ hip circumferences Mouth opening Sternomental and thyromental distances Cormack-Lehane score Four-grade scale for mask ventilation Convenience sample: general	No factors independently predicted DMV in women, but mouth opening and inadequate neck flexion predicted DMV in men. The DMV rate was 13.5% male, 3.6% female, 6.67% overall. Difficult laryngoscopy occurred in 10.8% male, 4.8% female, 6.67% overall.

						surgery patients during March-December 2015 Excluded: facial fractures/tumors, neck/mediastinum masses, head/neck radiation, cervical vertebrae injuries, patients needing rapid sequence intubation	A Mallampati score >2 was predictive for difficult laryngoscopy in both sexes. Inadequate flexion of the neck and a less than 16 cm sternomental distance was predictive for difficult laryngoscopy in men. Neck circumference and BMI were not predictive of either DMV or DL. **Notes:** Very low power for neck flexion, but 99.9% power for mouth opening in men as a predictor for DMV. The Mallampati score had 60% power for male

							patients and 90% for females. These results could be related to the low sample size of men in the study. The authors discussed that definition for DMV varies, which can lead to situations where ventilation may not be possible if the anesthesia provider does not correctly anticipate difficult airway. Conducted at one Turkish center, not a random sample, far fewer male patients. These issues can affect generalizability of results. This paper investigated sensitivity and specificity of airway assessment

							measures. In women, the Mallampati score had a sensitivity of 75% for difficult laryngoscopy. In men, the Mallampati score had a sensitivity of 50%. A sternomental distance of less than 16 cm would predict about 87% of cases. These sensitivities mean that many cases of difficult laryngoscopy would not be identified, which could result in insufficient preparation for difficult airway.
2018	Saasouh, W., Laffey, K., Turan, A., Avitsian, R., Zura, A., You, J., Zimmerman, N. M., Szarpak, L., Sessler, D. I., & Ruetzler, K. (2018). Degree of obesity is not associated with more than one intubation attempt: A large centre experience. *British Journal of Anaesthesia*, *120*(5), 1110-	To determine if a relationship exists between BMI and DI. Framework: None Noted	Retrospective cohort analysis Level V	Operating room/ general anesthesia Cleveland Clinic	67,000 patient records	Researchers analyzed patient records from the Cleveland Clinic Perioperative Health Documentation System for BMI, preoperative airway evaluation, and	Likelihood of DI increased linearly with BMI up until 30 kg/m^2. After 30, the likelihood remained the same. Found risk of DI was 10% in patients with obesity and 8%

	1116. https://doi.org/10.1016/j.bja.2018.01.019					airway difficulty/intubation attempts.	in patients without obesity. The risk of DI was not greater for patients with morbid obesity compared to patients with obesity. **Notes:** Providers used video laryngoscopy 14% of the time in patients with obesity compared to 7% in patients without, which could skew results by potentially making intubation easier. This study is the newest that was found, but other studies from the early 2000's are mentioned as having found that risk of DI does continue to increase with increasing BMI.

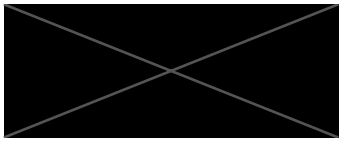
2018	Siaw, M. L., Tiwari, A., Chung, F., & Wong, D. T. (2018). Obstructive sleep apnea as a risk factor associated with difficult airway management - A narrative review. *Journal of Clinical Anesthesia, 45*, 63-68. https://doi.org/10.1016/j.jclinane.2017.12.024	To determine if OSA is a risk factor for difficult airway Framework: None Noted	Narrative/ literature review Level VI	Operating room	10 studies	**Literature review of:** EMBASE OVID Medline PubMed Cochrane Central Register of Controlled Trials Cochrane Database of Systematic Reviews Web of Science SCOPUS	14.5% of patients with OSA had DI versus 7.7% of patients without OSA. 2.5% of patients with OSA had difficult mask ventilation versus 0.7% of patients without OSA. **Notes:** The authors note that many patients have undiagnosed OSA, and obesity is a risk factor for OSA.
2018	Siriussawakul, A., Maboonyanon, P., Kueprakone, S., Samankatiwat, S., Komoltri, C., & Thanakiattiwibun, C. (2018). Predictive performance of a multivariable difficult intubation model for obese patients. *PloS one*, *13*(8). https://doi.org/10.1371/journal.pone.0203142	To evaluate how well a newly developed DI model predicted DI in patients with obesity. Framework: None Noted	Prospective observational study Level V	The DI model was designed for any bedside or pre-op clinic	1015 patients BMIs greater than or equal to 30	A literature review was performed initially to identify all possible airway assessments. Three different assessments were combined for three different predictive models, and sensitivity was determined.	The created equation: $Y = [(10.94 \times MMT\ class\ III,\ IV) + (10.89 \times NC/TM)] - BMI$ Patients received a 0 for a Mallampati score of I or II or a 1 for a score of III or IV

						Selected assessments: MMS Neck circumference to Thyromental distance ratio BMI DI measured with Intubation Difficulty Scale	If the patient received a total greater than or equal to 21.06, they were classified as potentially difficult intubation **Notes:** This study also notes that other combinations have been used in other studies, but that none offer the best sensitivity. The authors suggest that this model was not the best predictor for DI either and further study needs to be completed to identify more specific combinations for patients with obesity.

Note. Key to abbreviations used in chart: OSA – obstructive sleep apnea, BMI – body mass index, DI – difficult intubation, DMV – difficult mask ventilation, DL – difficult laryngoscopy, DLT – double lumen tube, MMS – modified Mallampati score, MCLC – Modified Cormack-Lehane Classification, DSE – distance from the skin to the epiglottis, TMHT – thyromental height test, NC/TMD – neck circumference to thyromental distance ratio. Key to Levels of Evidence: I: Systematic review or meta-analysis of randomized controlled trials; II: Randomized controlled trials; III: Nonrandomized controlled trials; IV: Controlled cohort studies; V: Uncontrolled cohort studies; VI: Descriptive or qualitative study, case studies, EBP implementation and QI; VII: Expert opinion from individuals or groups. Adapted from *Evidence-based practice in nursing and healthcare: A guide to best practice* (4th ed.), by B. M. Melnyk and E. Fineout-Overholt, 2019, p. 131.

Appendix D

CON and University Medical Center Approval Form



Click "download PDF" to save a copy of this page for your records.
Note: The IRB Office does not maintain copies of your responses.

Below is a summary of your responses

Download PDF

Quality Improvement/Program Evaluation Self-Certification Tool

Purpose:
Projects that do not meet the federal definition of human research pursuant to 45 CFR 46 do not require IRB review. This tool was developed to assist in the determination of when a project falls outside of the IRB's purview.

Instructions:
Please complete the requested project information, as this document may be used for documentation that IRB review is not required. Select the appropriate answers to each question in the order they appear below. Additional questions may appear based on your answers. If you do not receive a STOP HERE message, the form may be printed as certification that the project is "not research", and does not require IRB review. The IRB will not review your responses as part of the self-certification process. For projects being done at [redacted], site support will be required. Please [redacted]

Name of Project Leader:

Amy Nygren

Project Title:

Assessing CRNAs' Perceptions of the Adequacy of a Quick-Reference Guide (QRG) for Evaluating Airways of Patients with Obesity: A Quality Improvement Project

Brief description of Project/Goals:

The purpose of this quality improvement project is to assess anesthesia providers' perceptions of adequacy of a newly developed quick-reference guide (QRG). Knowledge gained from this pilot project could be used in future quality improvement and policy efforts aimed at improving anesthesia care of patients with obesity. Process: A quick-reference perioperative guide on airway assessment methods, based upon accepted national guidelines, will be developed. Anesthesia providers at one of ECU Health's medical facilities (site) will be asked several questions (through Qualtrics) about their perceptions of the adequacy of their current practice. An educational video about the use of a newly developed QRG will be made available to them, and they will be asked to use the QRG for two weeks. Upon completion of the two-week utilization period, they will be asked to complete a questionnaire about their perceptions of the adequacy of the QRG and their current practice. Qualtrics survey software will be used to deliver the intervention link and gather participant perceptions prior to and post implementation of the project. No patient information will be recorded or maintained during this project.

Will the project involve testing an experimental drug, device (including medical software or assays), or biologic?

- ○ Yes
- ● No

Has the project received funding (e.g. federal, industry) to be conducted as a human subject research study?

- ○ Yes
- ● No

Is this a multi-site project (e.g. there is a coordinating or lead center, more than one site participating, and/or a study-wide protocol)?

- ○ Yes
- ● No

Is this a systematic investigation designed with the intent to contribute to generalizable knowledge (e.g. testing a hypothesis; randomization of subjects; comparison of case vs. control; observational research; comparative effectiveness research; or comparable criteria in alternative research paradigms)?

- ○ Yes
- ● No

Will the results of the project be published, presented or disseminated outside of the institution or program conducting it?

- ● Yes

Would the project occur regardless of whether individuals conducting it may benefit professionally from it?

- (●) Yes
- ( ) No

Does the project involve "no more than minimal risk" procedures (meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests)?

- (●) Yes
- ( ) No

Is the project intended to improve or evaluate the practice or process within a particular institution or a specific program, and falls under well-accepted care practices/guidelines?

- (●) Yes
- ( ) No

Based on your responses, the project appears to constitute QI and/or Program Evaluation and IRB review is not required because, in accordance with federal regulations, your project does not constitute research as defined under 45 CFR 46.102(d). If the project results are disseminated, they should be characterized as QI and/or Program Evaluation findings. Finally, if the project changes in any way that might affect the intent or design, please complete this self-certification again to ensure that IRB review is still not required. Click the button below to view a printable version of this form to save with your files, as it serves as documentation that IRB review is not required for this project. 11/15/2023

Human Subject Research Determination Form

This form should be completed and submitted for review by the service lines impacted by the work prior to project initiation (including, but not limited to, collection or analysis of baseline data). Projects that are "Not Human Subjects Research" are not required to submit an IRB application in [redacted] To help make that determination, you may utilize the Decision Chart provided by the Office for Human Research Protections along with this worksheet. For any project where there is a question as to whether it qualifies as Quality Improvement or Research, or if certification of "Not Human Subjects Research" is needed for publication, please route to the UMCIRB office via email: umcirb@ecu.edu.

Please check the Office of Clinical Research Website or UMCIRB website to make sure that you have the most recent version of this form.

Project Title	Assessing Certified Registered Nurse Anesthetists' Perceptions of the Adequacy of a Quick-Reference Guide for Evaluating Airways of Patients with Obesity: A Quality Improvement Project
Project Leader	Amy Nygren
Project Leader Contact E-mail	nygrena22@students.ecu.edu
Department or Unit Affiliation	Anesthesiology
Project Advisor (if applicable)[1]	Maura McAuliffe

Additional Faculty, Staff, and Trainees Involved (add more rows if needed):

Name	Department or Unit	Role	Check this box if this team member will access PHI or PII for the purposes of this project.
Amy Nygren BSN, RN	ECU Nurse Anesthesia Program	Student	☐
Maura McAuliffe PhD, CRNA, FAAN	ECU Nurse Anesthesia Program	Project Advisor	☐
Travis Chabo CRNA, MSN, PhD	ECU Nurse Anesthesia Program	ECU CRNA Program Director	☐
			☐
			☐
			☐
			☐

[1] All student, resident, and fellow projects must have a faculty or unit leader designated as the advisor for the project.

			☐
			☐
			☐
			☐
			☐
			☐
			☐

Please answer the following questions to the best of your ability. If the answers to these questions change during the course of the project, please resubmit this form for review:

End Goal / Desired Outcome:

The purpose of this quality improvement project is to assess Certified Registered Nurse Anesthetists' (CRNAs') perceptions of adequacy of a newly developed quick-reference guide in helping to predict difficult airways in patients with obesity. A quick-reference guide, based upon accepted national guidelines, will be developed. CRNAs at ECU Medical Center's main OR will be asked several questions (through Qualtrics) about their perceptions of the adequacy of their currently used airway assessment methods and preparedness for identifying difficult airways in patients with obesity. An educational PowerPoint about the use of the newly developed quick-reference guide will be made available to them, and they will be asked to use the guide for two weeks. Upon completion of the two-week utilization period, they will be asked to complete a questionnaire about their perceptions of the adequacy of the guide. Qualtrics survey software will be used to gather participant perceptions of acceptability and adequacy of the quick-reference guide prior to and post implementation of the project. No patient information will be recorded or maintained during this project. Knowledge gained from this pilot project could be used in future quality improvement and policy efforts aimed at improving anesthesia care of patients with obesity.

Methodology / Intervention:

This project will consist of a single Plan, Do, Study, Act cycle using a pre- and post-implementation survey design. CRNAs will be contacted via email and asked to complete a pre-survey about their current airway assessment practices. Then, they will be asked to view a PowerPoint about use of the newly developed quick-reference guide and will be asked to utilize the quick-reference guide in their practice for two weeks. The quick-reference guide is based on current evidence that aligns with practices currently accepted within the facility to support CRNA practice regarding airway assessment of patients with obesity. After two weeks, they will then be asked to complete a post-survey addressing their perceptions of the quick-reference guide and their own practice. The primary researcher will be available electronically, by phone, or in person to consult with participants as needed. The quick-reference guide for this project will be a newly created informational tool focused on airway assessment for patients with obesity. Information and assessments included on the quick-reference guide are based on current evidence and fall within current accepted practice standards within ECU Medical Center.

Data to be collected:

[Data will be gathered directly from CRNA participants through completion of Qualtrics pre- and post-surveys delivered and completed electronically. Aside from participant emails, no identifiable data will be gathered. Data of interest is participant opinions and perceptions of practice and the newly developed quick-reference guide. All data will be gathered using Qualtrics survey software, then transferred to Excel for analysis. The only identifying information will be email addresses. Qualtrics survey software is accessed through ECU and involves multifactorial password protection. Data in Excel will be on a password protected personal laptop. Email addresses will be deleted from Excel files after both surveys are completed and analysis of results begins. No PHI will be collected for this project. Data will be stored in Qualtrics and in Excel files (de-identified) until student graduation, anticipated to be spring of 2025. The deidentified data will be analyzed with results shared via a poster presentation to the ECU Nurse Anesthesia Program students and faculty, with participants invited to view the presentation remotely. If requested, a presentation of results to the participating department will be provided. Additionally, analysis of results will be addressed in a DNP Project Paper, completion of which is required for program graduation. This paper will be posted in the ECU digital repository, The Scholarship.

Complete the following questions to guide leadership's determination of this project's status:

	True	False
The PRIMARY purpose of the proposed activity or project is limited to: - implementing a standard practice to improve the quality of patient care and to collect data regarding that implementation for clinical, practical, or administrative purposes, and/or - delivering healthcare and measuring and reporting provider performance data for clinical, practical, or administrative uses.	☒	☐
The activity or project would be carried out even if there was no possibility of publication in a journal or presentation at an academic meeting.	☒	☐
The activity or project falls under well-accepted care practices/guidelines and are designed to bring about immediate improvements in health delivery or quality of care. If "true" and the project is related to clinical activity, please provide a citation below as evidence that project activities fall within standards of care. Projects not directly related to clinical activity, such as medical education, do not need to provide a citation.	☒	☐

No prior attempts at developing a quick-reference guide were found in the literature synthesis for this quality improvement project. However, the use of multiple airway assessment methods may better predict difficult airways in patients with obesity because anatomy differs between patients of the same BMI, and physiological differences tend to correlate with different types of difficult airways (difficult mask ventilation, difficult intubation, and difficult laryngoscopy) (Thota et al., 2022). All types of difficult airways should be predicted and prepared for, if possible, to protect patients. Thota et al. (2022) demonstrated in their study that different airway assessment techniques predict different aspects of a difficult airway, and they discuss several combinations of airway assessments but fail to identify a single best combination. The quick-reference guide for this quality improvement project includes the most common assessment techniques that predict difficult airways.

Thota, B., Jan, K. M., Oh, M. W., & Moon, T. S. (2022). Airway management in patients with obesity. *Saudi Journal of Anaesthesia*, *16*(1), 76-81. https://doi.org/10.4103/sja.sja_351_21

The activity or project involves "no more than minimal risk" procedures. (i.e., the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests).	☒	☐

Please submit this form to your supervisor (or designee) for review and approval. Signature on this form certifies that that the below individual is in support of this project taking place and agrees with the project leader's answers to the above questions:

Supervisor's Name	[redacted]
Signature	[redacted]
Date	2/28/2024 | 11:47 PM EST

For Project Leaders: From the list below, please check the boxes for each service line where interventions may take place or where data may be collected. For each selected area, please route for signature for both the physician leader and administrator (preferably via DocuSign). Send a completed copy of the form to [redacted]

For Service Line Leaders: Signature on this form certifies that you are in support of this project taking place and agree with the answers to the above questions. If you are not in support of the proposed project, please discuss with the project leader, supervisor, and UMCIRB as needed.

	SERVICE LINE	SIGNATORY
☐	Heart & Vascular (Interventional Cardiology, Electrophysiology, Cardiac Surgery, Advanced Heart Failure, Cardiac Critical Care, Vascular Surgery, Cardio pulmonary rehab, Structural heart, & Thoracic Surgery)	[redacted]
☐	Cancer (Breast cancer, Lung cancer, Gynecologic cancer, hematology, GI cancer, Urologic cancer, and Head & Neck cancer)	[redacted]
☐	Neuro Sciences (Neurology, Neurosurgery, Neuro Degenerative Disease, Neuro Critical Care, Stroke, Neuro Radiology, & Spine)	[redacted]
☐	Orthopedics (Joints, Orthopedic Surgery, Rheumatology, Sports medicine, Orthopedic medicine, & Orthopedic Trauma)	

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[redacted]

☐ **Behavioral Health**
(Child / Adolescent Psychiatry, Behavioral medicine, & Adult Psychiatry)

☐ **Primary Care**
(Family medicine, Med-Peds, General Internal Medicine, Palliative Care, Geriatrics, & Sleep Medicine)

☐ **Children's Health**
(Pediatric Surgery, General Pediatrics, Well Newborn, Newborn & Pediatric Critical Care, Pediatric Hem-Onc, Neonatology, Pediatric medicine, Medicine subspecialities, surgical subspecialties)

☐ **Women's Health**
(Gynecology, Obstetrics, & Maternal Fetal Medicine)

☐ **Emergency Services**
(Emergency Preparedness, Emergency Management, & Emergency Services)

☐ **Physical Medicine & Rehab**
(Rehab, Therapy (OT, PT, SLP), Pain, Wound Care, & Audiology)

☒ **Adult Surgical Service**
(Anesthesiology, Trauma, ENT, Benign Urology, Plastics, Ophthalmology, Transplant Surgery, & Acute Care Surgery)

[redacted]

☐	Adult Medicine (Medical Critical Care, Infectious Disease, Hospital Medicine, Pulmonology, Endocrinology, Allergy, Dermatology, & Nephrology)	[redacted]
☐	Radiology	[redacted]
☐	Pathology & Lab Services	[redacted]

Optional Determination:

For any project where there is a question as to whether it qualifies as Quality Improvement or Research, or if certification of "Not Human Subjects Research" is needed for publication, please route to the UMCIRB office via email: [redacted]

☒ **Not Human Subjects Research:** The UMCIRB office has determined that based on the description of the project, approval by the IRB is not necessary. Any changes or modifications to this project may be discussed with the UMCIRB office at that time to ensure those changes do not elevate the project to human research that would need IRB approval.

☐ **Human Subjects Research:** This project requires review by the IRB prior to initiation. An application in the electronic IRB submission system should be submitted.

UMCIRB Office Staff Signature: [redacted] **Date:** 3/14/2024

The UMCIRB office will contact you if any further information is needed to make this determination. Please note that if the UMCIRB office determines the activity is not human subjects research, then any presentation, publication, etc. should not refer to the activity as such.

DocuSign

Certificate Of Completion

Envelope Id: 8198099F4EF24F5F87894CCBD61CA485
Status: Completed
Subject: Complete with DocuSign: NygrenA_2024_02_12_QIvsResearch_Corrected.docx
Source Envelope:
Document Pages: 7 Signatures: 3
Certificate Pages: 5 Initials: 0
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Record Tracking

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Signer Events	Signature	Timestamp
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Electronic Record and Signature Disclosure: Not Offered via DocuSign		

In Person Signer Events	Signature	Timestamp

Editor Delivery Events	Status	Timestamp

Agent Delivery Events	Status	Timestamp

Intermediary Delivery Events	Status	Timestamp

Certified Delivery Events	Status	Timestamp

Carbon Copy Events	Status	Timestamp
[redacted] [redacted] Security Level: Email, Account Authentication (None) **Electronic Record and Signature Disclosure:** Accepted: 11/21/2023 11:17:46 AM ID: 66447592-7a68-4abf-bd03-50df73b22dab	COPIED	Sent: 2/29/2024 2:45:24 PM Viewed: 3/1/2024 11:55:15 AM

Witness Events	Signature	Timestamp

Notary Events	Signature	Timestamp

Envelope Summary Events	Status	Timestamps
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Signing Complete	Security Checked	2/29/2024 2:45:22 PM
Completed	Security Checked	2/29/2024 2:45:24 PM

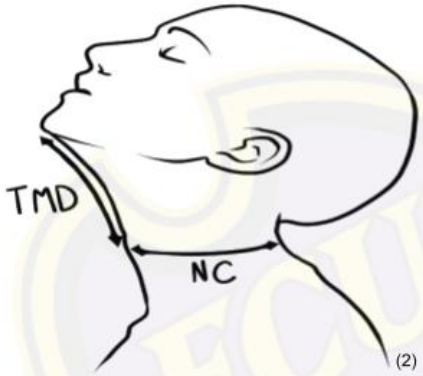
Payment Events	Status	Timestamps

Electronic Record and Signature Disclosure

Appendix E

Quick-reference Guide

Airway Assessment of the Patient with Obesity



(2)

Increased risk for DI if:

NC (>40cm) (5,6)
- Measure at cricothyroid cartilage in sitting position

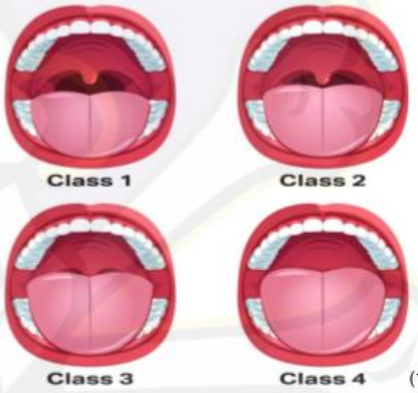
TMD (<6cm) (5,6)
- Measure from thyroid notch to mentum with head extended and mouth closed

NC:TMD Ratio (>5) (6,7)
- Better reflects distribution of adipose tissue around neck

Mallampati Score

- **Class III or IV correlated with difficult airway** (4,8)
- **Only moderate sensitivity when used alone - many events missed** (8)
- **Many different possible combinations:**
  - **Mallampati score III or IV with an increased NC predictive for DI** (3)
  - **Enhances 3-3-2 Rule sensitivity** (9)

The Mallampati Score



(10)

3-3-2 Rule (9)

Increased risk for DI if:

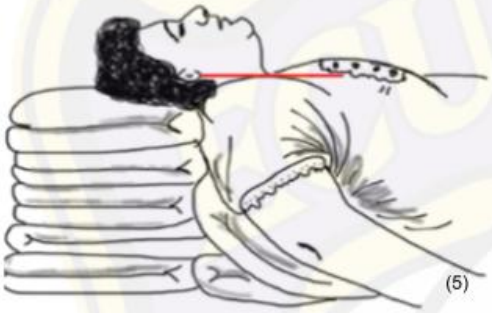
A) <3 fingers between upper and lower incisors	**B) <3 fingers in the hyomental distance**	**C) <2 fingers in the hyo-thyroid cartilage distance**

Enhanced results with Mallampati Score

(1)

Difficult Mask Predictors (4,5)

Age>50, BMI>30, beard, lack of teeth, history of snoring, Mallampati III or IV, male



(5)

Ramping (5)

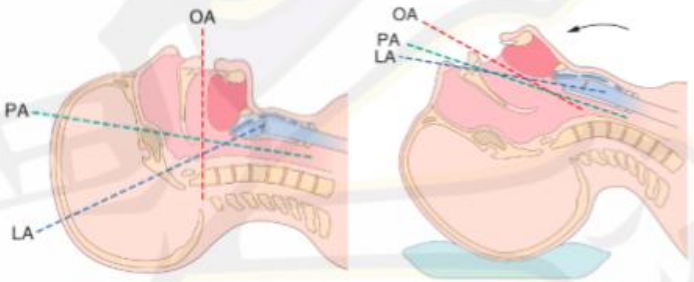
Ear level with sternal notch

- Aligns the 3 axes in patients with obesity - improved laryngoscopy view
- Decreases dependent atelectasis
- Improves V/Q
- Increases safe apnea time

Screening tool for OSA: STOP-Bang (11)

S	Does the patient **snore** loudly (louder than talking or loud enough to be heard through closed doors)?	Y/N
T	Does the patient often feel **tired**, fatigued, or sleepy during the day?	Y/N
O	Has anyone **observed** the patient stop breathing during their sleep?	Y/N
P	Does the patient have, or is the patient being treated for, high blood **pressure**?	Y/N
B	Does the patient have a **BMI** of more than 35?	Y/N
a	**Age.** Is the patient older than 50?	Y/N
n	Is the patient's **neck** circumference greater than 40cm?	Y/N
g	**Gender.** Is the patient male?	Y/N

Scoring: **Y ≥ 3 = high risk** of OSA
Y < 3 = low risk of OSA



Oral Axis (OA); Pharyngeal axis (PA); Laryngeal Axis (LA) (5)

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2. De Cassai, A., Papaccio, F., Betteto, G., Schiavolin, C., Iacobone, M., & Carron, M. (2019). Prediction of difficult tracheal intubations in thyroid surgery. Predictive value of neck circumference to thyromental distance ratio. *PLoS ONE*, *14*(2). https://doi.org/10.1371/journal.pone.0212976.g001

3. Emik, E., Gümüs-Özcan, F., Demirgan, S., & Selcan, A. (2021). Evaluation of the correlation between preoperative airway assessment tests, anthropometric measurements, and endotracheal intubation difficulty in obesity class III patients undergoing bariatric surgery. *Medicine*, *100*(36). https://doi.org/10.1097/MD.0000000000027188

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Appendix F

Emails to Participants

Initial Pre-Survey and Video Email to Participants

Good Evening,

Thank you for considering participation in a quality improvement project titled "Assessing Certified Registered Nurse Anesthetists' Perceptions of the Adequacy of a Quick-Reference Guide for Evaluating Airways of Patients with Obesity: A Quality Improvement Project." The purpose of this project is to assess CRNA perceptions of the usefulness of a quick-reference guide we developed to assist with assessing the airways of patients with obesity at ECU Medical Center.

Your participation is voluntary and will involve completing a short pre-implementation survey, viewing a 10-minute introductory PowerPoint presentation, using our quick-reference guide in your CRNA practice for two weeks, then completing a short post-implementation survey when the two-week implementation period is over.

Each survey and the introductory PowerPoint presentation should take less than 10 minutes to complete. The surveys were created and are completed using Qualtrics® survey software. The use of the quick-reference guide falls within currently accepted anesthesia practice. Your participation is voluntary and confidential. We will share the results of this QI study with you upon completion.

First, complete the pre-implementation survey provided link here.

Following completion of the survey, please view the introductory PowerPoint to learn about the evidence found for each assessment technique included on the quick-reference guide. The PowerPoint has voiceovers with additional information; this information is also bulleted in the notes section of each slide. I also provided you with a digital version of the quick-reference guide. Both the PowerPoint and digital version of the quick-reference guide are included as attachments to this email. I can also provide laminated copies of the quick-reference guide for your use, should you prefer that format.

Again, I thank you so much for your participation in this quality improvement project. I will be at the main OR at ECU Medical Center on May 22 and May 23 if you have any questions. You may also reach out to me or Dr. Maura McAuliffe by email at any time.

Sincerely,

Amy Nygren, BSN, SRNA, nygrena22@students.ecu.edu
Maura McAuliffe, PhD, CRNA, FAAN, Project Chair, mcauliffem@ecu.edu

Pre-Survey First and Second Reminder Emails to Participants
Hello,

I just wanted to send a quick reminder about the ongoing DNP Project on CRNA perceptions of the usefulness of a standardized airway assessment tool for patients with obesity (original email attached). If you've already filled out the pre-survey and viewed the introductory PowerPoint, thank you. If you haven't had a chance to do so yet, it's not too late and would be very helpful and much appreciated. After the end of next week, I will begin sending out the post-surveys.

The pre-survey link, introductory PowerPoint, and digital versions of the quick-reference guide are attached in the previous email.

Please let me know if you have any questions, and thank you again for your participation.

Sincerely,
Amy Nygren, BSN, SRNA
ECU Nurse Anesthesia Program
Class of 2025

Post-Survey Email to Participants
Good morning,

Thank you for your time and participation so far. It's now time to complete the brief post-survey.

If you have not filled out a pre-survey, I would really and truly appreciate your participation (it's just surveys and an introductory PowerPoint!). The link to the pre-survey is __link__, and you can follow it up by watching the introductory PPT and viewing the quick-reference guide, which are attached to this email. Laminated quick-reference guides are available for your use if you would like them, but their use is not mandatory for participation in this project.

If you've already completed the first survey, please complete the post-survey at link to the post-survey. It should take less than 2 minutes.

If you have any questions or issues with any of these links, please let me know. Again, thank you for your help and for being an excellent preceptor.

Sincerely,
Amy Nygren, BSN, SRNA
ECU Nurse Anesthesia Program
Class of 2025

Post-Survey Reminder Email to Participants
Good morning,
Thank you for your time and participation so far. It's now time to complete the brief post-survey.

If you have not filled out a pre-survey, I would really and truly appreciate your participation (it's just surveys and an introductory PowerPoint!). The link to the pre-survey is __link__, and you can follow it up by watching the introductory PPT and viewing the quick-reference guide, which are attached to the previous email. Laminated quick-reference guides are available for your use if you would like them, but their use is not mandatory for participation in this project.
If you've already completed the first survey, please complete the post-survey at link to the post-survey. It should take less than 2 minutes.
If you have any questions or issues with any of these links, please let me know. Again, thank you for your help and for being an excellent preceptor.

Sincerely,
Amy Nygren, BSN, SRNA
ECU Nurse Anesthesia Program
Class of 2025

Final Thank You Email to Participants
Good morning,

I just wanted to say thank you so much to everyone for helping me out with my DNP Project! I have collected all of the data I need to proceed with data analysis and will then be finishing my paper. Once it's complete, you all will be able to read it if you'd like. And if you liked the quick-reference guide and found it useful, you can feel free to continue to use it. Additional laminated copies can be provided if desired.

Thank you again! I hope to work with you more in the future.

Take care,
Amy Nygren, BSN, SRNA
ECU Nurse Anesthesia Program
Class of 2025

Appendix G

Pre- and Post-implementation Surveys

Pre-Implementation Survey:

1. When evaluating the airway of patients with obesity (BMI>30), to what extent do you use the following assessment methods?

   STOP-BANG:

   - Never
   - Some of the time
   - Most of the time
   - Always

   Mallampati score:

   - Never
   - Some of the time
   - Most of the time
   - Always

   Thyromental Distance:

   - Never
   - Some of the time
   - Most of the time
   - Always

   Neck Circumference:

   - Never
   - Some of the time
   - Most of the time
   - Always

   Neck Circumference: Thyromental Distance Ratio:

   - Never
   - Some of the time
   - Most of the time
   - Always

2. How useful do you find the following assessment methods to be in predicting difficult airway in patients with obesity?

STOP-BANG:

- I do not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful
- Very useful

Mallampati score:

- I do not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful
- Very useful

Thyromental Distance:

- I do not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful
- Very useful

Neck Circumference:

- I do not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful
- Very useful

Neck Circumference: Thyromental Distance Ratio:

- I do not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful

- Very useful

3. What percent of the patients that you care for in a typical two-week period would you estimate have obesity (BMI>30)?
    - 0%
    - > 0% but ≤ 25%
    - > 25% but ≤ 50%
    - > 50% but ≤ 75%
    - > 75% but < 100%
    - 100%
4. Please answer based on how true you believe the following statements to be:
    a. Patients with obesity are more difficult to mask-ventilate.
        - Entirely false
        - Somewhat false
        - Neither true nor false
        - Somewhat true
        - Entirely true
    b. Patients with obesity are more difficult to intubate.
        - Entirely false
        - Somewhat false
        - Neither true nor false
        - Somewhat true
        - Entirely true
5. Have you been trained to use point-of-care ultrasound (POCUS) to assess patients' airways?
    - No
    - Yes
6. How often do you use POCUS to assess any patient's airway?
    - Never
    - Some of the time
    - Most of the time
    - Always
7. How often do you use "ramping" for patients with obesity to optimize intubation conditions?
    - Never
    - Some of the time

- Most of the time
- Always

Post-Implementation Survey:

1. After implementation of the quick reference guide, when evaluating the airway of patients with obesity (BMI>30), to what extent do you use the following measures?

   STOP-BANG:

   - Never
   - Some of the time
   - Most of the time
   - Always

   Mallampati score:

   - Never
   - Some of the time
   - Most of the time
   - Always

   Thyromental Distance:

   - Never
   - Some of the time
   - Most of the time
   - Always

   Neck Circumference:

   - Never
   - Some of the time
   - Most of the time
   - Always

   Neck Circumference: Thyromental Distance Ratio:

   - Never
   - Some of the time
   - Most of the time

- Always

2. To what extent did you find each of these methods useful in predicting difficult airway in patients with obesity?

STOP-BANG:

- I did not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful
- Very useful

Mallampati score:

- I did not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful
- Very useful

Thyromental Distance:

- I did not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful
- Very useful

Neck Circumference:

- I did not use this tool
- Not at all useful
- Somewhat useful
- Mostly useful
- Very useful

Neck Circumference: Thyromental Distance Ratio:

- I did not use this tool
- Not at all useful
- Somewhat useful

- Mostly useful
- Very useful

3. What percent of the patients that you cared for in this two-week period would you estimate had obesity (BMI>30)?
    - 0%
    - > 0% but ≤ 25%
    - > 25% but ≤ 50%
    - > 50% but ≤ 75%
    - > 75% but < 100%
    - 100%
4. After using the quick reference guide, how true do you believe the following statements to be?
    a. Patients with obesity are more difficult to mask-ventilate.
        - Entirely false
        - Somewhat false
        - Neither true nor false
        - Somewhat true
        - Entirely true
    b. Patients with obesity are more difficult to intubate.
        - Entirely false
        - Somewhat false
        - Neither true nor false
        - Somewhat true
        - Entirely true
5. How often did you use point-of-care ultrasound (POCUS) to assess patients' airways in the last two weeks?
    - Never
    - Some of the time
    - Most of the time
    - Always
6. Would you be interested in attending an in-service on the use of POCUS for preoperative airway assessment?
    - Not at all interested
    - Somewhat interested

- Very interested

7. How often did you use “ramping” for patients with obesity to optimize intubation conditions?
    - Never
    - Some of the time
    - Most of the time
    - Always
8. Did you find the quick reference guide useful?
    - Not at all useful
    - Somewhat useful
    - Mostly useful
    - Very useful
9. How often did you use the quick reference guide in the last two weeks?
    - Never
    - Some of the time
    - Most of the time
    - Always
10. Which aspect(s) of the quick reference guide was/were most useful to your practice?

    _____

11. Which aspect(s) of the quick reference guide was/were least useful to your practice/what change(s) would you make to the guide?

    _____

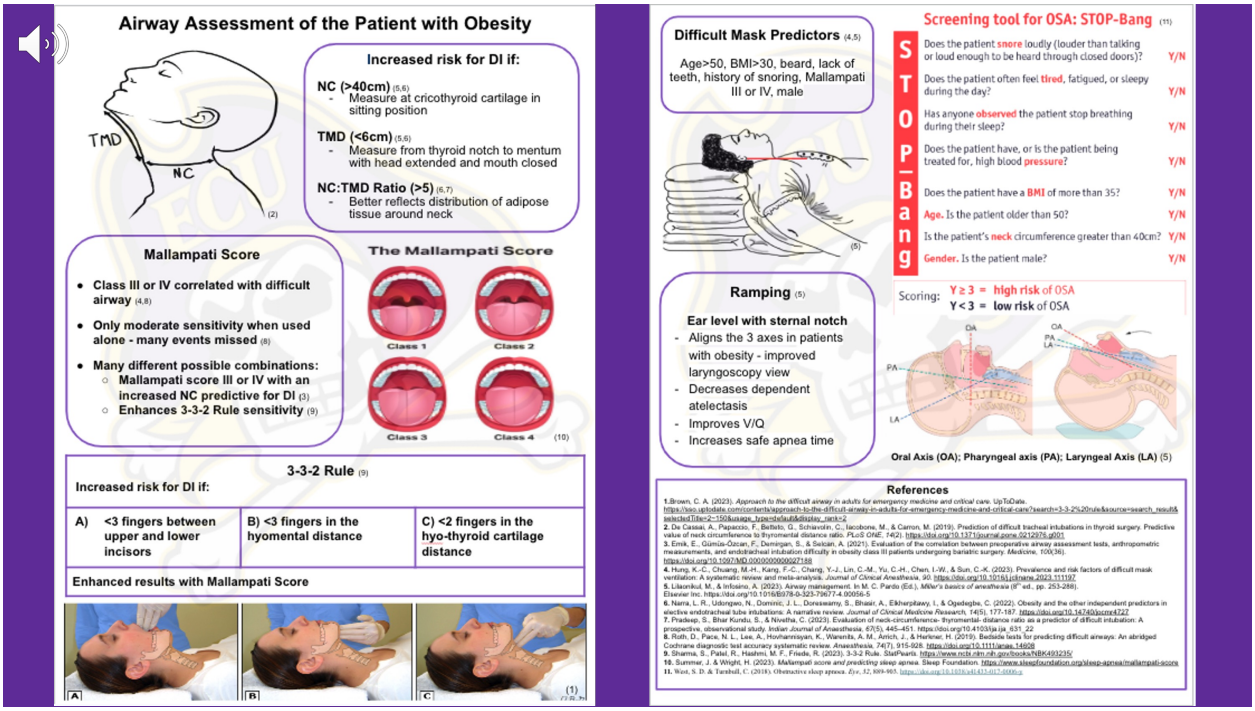
    _____

Appendix H

PowerPoint Slides

Airway Assessment of Patients with Obesity

By: Tyler Craney, Sarah McGuire, Amy Nygren, Lauren Powell



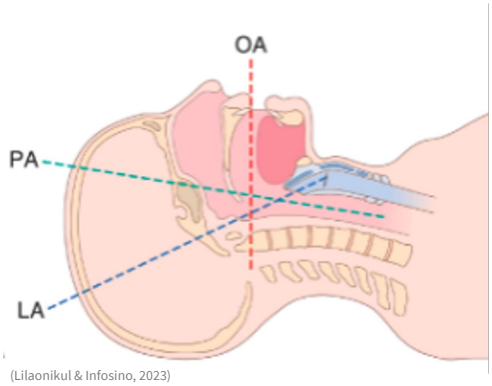
Obesity

BMI	Weight classification
Below 18.5	Underweight
18.5 – 24.9	Normal
25.0 – 29.9	Overweight
30.0 or higher	Obese
Cleveland Clinic	

(Cleveland Clinic, 2022)

- Physiological changes
  - Narrower airways from fat tissue deposits (Mehta et al., 2022; Moura et al., 2021)
  - Decreased lung volumes but increased oxygen consumption
- Related to difficult airway
  - Risk for difficult airway up to 14% (Mehta et al., 2022)
  - Risk increased linearly up to BMI of 30 but then no further increase (Saasouh et al., 2018)
- Body Mass Index (BMI) not the best predictor of difficult airway
  - Systematic review - researchers found BMI alone could not predict difficult airway (Hung et al., 2023)
- Variable patient physiology even within the same BMI groupings (Mehta et al., 2022; Thota et al., 2022)

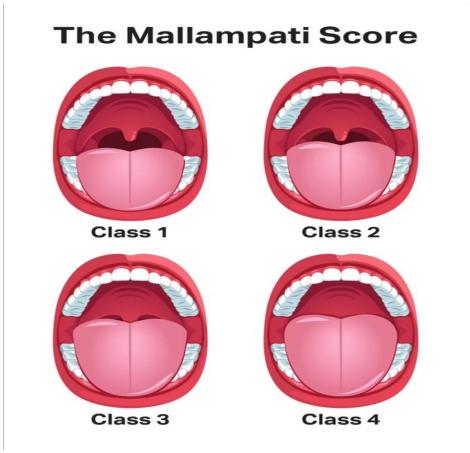
NC, TMD, & NC:TMD Ratio



(Lilaonikul & Infosino, 2023)

- Neck Circumference **(NC) > 40 cm** is correlated with difficult intubation (DI; Lilaonikul & Infosino, 2023).
- Thyromental Distance **(TMD) < 6 cm** is associated with a poor view during direct laryngoscopy
- **NC: TMD Ratio > 5** is a better predictor for DI than NC or TMD alone (Narra et al., 2022; Pradeep et al., 2023).

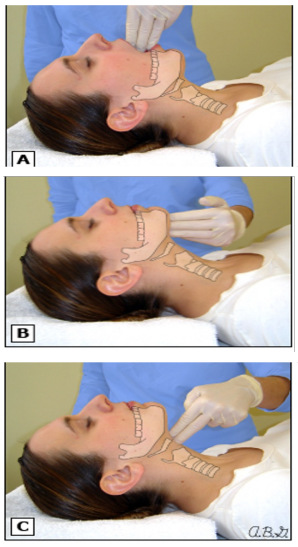
Mallampati Score



(Summer & Wright, 2023)

- Mallampati Class III or IV related to difficult airway (Hung et al., 2023)
- Independent predictive sensitivity may be the greatest of any single assessment, but sensitivity still only moderate (Roth et al., 2019)
- Multiple studies recommend using in combination, but combinations are variable and lacking in data

3:3:2 Method



Increased Risk for DI if:

<3 fingers between upper and lower incisors

OR

<3 fingers in the hyomental distance

OR

<2 fingers in the hyo-thyroid cartilage distance

Increased predictive value when combined with Mallampati Scoring ≥3

(Sharma et al., 2023)

Screening tool for OSA: STOP-Bang

S	Does the patient **snore** loudly (louder than talking or loud enough to be heard through closed doors)?	Y/N
T	Does the patient often feel **tired**, fatigued, or sleepy during the day?	Y/N
O	Has anyone **observed** the patient stop breathing during their sleep?	Y/N
P	Does the patient have, or is the patient being treated for, high blood **pressure**?	Y/N
B	Does the patient have a **BMI** of more than 35?	Y/N
a	**Age.** Is the patient older than 50?	Y/N
n	Is the patient's **neck** circumference greater than 40cm?	Y/N
g	**Gender.** Is the patient male?	Y/N

Scoring: **Y ≥ 3 = high risk** of OSA
Y < 3 = low risk of OSA

Developed by Chung F, Yegneswaran B, Liao P, Chung SA, Vairavanathan S, Islam S, Khajehdehi A, Shapiro C: *STOP Questionnaire A Tool to Screen Patients for Obstructive Sleep Apnea*, 2008.

(West & Turnbull, 2018)

OSA Screening: STOP-Bang Scoring

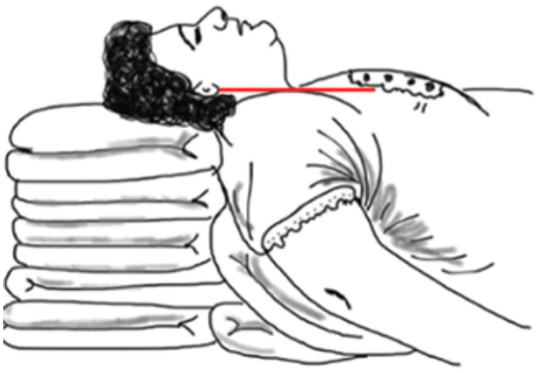
A significant number of patients with OSA go undiagnosed and untreated (Longnecker et al., 2018).

Patients with OSA are at an increased risk of airway complications.

OSA is formally diagnosed with a sleep study, but STOP-bang has been shown to be a QUICK and reliable screening tool. In fact, it was first developed for use in the perioperative environment

ASA Guidelines support preoperative screening for OSA (American Society of Anesthesiologists, 2014).

Ramping



(Lilaonikul & Infosino, 2023)

External auditory meatus should be level with the sternal notch (Lilaonikul & Infosino, 2023)

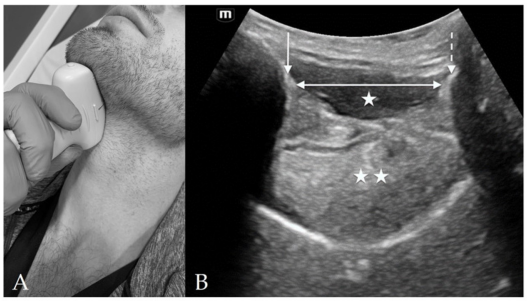
- Aligns the 3 axes in patients with obesity.
- Improves view during direct laryngoscopy.
- Decreases dependent atelectasis
- Improves V/Q
- Increases safe apnea time (Hasanin et al., 2020)

Difficult Mask Predictions

(Drägerwerk, 2024)

- History of snoring (Longnecker et al., 2018)
- BMI greater than 30
- Age older than 50 years
- Severely limited jaw protrusion
- Beard
- Lack of teeth
- Male (Pardo, 2023)

In the Pipeline



Suprahyoid View. (**A**) Suprahyoid probe placement on the subject's neck in sagittal orientation. (**B**) Suprahyoid view of anterior neck with curvilinear probe in sagittal orientation and probe indicator directed cranially. The mentum of the mandible is indicated by the *solid arrow* and the hyoid bone is indicated by the *dashed arrow*. Deep to the hypoechoic mylohyoid and geniohyoid muscles (*single star*) lies the tongue (*double star*). The hyomental distance (HMD) is spanned by the *double-headed arrow*.
(Lin et al. 2023)

POCUS Airway Assessment

Emerging tool in the assessment of difficult airways (Lin et al. 2023)

Promising preliminary results for increased sensitivity and specificity compared to physical assessments

There are numerous exams which vary in the skill-level required and accuracy

Image showing measurements of hyomental distance which has been demonstrated to be a quick, easily performed, high yielding exam.

Thank You!

Utilize the quick reference guide for 2 weeks

Be on the lookout for the post-implementation survey in your inbox

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