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Guidelines for the Optimal Assessment of Airway to Predict Difficult Intubation

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Guidelines for the Optimal Assessment of the Airway to Predict Difficult Intubation

Abstract

Managing the airway is the cornerstone of anesthesia care. However, difficult airway or intubation is not clearly defined. A major complication with a difficult airway is a cannot intubate, cannot ventilate (CICV) situation, which is reported to be as high as 10%. In addition, according to the American Society of Anesthesiologists (ASA) Closed Claim Study, "Adverse respiratory events are the most common type of injury, with difficult intubation [DI] and ventilation contributing to most of the cases. Twenty-eight percent of all anesthesia deaths are related to a CICV situation. As anesthesia evolves, basic airway assessments were developed and include mallampati (MP), thyromental distance (TMD), upper lip bite test (ULBT), and interincisor distance (IID). However, not one basic airway assessment accurately predicts a DI. The problem is inappropriate or inadequate airway management because a difficult airway can lead to an emergency, such as an anoxic brain injury, respiratory compromise, or even cardiac arrest. The DNP project aims to implement a standardized guideline for the preoperative assessment tool, the LEMON law, as the standard of care for preoperative airway assessment in patients undergoing surgical operations requiring endotracheal tube (ETT) intubation. Theoretical implementation plan at a medical center in the Midwest utilizing a direct supervision anesthesia model to enact the Plan-Do-Check-Act (PDCA) model to evaluate the effectiveness and outcomes relating to the prediction of difficult airway, the prevalence of hypoxia, and effect on patients.

Keywords: anesthesia, airway assessment, LEMON law, difficult airway

Problem Identification

Introduction to Problem

The cornerstone of anesthesia is safe and effective airway management. Ventilation, oxygenation, and endotracheal intubation are primary goals of anesthesia and airway management (Nagelhout & Elisha, 2018). Managing both the normal airway and the difficult airway is essential. There is no one universally accepted definition for the difficult airway. According to the practice guidelines of the American Society of Anesthesiologists (ASA), "A difficult airway is defined as the clinical situation in which a conventionally trained anesthesiologist experiences difficulty with facemask ventilation of the upper airway, difficulty with tracheal intubation, or both" (Apfelbaum et al., 2013, p. 251). Nagelhout and Elisha (2018) also include difficult laryngoscopy in the definition of the difficult airway. This situation is classified as *can't intubate, can't ventilate (*CICV) (Fayed et al., 2022). CICV which is one of the most challenging situations for the anesthesia provider.

Background

Anesthesia is essential for any surgery. However, physicians first performed surgery in the 19th century without anesthesia (Nagelhout & Elisha, 2018). James Gather was the pioneer of physician anesthesia, and until the 20th century, "Anesthesia remained a medical step-sister to surgery" (Nagelhout & Elisha, 2018, p.1). During the first few decades, anesthesia remained careless, but surgeons began to realize the importance of professional anesthesia (Nagelhout & Elisha, 2018). Thus, anesthesia continued to evolve.

Initially, anesthesia was given by physicians, but eventually, nurses began providing anesthesia. In 1956, the credentials for Certified Registered Nurse Anesthetist (CRNA) came into existence; however, nurse anesthetists had been administering anesthesia for more than 150 years

(AANA, 2022a). “The Civil War provided the first opportunity for nurses to assume the duties of anesthesia” (Nagelhout & Elisha, 2018, p. 2). In the 1880s, the Mayos, a family of surgeons, were the first to give the role of anesthesia to nurses due to a shortage of interns; however, the Mayos’ began to admire the nurses as they advanced anesthesia care (Nagelhout & Elisha, 2018). During World War I, anesthesia became more complex; Hodgins, the founders of the American Association of Nurse Anesthetists (AANA), developed nitrous and oxygen anesthesia and began a postgraduate anesthesia school (Nagelhout & Elisha, 2018). The beginning of nurse anesthetists is essential to understand the evolution of nurse anesthesia today.

Significance of Problem to Nurse Anesthesia

Early identification the difficult airway is essential for the anesthesia provider because difficult airways lead to emergencies resulting to mortality and morbidity. The incidence of CICV is reported to be as high as 10% (Hagberg et al., 2013). Thorough airway assessment, preparation, and planning are essential for helping to predict the CICV situation. To understand the significance of a difficult airway, first, it is crucial to understand the airway. The airway or windpipe is the passage air takes to go in and out of a person’s lungs. Air can be breathed in and out through either the mouth or nose. The airway is divided into the upper respiratory tract and the lower respiratory tract (Nagelhout & Elisha, 2018). Anesthesia providers must be experts of the airway.

Each of the components of the upper and lower airway are essential in delivering and utilizing oxygen or air that is breathed. The upper respiratory tract includes the nose, mouth, pharynx, and larynx. The lower respiratory tract consists of the trachea, bronchi, bronchioles, and alveoli. The body needs oxygen to survive. Each organ requires a specific amount of oxygen to function appropriately. With the induction of GA, the loss of consciousness, and impaired

reflexes, the anesthesia provider must manage the airway to ensure that patient is delivered sufficient amounts of oxygen.

Anesthesia providers manage the airway every single day of their careers. Before graduating from a CRNA program, a student must meet the Council on Accreditation of Nurse Anesthesia Education (COA) guidelines. A CRNA must log 2000 total clinical hours, 600 total cases, and 250 successful tracheal intubations (NBCRNA, 2022). As an anesthesia provider, it is imperative to be knowledgeable and proficient in the airway because loss of an adequate airway is the leading cause of mortality and morbidity in anesthesia.

CICV is a difficult airway situation. As previously stated, the definition of a difficult airway differs across literature, making it challenging to accurately measure the true incidence of a difficult airway. Nagelhout and Elisha (2018) describe that difficulty with one or more of the following suggests a difficult airway:

> 1. Mask ventilation with an appropriate mask seal with or without a jaw thrust maneuver.
> 2. Placement of SAD [supraglottic airway device] such as LMA [laryngeal mask airway].
> 3. Placement of ETT into the trachea. 4. Placement of an invasive airway such as a cricothyrotomy tube (p. 412).

Early detection of the difficult airway is critical. Difficulty with BVM (facemask ventilation) indications include no or poor chest rise, gastric air accumulation or entry, decreasing oxygen saturation on the pulse oximetry below 92% using a FiO2 (fractioned of inspired oxygen) of 100%, necessity of using two hand BMV, absent or inadequate bilateral breath sounds, no or poor carbon dioxide waveform capnography, and gas leaks around face mask requiring excessive use of O2 (oxygen) flush valve (Nagelhout & Elisha, 2018). A range of 0.9%-7.8% of cases experiences difficult BMV (Nagelhout & Elisha, 2018). In the CICV situation, “The major

complications identified were death, brain damage, emergency surgical airway placement, and unanticipated ICU [intensive care unit] admission" (Nagelhout & Elisha, 2018, p. 412). The anesthesia provider may ensure adequate oxygenation to avoid morbidity and mortality.

After examining the defined difficult airway, it is essential to investigate the risk factors associated with the difficult airway. The most critical evidence of a difficult airway is previous difficult intubation. According to a multicentered, retrospective cohort study by Reale et al. (2022), "Factors with the highest point estimates for the odds of difficult intubation included increased body mass index, Mallampati score III or IV, small hyoid-to-mentum distance, limited jaw protrusion, limited mouth opening, and cervical spine limitations" (p. 697). According to Nagelhout and Elisha (2018), acquired difficult airway conditions include morbid obesity, acromegaly, Ludwig angina, abscesses, laryngeal papillomatosis, epiglottis, croup, rheumatoid arthritis, ankylosis spondylitis, tumors of the airway, and trauma. Congenital conditions with the difficult airway include Pierre Robin syndrome, Treacher Collins syndrome, Goldenhar syndrome, Goiter, Klippel-Feil syndrome, and Down syndrome (Gupta et al., 2005). Since respiratory complications are an anticipated issue with the induction of anesthesia, appropriate airway assessment tools must be utilized to examine and prepare for the difficult airway appropriately.

Along with monitoring the vital signs of the patient, the airway is the most critical element during induction of anesthesia to maintain. According to the ASA Closed Claim Study, "Adverse respiratory events are the most common type of injury, with difficult intubation and ventilation contributing to the majority of the cases" (Fayed et al., 2022, p.1). Twenty-eight percent of anesthesia deaths are related to CICV situations, and difficult endotracheal intubations specifically account for 17% of all respiratory-related problems that lead to mortality (Bukhari et

al., 2018). Several tests and tools can be utilized to assess the airway. The basic airway assessments include mallampati (MP) classification, thyromental distance (TMD), interincisor distance (IID), head and neck movement (atlantooccipital [AO] function), and mandibular mobility. Before inducing anesthesia, the anesthesia provider utilizes basic airway assessments to examine the airway to predict the difficulty of a patient's airway.

Basic Airway Assessments

MP classification is used in an airway assessment as one of the predictors of a difficult airway. In the mid-eighties, a noninvasive airway assessment known as MP classification was developed to predict the risk of difficult intubation based on mouth opening (Yu & Rosen, 2020). Specifically, MP classification assesses the tongue size relative to the oral cavity (Mallampati, 1985). To assess MP, the patient is seated upright and instructed to open the oral cavity and extrude the tongue without phonation (Mallampati, 1985). Visible structures are then assessed to determine the grade from MP I (best view) to MP IV (worst view). Due to a high rate of false-positive and false-negative results, MP should not be the only airway assessment performed when assessing the difficulty of intubation (Nagelhout & Elisha, 2018). MP should be combined with other airway assessment tools to improve predictability of the difficult airway.

Another airway assessment tool is the TMD. "Thyromental distance represents the straight distance, with the neck fully extended and the mouth closed, between the prominence of the thyroid cartilage and the bony point of the lower mandibular border" (Nagelhout & Elisha, 2018, p. 318). A TMD less than 7 cm is considered short, which is associated with difficult airway intubation because the laryngeal and pharyngeal axes do not correctly align (Nagelhout & Elisha, 2018). With a short TMD, less space is present for tongue displacement, which compromises the ability to visualize the glottis and the vocal cords, leading to a difficult or failed

airway (Kiser et al., 2011). In addition to measuring in centimeters, the TMD can be measured using fingerbreadths. An appropriate TMD is 3 fingerbreadths, which is about 7 cm (Kiser et al., 2011). TMD can help predict the difficult airway.

IID can be a reliable tool in combination with other basic airway assessments. IID is the degree of mouth opening by the temporomandibular joint (TMJ) (Nagelhout & Elisha, 2018). For an appropriate degree of mouth opening for an adult, the distance between the upper and lower incisors should be 4 cm or 2 fingerbreadths (Gupta et al., 2005). A small or short distance is associated with a difficult airway because it obstructs the visualization of laryngeal structures, including the glottis and vocal cords (Nagelhout & Elisha, 2018). IID is one tool that can be utilized to predict a difficult airway.

AO flexion and extension is the ability of the patient to move their head and neck. AO flexion/extension, also called head and neck movement, measures the ability of a patient to be placed in a sniffing position, which provides alignment of the oral, pharyngeal, and laryngeal axes into a straight line (Gupta et al., 2005). To assess AO flexion and extension, the patient flexes the neck on the chest and fully extends the AO joint (Gupta et al., 2005). With poor head and neck movement, related to cervical arthritis or a small C-1 gap, it "enhance[s] the convexity of the neck and push[es] the larynx anteriorly. This situation can impair laryngoscopy and render endotracheal intubation difficult" (Nagelhout & Elisha, 2018, p. 318). Optimal head and neck movement are important to predict the difficulty of intubation by the anesthesia provider.

Mandibular mobility is the ability of the patient to move their mandible. Mandibular mobility, also referred to as the upper lip bite test (ULBT), is recently claimed to have the highest predictability (Bukhari et al., 2018). In 2018, Bukhari et al. (2018) performed a cross-sectional study to determine the predictive value of the ULBT in determining difficult airways

and discover statistically significant results to assess the validity of the predictability. To perform the ULBT, the patient moves the jaw forward and bites their upper lip with their bottom teeth (Nagelhout & Elisha, 2018). “Being able to protrude the mandible in front of the central incisors indicates relative ease for maneuvering the laryngoscope” (Nagelhout & Elisha, 2018, p. 318). Mandibular mobility is the most reliable single test for the anesthesia provider.

The basic airway assessments are not reliable tools independently. However, combined components of the basic airway assessments can be considered an advanced technique. The LEMON law is an example of an advanced airway examination. LEMON stands for

- L=Look externally (facial trauma, large incisors, beard or mustache, and large tongue)
- E=Evaluate the 3-3-2 rule (incisor distance <3 fingerbreadths, hyoid/mental distance <3 fingerbreadths, thyroid-to-mouth distance <2 fingerbreadths)
- M=Mallampati (Mallampati score ≥3)
- O=Obstruction (presence of any condition that could cause an obstructed airway)
- N=Neck mobility (limited neck mobility). (Brinbaumer, 2005, p. 1).

The LEMON law encompasses the basic airway assessment MP, AO function/extension, IID, and TMD. Additionally, the LEMON law includes assessing for obstructions and evaluating the patient by assessing structures that may impede successful intubation. Utilization of the LEMON law enhances the anesthesia provider's evaluation of the airway and helps predict intubation difficulty.

Certified Registered Nurse Anesthetists (CRNA) are responsible for providing anesthesia to patients in the perioperative setting. CRNAs possess communication skills, quality patient care, and a high understanding of the human body (Johnson & Johnson, 2021). When a patient is undergoing a surgical procedure, the CRNA's job is to monitor vital signs and manage the airway (Mayo Clinic, 2020). Specifically, with general anesthesia, the CRNA places either a laryngeal mask airway (LMA) or endotracheal (ET) tube to ensure adequate airway management. (Nagelhout & Elisha, 2018). CRNA's predict and manage difficult airways.

Since the anesthesia provider is an expert in the airway, they must understand potential complications associated with airway management. Specifically, "The prevalence of difficult intubation [airway] varies widely from 0.1% to 10.1%" (Koh, 2016, p. 1). According to a prospective multicenter observational study, 17 serious airway complications occurred, leading to either cancellation of surgery, airway management in recovery, unplanned intensive care unit (ICU) stay, or emergency front of neck airway access (Cumberworth et al., 2022). Of the predicted easy airways, 1 in 42,000 complications occurred (Cumberworth et al., 2022). Of those anticipated with a difficult airway, 1 in 315 experienced complications, which is 45 times more common than an easy airway (Cumberworth et al., 2022). Even though easy airways are more common than difficult airways, the anesthesia provider must be prepared for the difficult airway.

Accurate prediction of the difficult airway is imperative in preventing adverse complications with anesthesia. Anesthesia providers, patients, and the health care organization (HCO) will benefit from the appropriate detection of the difficult airway. With a standardized advanced airway assessment tool, such as the LEMON law, the goal is to provide the most accurate results to predict the difficulty of intubation.

With appropriate and early detection of the difficult airway, anesthesia providers can prepare special devices to aid in airway management and ET intubation. Thus, patients will benefit from avoiding potential adverse outcomes associated with a difficult airway, and the HCO will benefit from patient safety and cost savings.

Problem Statement

The problem is inappropriate or inadequate airway assessment because of a difficult airway can lead to an emergency, such as an anoxic brain injury, respiratory compromise, or even cardiac arrest.

PICOT Question

In adult surgical patients requiring endotracheal intubation, does the LEMON law preoperative advanced airway assessment compared with a basic airway assessment predict the difficulty of intubation in the operating room?

Project Objectives

- Develop EBP guidelines for LEMON law assessment use in the preoperative setting
- Develop a comprehensive plan to implement LEMON law assessment in the preoperative setting
- Develop a comprehensive plan on how to monitor and measure LEMON law assessment in preop
- Develop a comprehensive plan on how to adjust the guidelines if the difficult airways are unable to be detected

Literature Search

Databases

For evidence to answer the PICOT question, OneSearch was utilized to complete the literature search. OneSearch is compiled of scholarly journals, textbooks, websites, and articles into one search engine. OneSearch provides literature reviews, randomized controlled trials, and systematic reviews with multiple search engines specifically for medical professionals. Instead of searching multiple databases individually, OneSearch allows various databases to be explored simultaneously. Databases included in OneSearch include CINAHL, PUBMED, and Cochrane Library. In addition, OneSearch utilizes a Boolean Operator, which allows "AND," "NOT," and "OR" into the search engine to combine or eliminate terms to narrow the results. A literature review must be completed to determine if the data is statistically significant to assess the PICOT question asked. The data collected can support, not support, or render inconclusive for the asked PICOT question.

Search Terms

In the initial literature search, the first keywords searched in the abstract were "airway," "anesthes*," and "lemon." With the limitation of only full text online, 16 articles were found. To broaden the results, the exact keywords were searched for in "TX all text." Three hundred and twenty pieces returned with the limitation of only full text and scholarly journals published within the last five years. Again, the keywords were manipulated to narrow down the returned articles. With the range of years from 2007 to 2022, full text online articles, scholarly journals, and keywords searched in the abstract were "look," "evaluate," "mallampati," "obstruction," and "neck,*" 11 articles were found.

The final literature search performed included keywords "look," "evaluate," "mallampati," "obstruction," "neck,*" "lemon," and "airway" in "TX all text" and "anesth*" within the abstract, which yielded 38 results. Limitations of online full text and the year range of

2012 to 2022 were included. Lastly, textbooks were eliminated from the search. Therefore, 17 journal articles remained. Exclusion criteria included pediatric studies, ultrasound studies, articles not in English, prehospital studies, and studies without endotracheal intubation. From this literature search, six articles will be analyzed. Two additional articles will be interpreted that were referenced in one of the other studies being analyzed.

LEMON law

Management of the airway is critical for the anesthesia provider. Fatal results can occur with failed or delayed endotracheal intubation resulting from the difficulty of an airway (Seo et al., 2012). Prediction of the difficult airway is essential to ensure successful intubation on the first attempt (Ogboli-Nwasor et al., 2018). Recognition of the difficult airway allows time for optimal preparation and positioning, proper equipment nearby, and participation by experienced providers with difficult airways (Tamire et al., 2019). In an attempt to perform an airway assessment with high predictability of difficult intubations, a literature review was conducted to answer the PICOT question.

In 2005, Reed et al. (2005) performed the first prospective observational study of the assessment tool, the LEMON method. Every patient that came into the emergency department (ED) from June 2002 through September 2003 was assessed with the LEMON criteria (Reed et al., 2005). Those requiring endotracheal intubation were also graded by the Cormack and Lehane (CL) score (Reed et al., 2005). A total of 156 patients were intubated, with 114 being a CL grade 1 and 42 were grade 2, 3, or 4 (Reed et al., 2005). The LEMON assessment consisted of a score from 0-9 (Reed et al., 2005). Airway assessment scores included:

> "Number of positive unfavorable 'look' criteria" for 0-4 points, "Mouth opening less than three finger breadths" for 1 point, "Hyo-mental distance less than three finger breadths"

> for 1 point, "Thyro-hyoid distance less than two finger breadths" for 1 point, "Presence of an obstructed airway" for 1 point, and "Presence of poor neck mobility" for 1 point (Reed et al., 2005, p. 102).

Overall, the correlation was noted between an increase in LEMON score and an increase in CL grading score (Reed et al., 2005). Specific characteristics that lead to a higher airway assessment score included: large incisors, decreased inter-incisor distance (IID), and reduced thyroid to the floor of mouth distance (Reed et al., 2005).

In 2018, Ogboli-Nwasor et al. (2018) performed a prospective observational study of the use of the LEMON score in Africans. Participants of this study included 160 consecutive patients aged 18-65 with an ASA I-III undergoing a surgical procedure requiring endotracheal intubation (Ogboli-Nwasor et al., 2018). Similar findings to the study by Reed et al. were discovered, such as an increase in LEMON score correlates to a rise in CL grade (Ogboli-Nwasor et al., 2018). Specifically, in this study, a large tongue and reduced Hyo-mental distance increase the chances of difficult video laryngoscopy (Ogboli-Nwasor et al., 2018). Overall, this study proves that the LEMON criteria can predict difficult intubation well (Ogboli-Nwasor et al., 2018).

Hagiwara et al. (2015) performed a prospective validation of the modified LEMON score in ED patients. The modified LEMON score omits the MP if unable to obtain it due to the seriousness of the patient's condition (Hagiwara et al., 2015). In this multicentered designed study, 4034 intubations were evaluated, with 3313 patients intubated direct laryngoscopy and 610 with video laryngoscopy (Hagiwara et al., 2015). In this study, intubation is considered difficult if two or more attempts are made before successful endotracheal intubation is achieved (Hagiwara et al., 2015). In conclusion, "We found high sensitivity and a negative predictive value of the modified LEMON criteria for predicting the difficult intubation. The modified

LEMON might assist ED providers in better identifying difficult intubations" (Hagiwara et al., 2015, p. 1492).

Because of the COVID-19 pandemic, to decrease exposure to anesthesia providers, Hrishi et al. (2021) performed a comparative study to evaluate the effectiveness of virtual airway assessments (VAA) compared with direct airway assessments (DAA). The LEMON law is not directly being studied in this prospective observational study; instead, the LEMON criteria was the standard airway assessment scoring system (Hrishi et al., 2015). "The LEMON score had an overall 'almost perfect agreement' between DAA and VAA" (Hrishi et al., 2015, p. 719), proving an alternative for anesthesia providers to decrease exposure.

Ji et al. (2018) retrospectively reviewed 114 adult trauma patients undergoing endotracheal intubations for emergent surgery with general anesthesia. This study reviewed the modified LEMON law (also called LEON) between March 2016 and August 2016, excluding already intubated patients or those receiving regional anesthesia (Ji et al., 2018). Based on this study's results, LEON scores of three or greater can predict the difficult intubation; specifically, limited neck mobility can increase the difficulty (Ji et al., 2018). Even though previous studies proved the predictability of the LEMON criteria, one specific definition or criteria was not widely utilized; therefore, Ji et al. (2018) used the IDS score and classified greater than five as a difficult intubation. In conclusion, "The LEON score may be used as one of the evidence [in] predicting difficult airway, thereby being helpful to increase safety in the airway management of adult trauma patients undergoing emergency surgery" (Ji et al., 2018, p. 5).

In a cross-sectional study by Tamire et al. (2018), there were 242 participants, with 33 patients (13.6%) being a difficult laryngoscopy and 12 (5%) being a difficult intubation. Therefore, 33% of difficult laryngoscopies were difficult intubations (Tamire et al., 2018). In this

study, the LEMON law is not directly studied; however, Tamire et al. (2018) suggest using more than one test. In combination, MP, IID, TMD, and CL show improved sensitivity and specificity and found better predictability in difficult laryngoscopes and intubations (Tamire et al., 2018).

Seo et al. (2012) utilized seven airway assessment factors to predict the difficulty of intubation based on the total airway score (TAS). This study selected 305 patients ASA I or II between 19-70-years-old undergoing elective surgery requiring endotracheal intubation. The seven preoperative assessments included are MP, TMD, head and neck movement, body mass index (BMI), buck teeth, inter-incisor gap (also known as IID), and ULBT (Seo et al., 2012). The LEMON law is not directly studied by Seo et al. (2012); instead, it is mentioned as "the LEMON method, [has] been used to make airway assessments, but depending on the author and research method, the results have been different" (p. 492) and "the LEMON method is commonly used" (p. 495). In conclusion, Seo et al. (2012) found that using many airway assessments and a TAS>6 is a high predictor of difficult intubation and is better than just one airway assessment. However, if only one airway test is performed, the UBLT is very useful (Seo et al., 2012).

In the retrospective evaluation of airway management by Sankar et al. (2016), 48 cases were evaluated to determine if blind awake intubation could be considered in the anesthetic management algorithm in facilities without fiberoptic intubation. The LEMON law is not being directly studied; however, the prediction of difficult intubation was assessed and recorded based on the LEMON criteria (Sankar et al., 2016). In conclusion, blind awake intubation is a viable option (Sankar et al., 2016). However, it is recommended for each anesthesiology department to determine guidelines for implementation in an institution (Sankar et al., 2016).

Exclusion Criteria/Limitations

"Even though the difficulty in airway management is a major cause of morbidity and mortality in anesthetic practice, attention is not given to the prevalence of this problem and improvement of preoperative airway assessments" (Tamire et al., 2018, p. 4). In addition, the lack of a universally accepted definition of difficult airways leads to insufficient study results and advancements (Ji et al., 2018). However, Seo et al. (2012) utilized the definition by the IDS to predict the difficult intubation. Of the literature reviewed, common exclusion criteria include emergent trauma intubations in the ED, ASA IV or V, previous difficult intubations, elderly, pediatrics, or little head and neck movement (Ji et al., 2015; Ogboli-Nwasor et al., 2018; Tamire et al., 2018). In addition, the majority of the studies were limited to self-reporting bias, multiple physicians assessing the airway, students performing endotracheal intubation, and patients with increased BMI (Hagiwara et al., 2018; Reed et al., 2005; Tamire et al., 2018; Hrishi et al., 2021).

Summary of Findings

The studies performed by Reed et al. (2005), Ogboli-Nwasor et al. (2018), Hagiwara et al. (2015), and Ji et al. (2018) all acquired similar results. With these four studies, the LEMON law is proved to accurately predict difficult intubation. In the studies by Hrishi et al. (2021) and Sankar et al. (2016), the LEMON criteria are accepted as a proper airway assessment with high predictability. Tamire et al. (2018) and Seo et al. (2012) recognize the LEMON law but do not directly promote it. Instead, Tamire et al. (2018) and Seo et al. (2012) conclude using multiple airway assessments to appropriately determine the difficult airway.

Throughout these studies, each found specific characteristics or assessments more accurate than others. For instance, Seo et al. (2012) found the UBLT to be the most accurate single test, while Tamire et al. (2018) saw the combination MP, IID, TMD, and CL. Ogboli-Nwasor et al. (2018) concluded a large tongue and reduced hyo-mental distance were more

accurate predictors, and Reed et al. (2005) discovered large incisors, decreased IID, and reduced thyroid to the floor of mouth distance to be more accurate.

Of the eight articles reviewed, Appendix D provides significant evidence supporting the use of the LEMON law as the primary predictor of difficult airways. Findings represent the use of multiple basic assessment tools, specific assessments/characteristics, and the importance of prediction. Overall, the literature reviewed supports the general accepted use of the LEMON law.

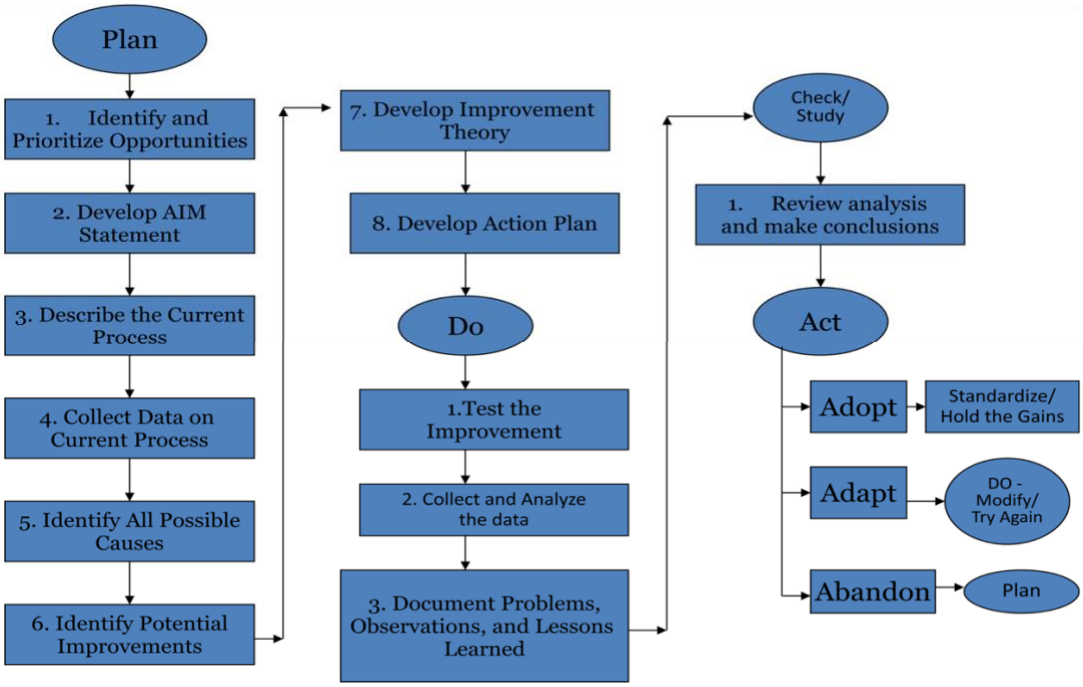
Model Framework

The project planning tool, Plan-Do-Check-Act (PDCA), helps start new improvement projects, implement change, and work toward continuous change (American Society for Quality [ASQ], n.d.). PDCA is a four-stage model focused on problem-solving (Minnesota Department of Health Center for Public Health Practice [MDH], n.d.). "This QI [quality improvement] tool [PDCA] maps a process to help improve processes and eliminate inefficiencies" (MDH n.d., p. 1). In 2010, Gorenflo and Moran introduced the ABCs of PDCA, a circular diagram describing the continuous improvement opportunity through the PDCA problem-solving model (MDH, n.d.). However, as seen below, the adapted Figure 1 outlines the PDCA in more detail than the circular diagram.

Figure 1

PDCA Flow Chart

Adapted from Gorenflo and Moran, The ABCs of PDCA



Note: Minnesota Department of Health Center for Public Health Practice. (n.d.). *PDSA: Plan-do-study-act (rapid cycle improvement) - Minnesota dept. of health. Minnesota Department of* Health. https://www.health.state.mn.us/communities/practice/resources/phqitoolbox/docs/pdsa_flowchart.pdf

Plan-Do-Check-Act Procedure

To understand the appropriate stages of the PDCA model, ASQ (n.d.) outlined the PDCA procedure below:

1. **Plan:** Recognize an opportunity and plan a change.
2. **Do:** Test the change. Carry out a small-scale study.
3. **Check:** Review the test, analyze the results, and identify what you've learned.
4. **Act:** Take action based on what you learned in the study step. If the change [does] not work, go through the cycle again with a different plan. If you were successful,

> incorporate what you learned from the test into wider changes. Use what you learned to plan new improvements, beginning the cycle again (paragraph 3).

Plan

In the first stage, the detailed flow sheet in figure 1 prompts eight questions to be evaluated. To address the PICOT question, the plan includes implementing the use of the advanced airway technique, the LEMON law, in the preoperative setting.

Do

In the second stage, figure 1 prompts three questions addressing testing the improvement, collecting and analyzing data, and documenting results learned (MDH, n.d.). When addressing the PICOT question, this stage consists of implementing the advanced airway assessment in the preoperative setting, evaluating the effectiveness, and documenting learning outcomes.

Check

In the third stage, check, results are reviewed, and conclusions are drawn. In this stage, the LEMON law as a preoperative airway assessment will be evaluated to determine the predictability of a difficult airway.

Act

Lastly, in the fourth stage, act, the results determine whether to adapt, adopt, or abandon the proposed plan (MDH, n.d.). This stage deciphers the feasibility of implementation of the proposed evidence-based research gained. The LEMON law could be kept, modified, or completely unused at this stage.

Scaffolding the Project

Implementation Plan

Overall Goal

Based on supportive research from the literature analysis and synthesis, the DNP project aims to implement the LEMON law as the standard of care for preoperative airway assessment in patients undergoing surgical operations/procedures requiring endotracheal tube (ETT) intubation.

To achieve the overall aim of the DNP project, the Plan-Do-Check-ACT (PDCA) strategy will be theoretically discussed for implementation to address the problem, which allows for potential implementation in the future. The PDCA theoretical implementation discussed below is for a medical hospital in the Midwest that utilizes the direct supervision model. The anesthesia department includes anesthesiologists, certified registered nurse anesthetists (CRNA), and anesthesia assistants (AA). At this facility, student registered nurse anesthetists (SRNA) and anesthesia residents also participate in anesthesia care during the perioperative setting. Below is the plan for future implementation following the quality improvement PDCA model. To implement this project in the future, the project team will follow the following sections Plan, Do, Check, and Act for appropriate implementation.

Plan

First, the 'Plan' step must clearly be understood. As previously discussed, the 'Plan'' step is the first stage in the PDCA model (Minnesota Department of Health Center for Public Health Practice [MDH], n.d.). The 'Plan' identifies the problem and plan for change (MDH, n.d.). Because there is no clear definition of a difficult airway or standardized advanced airway assessment, the need to implement one is present (Nagelhout & Elisha, 2018). Based on the literature review and synthesis, the opportunity to implement LEMON law as a standardized advanced airway assessment is present.

The chief CRNA devises a plan to implement the LEMON law as the standard airway assessment for all adult surgical patients requiring ETT intubation. To effectively utilize the

PDCA model, the chief CRNA will address the eight steps of the 'Plan' stage (MDH, n.d.). Based on Figure 1 noted above, steps 1 and 2 are already described. Step 3 entails understanding the current process (MDH, n.d.). At this medical institution, the anesthesiologists conduct the full preoperative anesthesia assessment. Each anesthesia provider asks questions to evaluate the optimal anesthesia for each patient. In addition, the anesthesia provider performs an oral examination based on physical features, mallampati (MP) score, etc. However, there is no standard airway assessment, guideline, or check that each anesthesiologist is required to follow. To collect data on the current process (step 4), the following survey (Appendix A) will be given to each anesthesia provider in the anesthesia department, including anesthesiologists, CRNA, AA, SRNA, and anesthesia residents.

Step 5 includes identifying all possible causes of the problem (MDH, n.d.), which can be understood through discussion with anesthesia providers and survey results. Step 6 identifies potential improvements and step 7 develops improvement theory (MDH, n.d.), which can be devised after survey results are obtained. Lastly, step 8 of the 'Plan' stage includes developing the action plan (MDH, n.d.). An appropriate action plan will be developed, assuming survey results conclude the need for a standardized airway assessment tool and an increased understanding of the LEMON law. The action plan devised by the chief CRNA includes adequate and appropriate education for all anesthesia providers. Thus, an educational meeting will be held with mandatory attendance to discuss the action plan.

The action plan includes a discussion with the anesthesia department of problem identification, support of literature from literature analysis and synthesis, clear expectations for a plan to fix the problems, and monitoring outcomes with implementation.

Steps of Action Plan for Implementation of LEMON law as Standardized Advanced Airway Assessment:

1. Describe the problem with no standardized advanced airway assessment
    a. Describe LEMON law and utilization as an airway assessment
    b. See Appendix B for guidelines on the appropriate implementation of the LEMON law
2. Provide evidence of literature review, analysis, and synthesis
    a. Results include LEMON law as an accurate predictor of difficult airway
3. Implementation of LEMON law
    a. Scoring system of LEMON law (Appendix B)
    b. Include LEMON law in the template of the preoperative anesthesia note
4. Discuss potential outcomes
    a. Prediction of difficult airway/intubation or difficult bag valve mask ventilation
    b. Incidence of hypoxia
    c. Impact on workflow/ amount of time spent with the patient
    d. Effect on budget
    e. The overall impact of an assessment tool for anesthesia providers

After ensuring appropriate education of all anesthesia providers, the action plan will be implemented into practice with planned surveys one month and four months after initiation.

Do

The 'Do' stage, as previously discussed, includes three steps. Step 1 is measuring the improvement (MDH, n.d.). Step 2 analyzes and collects data from the implemented plan (MDH,

n.d.). Lastly, step 3 is discovering problems and understanding potential improvements (MDH, n.d.).

In the 'Do' stage, the Chief CRNA will ensure adequate and appropriate implementation of the previously stated action plan. After one month of implementation, the Chief CRNA will survey (Appendix C) to evaluate outcomes. Again, after four months, another survey will be conducted (see Appendix C). The results of both surveys will be compared and analyzed to understand the effects of the data collected. Depending on the survey results, the Chief CRNA will recognize problems, observe issues with the implementation, document lessons learned, and plan for future improvement.

Check

'Check' is the third stage of the PDCA model, which includes one step to review the analysis and draw conclusions (MDH, n.d.). During the 'Check' stage, the Chief CRNA will analyze data gathered in the 'Do' stage to conclude the effect of the implementation of the LEMON law on anesthesia providers and patients. The Chief CRNA will evaluate positive, negative, or neutral outcomes concerning implementing the standardized LEMON law assessment tool. After determination of what was learned throughout stages' Plan' and 'Do,' the Chief CRNA will conduct another mandatory anesthesia provider meeting to discuss findings. During the meeting, the Chief CRNA will inquire about benefits, strengths, weaknesses, or modifications to the action plan. With the information learned throughout the session, the Chief CRNA will move to the fourth stage of the PDCA model.

Act

Lastly, in the PDCA model is the 'Act' stage. In the 'Act' stage, there are three potential outcomes. The Chief CRNA will determine one of the three outcomes (adopt, adapt, or abandon)

to utilize (MDH, n.d.). Adopt includes continuing the action plan and accepting the LEMON law as the standardized airway assessment tool for all adult surgical patients requiring ETT intubation (MDH, n.d.). Adapt includes modification of the action plan and trying the new action plan following the PDCA cycle (MDH, n.d.). Abandon includes not continuing implementation of the LEMON law (MDH, n.d.).

After the decision by the Chief CRNA to either adopt, adapt, or abandon the LEMON law as the standardized airway assessment tool for all adult surgical patients requiring ETT intubation, a mandatory meeting of the anesthesia providers will be conducted. The findings will be discussed in this meeting, and appropriate actions will be initiated based on the 'Act' most suitable for the situation.

Outcome Analysis Plan

In the future, implementing the previously discussed action plan following the PDCA model, an outcome analysis plan must be identified. The tool to evaluate the outcomes is a survey. After completing the survey questions in Appendix A, the results will be analyzed to aid in adequate education of the LEMON law to anesthesia providers. Appendix C identifies survey questions to be assessed one month and four months post initiation of the LEMON law to evaluate the new standardized airway assessment tool's effectiveness and monitor outcomes. Specific outcomes assessed include:

- Increased prediction of difficult airway/intubation or difficult bag valve mask ventilation
- Decreased prediction of difficult airway/intubation or difficult bag valve mask ventilation
- Increased incidence of hypoxia
- Decreased incidence of hypoxia
- Negative impact on workflow/ increased amount of time spent with the patient

- Positive/neutral impact on workflow/ decreased/same amount of time spent with the patient
- Positive effect on the budget
- Negative effect on the budget
- No effect on the budget
- Positive overall impact of an assessment tool for anesthesia providers
- Negative overall impact of an assessment tool for anesthesia providers
- Neutral overall impact of an assessment tool for anesthesia providers

The outcomes will be compared from one month and four months after implementation to assess the benefits, strengths, weaknesses, and potential modifications to ensure the most appropriate action plan for the LEMON law as the standard of care for preoperative airway assessment. In addition, further studies can be conducted to evaluate the total points (0-10) from the LEMON law scoring system to predict difficult airways.

Success will be monitored by outcomes beneficial to the patient and the anesthesia provider. Potential beneficial outcomes to determine success are increased frequency of identification of difficult airway or difficult bag mask valve ventilation, decreased or no change in cost of stay, the positive or neutral overall impact of an assessment tool for anesthesia providers, and reduced incidence of hypoxia. In addition, during the final meeting of the Chief CRNA with the anesthesia department, anesthesia providers are encouraged to share other outcomes experienced.

One limitation includes noncompliance with anesthesia providers. Chart audits can be utilized to assess the compliance of anesthesia providers. With the plan devised, patients undergoing monitored anesthesia care (MAC) cases or laryngeal mask airway (LMA) will not be

required a LEMON law assessment charted in their preoperative note. Thus, if any complication arises, the LEMON law will not be completed, and adequate prediction of the difficult airway may not be adequately assessed. Another limitation includes the multitude of different providers completing the LEMON law assessment. Although there is a standardized guideline (Appendix B), some anesthesia providers may differ in the scoring system.

Facilitators include the Chief CRNA, anesthesiologists, AA, and CRNA. The cooperation and compliance of the entirety of the anesthesia department can ensure an easy and smooth transition to the new standardized airway assessment tool. In addition, notification by email to other providers in the preoperative setting to announce the change is required. Surgeons, physicians, preoperative nurses, nursing assistants, and circulating nurses will be notified of the new airway assessment protocol to ensure the appropriate documentation is complete before the patient moves into the intraoperative setting.

Timeline

In the future, if this implementation plan following the PDCA model is implemented, an appropriate timeline must be set. For ease of understanding, specific months are mentioned to help facilitate a timeline. As previously mentioned, the survey in Appendix A will be completed first. Appendix A will be completed by all anesthesia providers by the second Monday in January and provided on the first day of January. Next, the first mandatory staff meeting will be held on the first Wednesday of February. After that, the second Monday of February will begin the first day of using the LEMON law as the standard of care for preoperative airway assessment in patients undergoing surgical operations/procedures requiring endotracheal tube (ETT) intubation.

For one month (beginning the second Monday of March), all anesthesia providers must complete the survey in Appendix C before the last Monday in March. The survey in Appendix C will be conducted again for four months (beginning the second Monday of June) from initiation by all anesthesia providers. The survey must be completed before the last Monday in June. Finally, the last staff meeting will be held on the first Wednesday of July to discuss the findings from the survey and determine the 'Act' stage.

Overall, the timeline for the project is seven months, from the beginning of the first survey to the end of the last mandatory staff meeting. Throughout the process, two mandatory staff meetings are included in the timeline for all anesthesia providers, completion of three surveys, and utilization of LEMON law as the standard of care for preoperative airway assessment for patients undergoing surgical operations/procedures requiring endotracheal tube (ETT) intubation.

Budget

At the proposed hospital in the Midwest, a staff meeting is held every Wednesday morning from 7 AM-8 AM. Because this is already a standard and a part of the budget, no additional funding or cost is necessary to pay anesthesia providers. Since all charting will be done electronically for the LEMON law assessment in the preoperative note, no additional fee is needed for paper or ink. In addition, the survey will be sent out via email and completed through the free online survey monkey website. The Chief CRNA will be given 4 hours to evaluate each survey result and one hour of preparation time for each of the two meetings. The anesthesia department will pay the Chief CRNA's hours as educational hours. Overall, the budget is minimal and can be asked to be absorbed by the anesthesia department.

Conclusion

In conclusion, the literature review and synthesis revealed the LEMON law as an accurate predictor of difficult intubation. An implementation plan was devised utilizing the PDCA model for a hospital in the Midwest. In the future, the action plan can be implemented in the preoperative setting to effectively predict the difficulty of intubation and avoid CICV situations. This DNP project seeks to implement the LEMON law and best practice guidelines while decreasing adverse complications of anesthesia relating to failed or difficult intubations.

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Appendix A

'Plan' Survey Questions

1. Age:

a. 20-30 yrs

b. 30-40 yrs

c. 40-50 yrs

d. >50 yrs

2. Anesthesia Experience:

a. CRNA

b. SRNA

c. Anesthesia Resident

d. Anesthesiologist

e. AA

3. Years of Experience

a. 0-5 yrs

b. 5-10 yrs

c. 10-20 yrs

d. 20-30 yrs

e. 30 + yrs

3. What airway exams do you perform on every patient (circle all that apply)?

a. Mallampati score

b. Thyromental distance

c. 3-3-2-test

d. Upper lip bite test (if applicable)

e. Other _____

4. Which of the following is your preferred test for predicting a difficult airway?

a. Mallampati score

b. Thyromental distance

c. 3-3-2-test

d. Upper lip bite test (if applicable)

e. Other _____

5. Do you know what the LEMON law airway assessment tool is?

a. Yes

b. No

6. If so, do you utilize the LEMON law airway assessment tool?

a. Yes

b. No

c. n/a

7. Do you think current preop airway assessment practice is adequate to predict difficult intubations?

a. Yes

b. No

8. Do you think there should be a standardized airway assessment in preop for all patients requiring endotracheal tube intubation?

a. Yes

b. No

9. What apprehensions regarding integrating the LEMON law in all preoperative airway assessments?

a. Not enough time in preop

b. Too expensive

c. Unnecessary addition to an airway assessment

d. Potential for inaccuracy

e. Other _____

f. None

Appendix B

Standardized Airway Assessment Guidelines

TITLE: Guidelines for Optimal Assessment of the Airway to Predict Difficult Intubation	**NUMBER:**
ISSUE DATE: 09/16/2022	**EFFECTIVE DATE:**
DEVELOPED/REVISED BY: Morgan Gidley	**DATE REVIEWED:**
REVIEWED BY: Dr. Kacy Ballard	**APPROVED BY:** Dr. Kacy Ballard

SCOPE: This guideline is in effect for the proposed hospital of interest for the DNP project.

STATEMENT OF PURPOSE:

The purpose of this guideline is to provide evidence-based practice recommendations for preoperative advanced airway assessment. A cannot intubate, cannot ventilate (CICV) situation results in hypoxia, morbidity, and mortality. In the best preparation by the anesthesia providers for airway management, identification and prediction of difficult intubation (DI) are crucial. Current airway assessment practices include Mallampati (MP), interincisor distance, thyromental distance, upper lip bite test, and atlantooccipital movement. Each test provides poor predictability of a DI. The research concludes that multiple basic airway assessments can better predict a DI than just one. However, each anesthesia provider may use one to all five basic airway assessment tools. A standardized advanced airway assessment tool should be utilized to ensure adequate detection and accurate predictability. According to research, the advanced airway assessment tool, the LEMON law, provides acceptable predictability of a DI. Thus, following the LEMON law ensures anesthesia providers utilize the same airway tool with appropriate detection of DI.

DEFINITIONS:

- **Cannot ventilate-** when the anesthesia provider cannot bag-mask ventilate (BMV) in a patient
- **Difficult intubation/cannot intubate-** the skilled anesthesia provider cannot place an endotracheal tube (ETT) into the airway through the glottis and vocal cords
- **Endotracheal intubation-** a medical procedure in which a tube is placed into the windpipe (trachea) through the mouth or nose
- **Mallampati-** classification to predict the risk of difficult intubation based on mouth opening
- **Interincisor distance-** degree of mouth opening by the temporomandibular joint
- **Thyromental distance-** represents the straight distance, with the neck fully extended and the mouth closed, between the prominence of the thyroid cartilage and the bony point of the lower mandibular border
- **Upper lip bite test (mandibular mobility)- the** ability of a patient to move the jaw forward and bite their upper lip with their bottom teeth

- **Atlantooccipital movement-** also called head and neck movement, measures the ability of a patient to be placed in a sniffing position, which provides alignment of the oral, pharyngeal, and laryngeal axes into a straight line
- **LEMON law-**
    - L=Look externally (facial trauma, large incisors, beard or mustache, and large tongue)
    - E=Evaluate the 3-3-2 rule (incisor distance <3 fingerbreadths, hyoid/mental distance <3 fingerbreadths, thyroid-to-mouth distance <2 fingerbreadths)
    - M=Mallampati (Mallampati score ≥3)
    - O=Obstruction (presence of any condition that could cause an obstructed airway)
    - N=Neck mobility (limited neck mobility)

POLICY:

The guideline is applied to anesthesia providers performing preoperative airway assessments on patients requiring endotracheal intubation. This guideline intends to standardize the airway assessment tool utilized by all anesthesia providers at a given facility. It is intended to improve patient outcomes, improve prediction and accurate detection of DI, and better prepare anesthesia providers for CICV. This guideline is not a substitute for clinical judgment and does not establish legally enforceable requirements or responsibilities.

GUIDELINES:

1. Airway Assessment:
    a. LEMON law assessment tool utilization on all adult surgical patients requiring endotracheal intubation
    b. Airway assessment scoring system:
        i. L=Look externally
            1. 1 point: facial trauma
            2. 1 point: large incisors
            3. 1 point: beard or mustache
            4. 1 point: large tongue
        ii. E=Evaluate the 3-3-2 rule
            1. 1 point: incisor distance <3 fingerbreadths
            2. 1 point: hyoid/mental distance <3 fingerbreadths

3. 1 point: thyroid-to-mouth distance <2 fingerbreadths

iii. M=Mallampati

1. 1 point: Mallampati score ≥3

iv. O=Obstruction

1. 1 point: the presence of any condition that could cause an obstructed airway

v. N=Neck mobility

1. 1 point: limited neck mobility

c. Total Score: 10 points

i. For each category, the patient receives 1 point if it is present and 0 points if it is absent. The higher the number means, the higher chance of a difficult airway and vice versa.

*Note: Modified from LEMON score and assessment from Ji, S. M., Moon, E. J., Kim, T. J., Yi, J. W., Seo, H., & Lee, B. J. (2018). Correlation between modified lemon score and intubation difficulty in adult trauma patients undergoing emergency surgery. *World Journal of Emergency Surgery*, *13*(1). https://doi.org/10.1186/s13017-018-0195-0 and Brinbaumer, D. (2005, February 16). *Airway assessment using "LEMON" score predicts difficult ED intubation*. NEJM journal watch. https://www.jwatch.org/em200502160000001/2005/02/16/airway-assessment-using-lemon-score-predicts

2. Airway Management:

a. Always be prepared for a difficult airway and understand difficult airway algorithm

b. All aspects are scored equally; however, some indicators are better predictors of difficult airway or difficult ventilation
    i. Understand the weight of difficulty with each point the patient receives
c. Score 0
    i. It should not be a difficult airway
d. Score 1-3
    i. Low chance of difficult airway
e. Score 4+
    i. Be prepared for difficult airway

3. Documentation:
    a. LEMON law template will be added to the preoperative anesthesia note
        i. Ensure all aspects of LEMON law are charted and reviewed by the anesthesia provider

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difficult intubation defined by the intubation difficulty scale (IDS): predictive value of 7 airway assessment factors. *Korean Journal of Anesthesiology*, *63*(6), 491. https://doi.org/10.4097/kjae.2012.63.6.491

Appendix C

'Do' Survey Questions

1. Age:

e. 20-30 yrs

f. 30-40 yrs

g. 40-50 yrs

h. >50 yrs

2. Anesthesia Experience:

f. CRNA

g. SRNA

h. Anesthesia Resident

i. Anesthesiologist

j. AA

3. Years of Experience

a. 0-5 yrs

b. 5-10 yrs

c. 10-20 yrs

d. 20-30 yrs

e. 30 + yrs

4. On what percentage of adult surgical patients that require endotracheal intubation do you utilize the LEMON law assessment tool?

a. 100%

b. >90%

c. >75%

d. >50%

e. <50%

5. Do you find the LEMON law a more accurate predictor of difficult airways?

a. yes

b. no

6. Do you have difficulty charting the LEMON law in the preoperative anesthesia note?

a. yes

b. no

7. Do you like adding the LEMON law as a standard airway assessment required by all anesthesia providers?

a. yes

b. no

8. What complication do you have regarding integrating the LEMON law in all preoperative airway assessments?

a. Not enough time in preop

b. Too expensive

c. Unnecessary addition to an airway assessment

d. Potential for inaccuracy

e. Other _____

f. None

9. What suggestions do you have to improve the use of LEMON law?

a. Printed sheet filled out and placed in a paper copy of the chart

b. Other _____

c. None

10. Outcomes associated with the LEMON law assessment tool (circle all that apply)

a. Increased prediction of difficult airway/intubation or difficult bag valve mask ventilation

b. Decreased prediction of difficult airway/intubation or difficult bag valve mask ventilation

c. Increased incidence of hypoxia

d. Decreased incidence of hypoxia

e. Negative impact on workflow/ increased amount of time spent with the patient

f. Positive/neutral impact on workflow/ decreased/same amount of time spent with the patient

g. Positive effect on the budget

h. Negative effect on the budget

i. No effect on budget

j. Positive overall impact of an assessment tool for anesthesia providers

k. Negative overall impact of an assessment tool for anesthesia providers

l. Neutral overall impact of an assessment tool for anesthesia providers

Appendix D

Synthesis Table of Findings

Citation	Conceptual Framework	Design/ Method	Sample/Setting	Major Variables; definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of evidence
Article 1: Can an airway assessment score predict intubation success in the emergency department?									
Reed, M. J., Dunn, M. J., & McKeown, D. W. (2005). Can an airway assessment score predict intubation success in the emergency department? *Emergency Medicine Australasia*, *17*(1), 94–96. https://doi.org/10.1111/j.1742-6723.2005.00684.x	N/a	Methods: Prospective observational study.	Sample size: 156 patients required endotracheal intubation in all patients entering a UK hospital between 2002 and 2003. Each patient was assessed for four "look" criteria, three "evaluate" measures, airway obstruction, and neck mobility. MP was considered if possible. If endotracheal intubation was required, a CL score was given Exclusion criteria: No exclusion criteria were noted.	Independent: LEMON law assessment Dependent: CL score	The outcome measured is the prediction of difficult intubation. Each patient was scored based on the LEMON criteria. If the patient required endotracheal intubation, the LEMON score was compared with the CL score to assess the correlation between LEMON scores and difficult intubations.	P< 0.05	The findings conclude the LEMON method can successfully stratify the risk of difficult intubation, specifically in the ER. A shorter IID, prominent incisors, and decreased thyromental distance are correlated with a poor laryngoscopic view (grade 2, 3, or 4).	Level 2	Limitations: The same person performed intubation and the LEMON assessment, which could lead to bias. Different observers assessed each patient, which led to LEMON assessment variability. Feasibility in practice: Designed as a quick and easy assessment tool, which is helpful in training and suggested to be implemented.
Article 2: Use of the "L-E-M-O-N" Score in Predicting Difficult Intubation in Africans									
Ogboli-Nwasor, E., Mshelia, D., & Isamade, E. (2018). Use of the "L-E-M-O-N" score in predicting difficult intubation in Africans. *Nigerian Journal of Basic and Clinical*	N/a	Methods: Prospective observational study	Sample Size: 160 consecutive ASA I-III surgical patients between 18-65 years old from October through December of 2011. Preoperatively the LEMON criteria were assessed, which were compared with CL scores. Exclusion criteria: Patients	Independent: LEMON law assessment Dependent: CL score	The primary outcome measure is the ability of the LEMON score actually to predict intubation difficulty. The LEMON score and CL score are compared to assess the accuracy in predicting a difficult airway by the	P< 0.05	The findings reveal the combination of assessment tools within the LEMON scoring system significantly improves the predictability of difficult	Level 2	There were no stated limitations of this study or any mention of bias. Feasibility in practice: Utilization of the LEMON tool is helpful in preparation to reliably predict the difficulty of intubation.

Sciences, *15*(1), 17. https://doi.org/10.4103/njbcs.njbcs_25_16			who: declined participation, ASA IV and V, older than 65 or younger than 18 years old, we're unable to sit, gross anatomical abnormality of the head and neck, recent surgery or trauma to head/neck, severe cardiorespiratory disorders, requiring RSI or awake intubation, obstetrical, surgical patients, history of difficult intubation, regional anesthesia or conscious sedation, and emergence surgical procedures.		LEMON criteria. The secondary outcome was determining the incidence of difficult intubation in the study population and finding the usefulness of different airway features in predicting difficult intubation.		intubation. In addition, as the LEMON score increases, the likelihood of difficult visual laryngoscopy also increases.		
Article 3: Prospective validation of the modified LEMON criteria to predict difficult intubation in the ED									
Hagiwara, Y., Watase, H., Okamoto, H., Goto, T., & Hasegawa, K. (2015). Prospective validation of the modified LEMON criteria predicts difficult intubation in the ED. *The American Journal of Emergency Medicine*, *33*(10), 1492–1496. https://doi.org/10.1016/j.ajem.2015.06.038	N/a	Methods: Prospective observational multicenter study.	Sample size: 13-center prospective observational study, in which data was collected from February 2012 through September 2014. Four thousand thirty-four encounters were recorded, and 3313 were intubated with direct laryngoscopy and 610 with video laryngoscopy. Exclusion criteria: No exclusion criteria were noted.	Independent: modified LEMON assessment Dependent: intubation difficulty	The primary outcomes were sensitivity, specificity, and predictive values of the modified LEMON law for predicting difficult intubation (requiring two or more intubation attempts.	Negative predictive values of 98.2% and 99.0% respectively.	The findings conclude a high sensitivity and a negative predictive value of the modified LEMON criteria for predicting difficult intubation.	Level 2	Limitations: Subject to self-reporting bias, lack of established criterion standard definition for difficult intubation in ED setting, and the sample consisted mainly of EDs from Japan. Feasibility in practice: The modified LEMON criteria will help identify and predict difficult intubations in the ED, which will increase patient outcomes.
Article 4: A comparative study to evaluate the efficacy of virtual versus direct airway assessment in the preoperative period in patients presenting for neurosurgery: A quest for safer preoperative practice in neuroanesthesia in the backdrop of the COVID-19 pandemic!									
Hrishi, A. P., Prathapadas	N/a	Methods: Prosp	Sample size: 55 patients undergoing	Independent: Virtual airway	The primary outcome assessed is the	Statistica	The findings conclude	Lev	Limitations: Patients with high BMIs were

, U., Praveen, R., Vimala, S., & Sethuraman, M. (2021). A a comparative study to evaluate the efficacy of virtual versus direct airway assessment in the preoperative period in patients presenting for neurosurgery: A quest for safer preoperative practice in neuroanesthesia in the backdrop of the COVID-19 pandemic! *Journal of Neurosciences in Rural Practice*, *12*(04), 718–725. https://doi.org/10.1055/s-0041-1735824		ective, observational study	elective neurosurgical procedures. In these patients, mouth opening (MO) and any anomalies of tongue and palate, MP, TMD, ULBT, and neck movements were assessed, and the LEMON scoring system was utilized. Exclusion criteria: Patients with altered sensorium and psychological abnormalities.	assessment Dependent: Direct airway assessment	efficacy of virtual airway assessment (VAA) done via telemedicine in comparison with direct airway assessment (DAA) and evaluate the feasibility of VAA as a part of the pre-anesthetic evaluation (PAE) during the COVID-19 pandemic.	llysignificant: P< 0.05 Highly significant: P< 0.01	PAE and VAA with telemedicine can be used as an alternative to DAA for consultations during the COVID-19 pandemic to protect anesthesia providers. However, most of the patients participating in the study were classified as MP 1 or 2. Thus, VAA is not tested reliably in MP 3 or 4.	el 2	omitted. Patient satisfaction scores were unable to be evaluated due to COVID-19. Oral exams were not pictured or recorded, so different anesthesia providers may score patients differently. Feasibility in practice: PAE and VAA can be used in practice. However, further multicentered randomized controlled trials can be completed to strengthen the evidence.
Article 5: Correlation between modified lemon score and intubation difficulty in adult trauma patients undergoing emergency surgery.									
Ji, S. M., Moon, E. J., Kim, T. J., Yi, J. W., Seo, H., & Lee, B. J. (2018). Correlation between modified lemon score and intubation difficulty in adult trauma patients undergoing emergency surgery. *World*	N/a	Methods: A retrospective review of medical records.	Sample size: 114 medical records of adult trauma patients who underwent emergency surgery under general anesthesia. A modified LEMON score was identified preoperatively, and the intubating doctor self-reported difficulty of intubation with the intubation difficulty scale (IDS) score.	Independent: LEON method Dependent: intubating difficulty scale (IDS)	The primary outcome identified is a correlation between modified LEMON score and difficulty of intubation to determine if the revised LEMON law can accurately predict the difficulty of intubation.	P< 0.001	The findings conclude the modified LEMON score (also called LEON) may be used to predict difficult intubations to increase patient safety and airway management. A LEON score 3 or greater may	Level 2	Limitations: The self-reporting doctor may be unreliable or biased. Selection bias in intubation device chosen. This study does not include severe or traumatic injury patients that required immediate endotracheal intubation. An NMBA was used in this study, which can alter the IDS score. Feasibility in practice:

Journal of Emergency Surgery, *13*(1). https://doi.org/10.1186/s13017-018-0195-0			Exclusion criteria: No exclusion criteria were noted.				be difficult intubation (even with a video laryngoscope).		LEON predicts difficult airways, making it useful in practice to increase patient safety and improve airway management.
Article 6: Predictive Values of Preoperative Tests for Difficult Laryngoscopy and Intubation in Adult Patients at Tikur Anbessa Specialized Hospital.									
Tamire, T., Demelash, H., & Admasu, W. (2019). Predictive Values of Preoperative Tests for Difficult Laryngoscopy and Intubation in Adult Patients at Tikur Anbessa Specialized Hospital. *Anesthesiology Research and Practice*, *2019*, 1–13. https://doi.org/10.1155/2019/1790413	N/a	Method: A facility-based cross-sectional study.	Sample size: 242 patients participated. 33/242 were difficult laryngoscopies, and 12/242 were difficult intubations (4 or more attempts). Most of the patients were ASA I or II, with a couple of ASA III. Exclusion criteria: age <18, critically ill patients in which airway assessment is complex, psychiatric patients, obstetric patients, patients with goiter, and patients with known airway difficulty (congenital or acquired).	Independent variables: age, sex, ASA physical status, IIDMP class, TMD, mandibular protrusion, sternomental distance, laryngoscopic grade, premedication used and its dose, drug used for induction and its dose, a muscle relaxant used and its dose, qualification of the anesthetist, type and size of the laryngoscope, and external laryngeal pressure Dependent variables: difficult laryngoscopy, difficult intubation	The primary outcome evaluated was the magnitude and predictability of preoperative tests for difficult laryngoscopy and intubation.	P< 0.05	The findings include that a combination of IID, TMD, CL, and MP show improved sensitivity and specificity and was found to be better in predicting difficult intubation and laryngoscopy.	Level 4	Limitations: Most laryngoscopies were performed by students, which may contribute to a higher degree of difficulty, airway management may not follow the standard guideline, and lack of standardization cutoff values for preoperative airway parameters. Feasibility in practice: One test is not 100% accurate. It is recommended to use a combination of tests such as MP, TMD, and IID
Article 7: Predictors of difficult intubation defined by the intubation difficulty scale (IDS): predictive value of 7 airway assessment factors.									
Seo, S. H., Lee, J. G., Yu, S. B., Kim, D. S., Ryu, S. J., & Kim, K. H. (2012). Predictors	N/a	Methods: single descriptive study	Sample size: 305 ASA I & II patients, 19-70 years old, who underwent elective surgery with endotracheal	Independent: MP, TMD, head and neck movement, BMI, buck	The primary outcome studied is identifying airway assessment factors and total airway	P< 0.05	The findings conclude that using many airway assessment factors and	Level 6	Limitations: No limitations noted. Feasibility in practice: Utilization of many airway tools is beneficial in predicting a

of difficult intubation defined by the intubation difficulty scale (IDS): predictive value of 7 airway assessment factors. *Korean Journal of Anesthesiology*, *63*(6), 491. https://doi.org/10.4097/kjae.2012.63.6.491			intubation. A total of 7 preoperative airway assessment factors were assessed. After endotracheal intubation, the patients were split into two groups based on IDS score. Exclusion criteria: Patients with limited head and neck movement, impairment of temporomandibular joint, or oral or laryngeal tumors.	teeth, IID, and UBLT Dependent: difficult intubation	score (TAS) for predicting difficult intubations by the IDS score.		finding TAS >6 is a better method than just one assessment tool to predict the difficulty of intubation. In addition, if TAS cannot be calculated, UBLT is an instrumental stand-alone test for predicting difficult intubations.		difficult airway. If only one assessment can be performed, UBLT is most indicative when predicting the difficult intubation.
Article 8: Retrospective evaluation of airway management with blind awake intubation in temporomandibular joint ankylosis patients: A review of 48 cases.									
Sankar, D., Krishnan, R., Veerabahu, M., Vikraman, B., & Nathan, J. (2016). Retrospective evaluation of airway management with blind awake intubation in temporomandibular joint ankylosis patients: A review of 48 cases. *Annals of Maxillofacial Surgery*, *6*(1), 54. https://doi.org/10.4103/2231-0746.186126	N/a	Methods: A retrospective study.	Sample Size: A total of 48 cases of patients with TMJ ankylosis were included in this study. Airway assessments were performed utilizing the LEMON score in all patients evaluated. Exclusion criteria: No exclusion criteria were noted.	Independent: intubation technique Dependent: difficulty of intubation	The primary outcome studied is that blind awake intubation could be considered in the anesthetic management algorithm in institutions without fiberoptic intubation.	Blind awake intubation: 98% Fiberoptic awake intubation: 6% Surgical airway: 2%	This retrospective study concludes that careful airway exams, identification of potential problems, and creation of a backup plan are essential to provide the best patient care. In this study, blind awake intubation is a viable option when fiberoptic intubation is unavailable.	Level 2	Limitations: None noted. Feasibility of practice: The study suggests each anesthesiology department develop specific guidelines and algorithms for their institution.