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California State University, Fullerton  
California State University, Long Beach  
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MANAGING A DIFFICULT AIRWAY

A DOCTORAL PROJECT

Submitted in Partial Fulfillment of the Requirements

For the degree of

DOCTOR OF NURSING PRACTICE

By

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## ABSTRACT

The management of a difficult airway is one of the fundamental competencies required for all anesthesia providers. Despite the Difficult Airway Algorithm guidelines developed by the American Society of Anesthesiologists, high rates of mortality and morbidity related to anesthesia and difficult airways continue. Commonly found causes of difficulties with poor airway management were poor adherence to appropriate recommendations as well as a decline in retention of knowledge after training (Arriaga et al., 2013). A “Cannot intubate, cannot ventilate” situation in real life is rare, and may be difficult for anesthesia providers to achieve and maintain competency through clinical experiences. For this doctoral project, a semi-annual training program was developed to bring awareness, improve practice to existing skills, and enhance professional competencies among practicing anesthesia providers. The program included an educational module that culminated in a simulation scenario with a Failed Airway; checklists for evaluation were developed.

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## BACKGROUND

Management of the difficult airway is one of the most challenging tasks faced by anesthesia providers. Difficult airway management remains a leading cause of anesthesia deaths and malpractice claims in the United States (Kennedy, Cannon, Warner, & Cook, 2014). A difficult airway is caused by anatomic characteristics of patients such as any of the following: a small mouth opening, a large tongue, protruding upper teeth, a stiff neck, limited or inability of neck extension, an unstable cervical spine, cervical swelling after an operation, tumor in the airway area, short chin, or obesity with redundant tissue around the airway (Langenstein & Cunitz, 1996). As many as 6.2% of intubations are difficult (Hubert, Duwat, Deransy, Mahjoub, & Dupont, 2014). Whereas difficult intubation and difficult ventilation occurs in 1.5% of procedures, impossible intubation and difficult ventilation occurs in 0.3% of procedures, and “cannot intubate and cannot ventilate” events occur in 0.07% of procedures. Unfortunately, anesthesia providers cannot always predict which patients will have difficult airways. Therefore, despite advances in technology and improvements in techniques, airway complications can still result in patient deaths.

The American Society of Anesthesiologist (ASA), conducted the Closed Claims Project (ASA-CCP) in 1985 to examine all malpractice insurance claims made that year. The purpose was to identify the causes of anesthesia-related patient injuries to improve patient safety. The ASA-CCP retrieved data from practice claims of 35 participating malpractice insurance carriers. The latest report in 2010, revealed that 25% of the claims were related to death and 17% were due to respiratory complications (Metzner et al., 2011; Cook & MacDougall-Davis, 2012). In addition, hypoxia was identified as the most

common cause of airway-related deaths by the Fourth National Audit Project in 2011 (Cook & MacDougall-Davis, 2012). To improve established guidelines, this project reviewed cases of airway-related death to determine risk factors that were either missed or discounted. It was revealed that in half of the claims despite patients being identified as “predicted or anticipated difficult airway,” many anesthesia providers proceeded with the standard general anesthetic practice (Cook & MacDougall-Davis, 2012).

In the presence of an anticipated difficult airway, the ASA guidelines recommend that when high risk patients are identified, procedures must include preparing for an awake intubation. Additionally, cases occurring during induction were associated with poorer outcomes such as hypoxia and respiratory complications (Cook & MacDougall-Davis, 2012). The ASA-CP found 67% of claims occurred at induction of anesthesia where patient had adverse outcomes compared to 20% at extubation (Cook & MacDougall-Davis, 2012).

Since the development of the American Society of Anesthesiologists Difficult Airway Algorithm (ASA DAA), the number of claims and severity of outcomes during anesthesia induction have decreased (Cook & MacDougall-Davis, 2012; Law et al. 2013; Metzner et al. 2013). However, studies repeatedly iterate that mortality and morbidity related to anesthesia is due to inadequate ventilation resulting in hypoxia. The reason for this is due to providers not following the ASA DAA guidelines and not executing a cricothyrotomy, a surgical emergency airway in a reasonable time frame (Greenland, et al., 2011).

In an effort to improve outcomes, the American Society of Anesthesiologists (ASA) adopted a Difficult Airway Algorithm (DAA) in 1993, with revisions in 2003 and

2013. This algorithm guides anesthesia providers who are unable to establish an airway by tracheal intubation using direct laryngoscopy. The Difficult Airway Algorithm (DAA) provides a coherent cognitive framework for approaching various airway management scenarios encountered in clinical practice. However, even using this guideline, studies reveal that more than 3-4 intubation attempts increases the incidence of airway trauma and edema, and may ultimately result in a potentially lethal airway event (Hubert et al., 2014).

Although the national guidelines exist, providers do not necessarily follow the guidelines recommendation. Due to the rarity of “cannot intubate and cannot ventilate” (CICV) situations, providers may not remember, thus may miss or skip recommended steps of the guidelines. Commonly found causes of mortality and morbidity with difficult airways are poor adherence to appropriate recommendations as well as a decline in retention of knowledge after training (Arriaga et al., 2013). In any event, failure to effectively manage these life threatening complications can lead to patient deaths.

### **Problem Statement**

During the past four years, two deaths occurred at the local facility related to inadequate management of a difficult airway. The local quality improvement (QI) committee reviewed those cases and reached the consensus that improvement of care was needed. After several meetings where records of difficult airway events were reviewed, members documented that providers and staff members took longer than expected to obtain adequate help and begin appropriate interventions because members of the operating room staff were unsure what to do.

## **Purpose Statement**

The primary objective for this Doctor of Nursing Practice project is to improve the quality of care by decreasing the number of mortality and morbidity at the local facility to improve patient outcomes. Therefore, implementation of a semi-annual difficult airway training program is to bring awareness, improve practice to existing skills, and enhance professional competencies among the anesthesia providers. The training addressed difficult airway scenarios which complies with the national ASA DAA guidelines focusing on CICV needing a cricothyrotomy. The project, which will include specific products, has several deliverables: (1) protocol for managing a difficult airway, (2) teaching/learning methods that utilize computer modules, education films, check list, simulations, debriefing, and (3) evaluation checklist for both DAA and cricothyrotomy procedure.

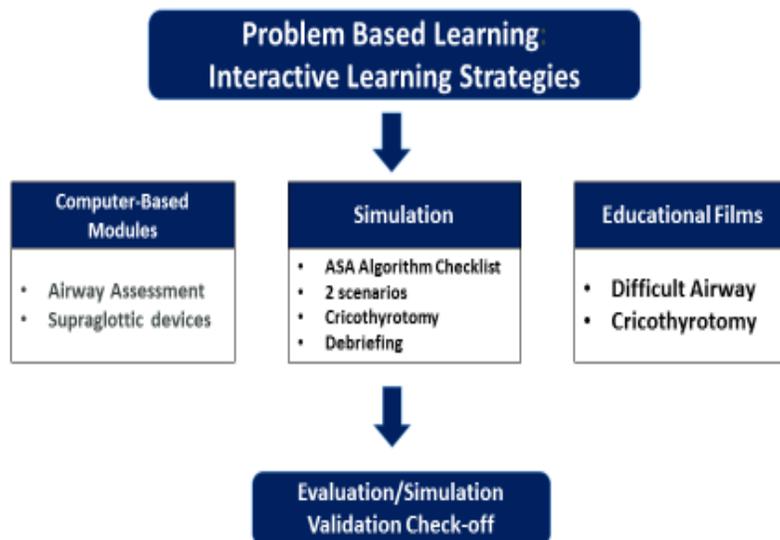
The target audience were anesthesia providers who were evaluated using a skills proficiency validation checklist (Appendix A). Additionally, registered nurses, circulating nurses, certified surgical technicians, surgeons, and ancillary staff in an operating room at the local facility also participated in the training; however, a proficiency evaluation checklist was not required for staff members in those roles.

## **Supporting Framework**

The Competency Outcomes and Performance Assessment (COPA) Model developed by Lenburg (1999) was used for this project. This model serves as a framework that supports competency outcomes and assessment required for practice, along with accountability in practice skills (Lenburg, 1999). However, since this is a quality improvement project, a formal competency evaluation will not be conducted. The

anesthesia providers in this organization are all national board certified, therefore by law they are legally registered to practice.

As seen in Figure 1, the COPA Model emphasizes “critical thinking over tasks, concepts over cases, integrated actual performance over test results, and performance based expectations over procedures” (Lenburg, 1999, p. 5). This model provides the basis for establishing the criteria in fulfilling their participation in this quality improvement project.



*Figure 1.* For creating practice improvement program to keep practicum current. COPA Model adapted from by Lenburg, 1999.

The COPA Model is organized around four concepts that are essential to professional practice: core practice competencies, end-result competency outcomes, practice-driven interactive learning strategies, and objective competency performance examinations. In addition, the COPA Model identifies processes necessary and desired outcomes for this project:

- What are the essential competencies and outcomes for competency practice?
- What are the indicators that define those competencies?
- What are the most effective ways to learn those competencies?
- What are the most effect ways to document that the practitioners have achieved the required competencies?

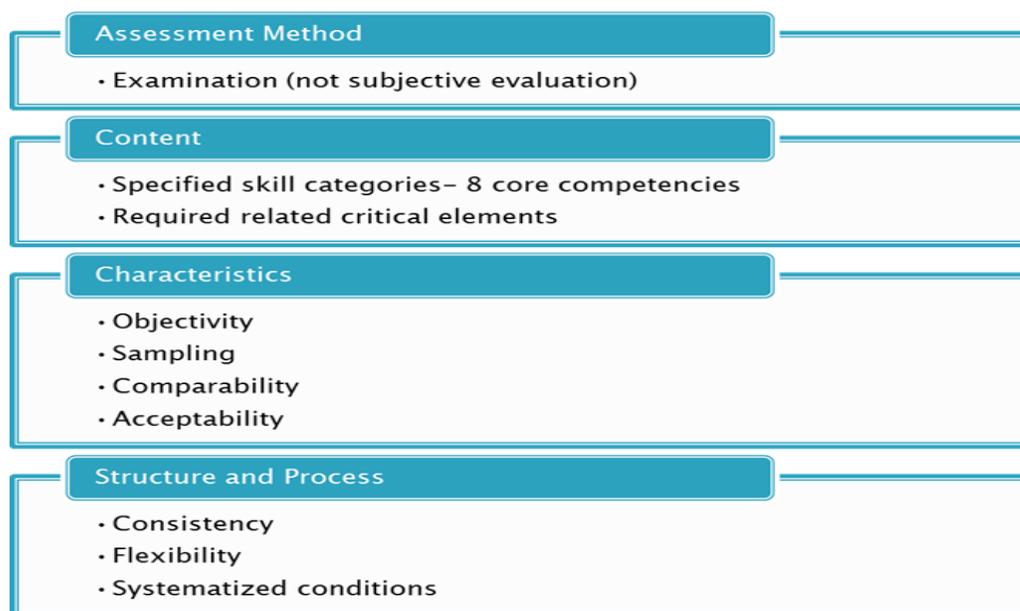
The first guiding question, “What are the essential competencies and outcomes for contemporary practice?” has two purposes. First, it identifies required competencies and formats them as practice-based outcomes rather than objectives. According to Lenburg, (1999), objectives are a way to learn content, thus, do not often reflect practice abilities or clinical skills for which the content is to be learned. Second, competency outcomes identify results to be attained and include skills required for providers to be deemed competent. In determining competency outcomes, it is essential to determine what performance or competence is expected at the end of the pre-assessment period. More importantly, outcomes are specific and performance competencies are actual skills used in practice.

The second guiding question requires that specific indicators or critical elements include only those actions that are mandatory for actual competence. Critical elements are defined as the observable behaviors or actions that are mandatory and must be performed. They represent necessary steps and include only actions essential for documenting competence for a given ability.

The third guiding question is discovering the most effective ways of learning the competencies. Lenburg (1999) discussed the importance of practice-driven interactive learning strategies. Interactive learning strategies address learners’ need to be active in

the learning process and to interact with others. Additionally, they provide opportunities to strengthen observations, listening, communication, and interpersonal skills. Strategies such as problem-based learning, simulations, case studies, and team projects are all examples of interactive learning strategies which can be successful in assisting learners to acquire competency. In contrast, traditional lectures and multiple choice tests may lead to completion of a course but they often are ineffective in leading to retention of knowledge. In addition, they do not often allow for enhancing skill confidence in the area of critical thinking, communication, management, and leadership (Lenburg, 1999).

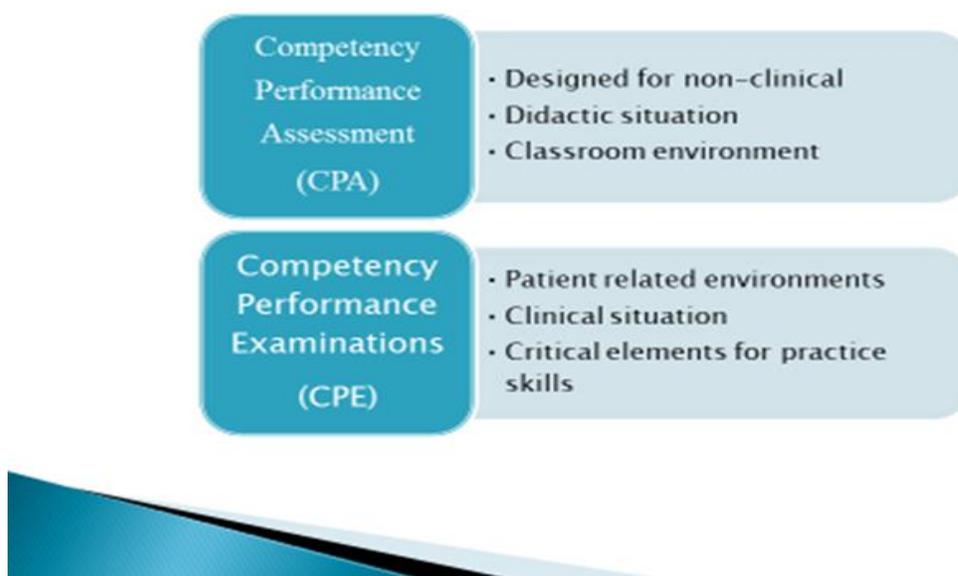
The fourth guiding question uses 10 psychometric concepts to develop and implement performance assessment. These concepts are seen in Figure 2.



*Figure 2.* Ten psychometric concepts from the COPA Model to develop and implement performance assessment adapted from “The framework, concepts and methods of the competency outcomes and performance assessment (COPA) model” by Lenburg, 1999, *Online Journal of Issues in Nursing* 4. Copyright 2015 by the American Nurses Association.

Finally, there are two types of performance evaluation concepts; Competency Performance Assessments (CPAs) and Competency Performance Examinations (CPEs) (see Figure 3). CPAs are designed for use in non-clinical, didactic, classroom type situations. For this doctoral project, CPAs were used for the educational and training portions of the program. The CPAs included computer-based modules and educational films. CPEs were used for patient related environments, clinical situations and critical elements that were involved in promoting competency for core practice skills (Lenburg, 1999). CPEs in this project were the scenarios simulations and debriefing portion of the program.

## Types of Performance Evaluation



*Figure 3.* Two types of Performance Evaluation adapted from “The framework, concepts and methods of the competency outcomes and performance assessment (COPA) model” by Lenburg, 1999, *Online Journal of Issues in Nursing* 4. Copyright 2015 by the American Nurses Association.

## **REVIEW OF LITERATURE**

### **Overview**

In order to develop a program that is sustainable and that will promote lasting behavioral change in the management of difficult airways, a thorough review of literature was conducted in addition to consultations with clinical and educational experts. The search for evidence to support the project used multiple computerized databases (CINAHL, Wiley Online, Science Direct, PubMed, ERIC, Allied Health Plus, Cochrane Library, and Google Scholar), and allowed varied evidence sources (e.g., research studies, case reports, textbooks written by airway experts). Many studies were compiled, including several meta-analyses and systematic reviews, which focused on the components of difficult airway competency.

### **Defining a Difficult Airway**

A difficult airway can be defined as a clinical situation in which a trained anesthesia provider experiences difficulty with face mask ventilation, difficulty with tracheal intubation, or both (Kennedy, Cannon, Warner, & Cook, 2014).

The difficult airway has four dimensions and will further be discussed in this section (1) Difficult ventilation, (2) Difficult laryngoscopy, (3) Difficult placement of the supraglottic external device, and (4) Difficult cricothyrotomy.

### **Difficult Ventilation**

Mask ventilation (MV) is the most basic skill of managing an airway. Yet, it is the most essential skill in airway management. It is the primary technique of ventilation before tracheal intubation or insertion of any airway device. Its most unique role serves as a rescue technique for ventilation should a difficult intubation occurs or fail. The

ability to establish adequate MV has, therefore, become a major branch point in any difficult airway algorithm.

Difficult mask ventilation (DMV) has been defined as mask ventilation that is inadequate to maintain oxygenation, unstable MV, or MV requiring two providers (Kheterpal et al. 2013). Furthermore, airway difficulty can lead to impossible mask ventilation (IMV). This situation is denoted by absence of end-tidal carbon dioxide measurement and lack of perceptible chest wall movement during positive pressure ventilation. This occurs despite attempts to insert airway adjuvants and assistance by additional personnel.

One of the primary responsibilities of an anesthesia provider is to maintain adequate oxygenation and ventilation. This is accomplished by maintaining a patent upper airway. Being able to provide ventilation by bag mask, when faced with a difficult or failed tracheal intubation, can result in serious complications and or death. The most serious complication of DMV is failure to establish ventilation, resulting in death or hypoxic brain damage. Difficult mask ventilation (DMV) is defined as difficulty in maintaining a mask seal and obtaining a satisfactory capnography (end-tidal CO<sub>2</sub>) and tidal volume (Cattano et al., 2014).

The incidence of difficult mask ventilation (DMV) varies from 0.08% to 15% (Cattano et al., 2014). In a retrospective study of 1399 patients' records, determined that 124 (8.9%) patients were found to be difficult to mask ventilate (Cattano et al., 2014). The tool used to determine level of difficulty was a mask ventilation ease grading scale of 0 – 1 (easy), to 2-3 (difficult). Grade 0 and 1 were identified as easy with a grade 1 requiring usage of an oral airway. Grade 2 and 3 were identified difficult ventilation.

Grade 2 required 2 handed ventilations and a grade 3 required an extraglottic device. The ASA Task Force's definition, in its present language, lists the general mechanisms underlying a DMV situation. The clinical situation of DMV, however, constitutes a continuum, one end of which is "easy" MV and the other is IMV "Impossible".

A commonly used ventilation classification is Han's Mask Ventilation Classification (MVC). According to Han's MVC a Grade 0 ventilation by mask was not attempted. Grade 1, the patient was ventilated by mask. Grade 2, patient was ventilated by mask with oral airway or other airway adjuvants. Grade 3, was identified as a difficult mask ventilation (inadequate, unstable, or requiring two practitioners). Whereas Grade 4, the patient was unable to be mask ventilated.

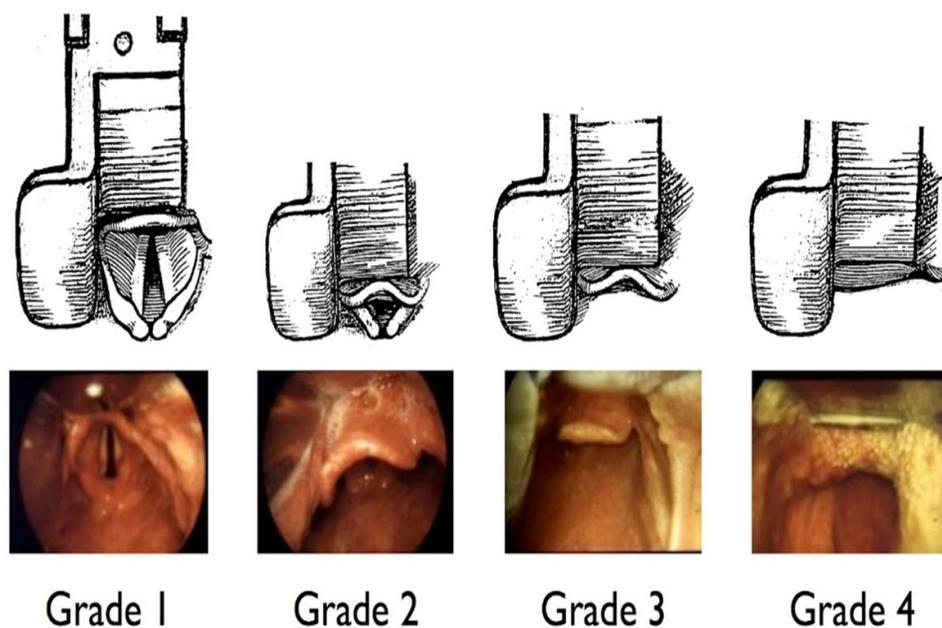
### **Difficult Laryngoscopy**

One factor that contributes to difficult intubation is poor visualization of the glottic opening from a difficult laryngoscopy. Poor visualization of the glottis is due to the anterior location of the larynx placing it out of direct view. A difficult laryngoscopy is caused by anatomic characteristics of patients such as any of the following: a small mouth opening, a large tongue, protruding upper teeth, a stiff neck, limited or inability of neck extension, an unstable cervical spine, cervical swelling after an operation, tumor in the airway area, short chin, or obesity with redundant tissue around the airway (Hasegawa, Shigemitsu, Hagiwara, Chiba, Watase, Brown, & Brown, 2012).

As part of the DAA, the recommended maximum attempts of intubations should be no more than two or three attempts. The consequences of multiple tracheal intubation attempts of greater than three times have been evaluated in multiple studies. A retrospective study examined 2,833 critically ill subjects requiring emergency intubation

and reported that more than 2 attempts at intubation resulted in an increased rate of hypoxia (70% vs 12%) (Apfelbaum et al., 2013). Additionally, another study of 2,616 emergency department subjects, 11% required at least 3 attempts at intubation. These patients were compared with those who were intubated in one or two attempts. Subjects requiring more than two attempts experienced higher rates of adverse events (35% vs 9%) (Hasegawa et al. 2012). The adverse events can be detrimental and they include esophageal intubation with delayed recognition, hypotension, regurgitation, hypoxia, dysrhythmia and cardiac arrest, dental or lip trauma, endobronchial intubation, and airway trauma.

The incidence of difficult laryngoscopy and intubation in various settings has been reported in a wide range from 1% to 15% in patients undergoing general anesthesia. Difficult laryngoscopy and intubation implies that the anesthesia provider had a poor view of the glottis. Cormack and Lehane (CL) introduced the most widely utilized system of categorizing the degree to which the glottis can be visualized during laryngoscopy (see Figure 4). The CL classification is a grading system commonly used to describe the view of the larynx during direct laryngoscopy. The grading system begins with grade 1 to grade 4. Grades 3 and 4, in which the glottis is not visualized, are considered difficult intubations.



*Figure 4.* A new practical classification of laryngeal view; Cormack-Lehane (CL) classification.

### **Difficult Placement of Supraglottic Airway Device**

The term supraglottic airway device is defined as any airway management device that allows gas to enter and exit the airway via an airway tube, which sit above the glottis. However, because a number of device designs incorporate components that are inferior to, but remain outside the glottis, the term “Extraglottic airway device” (EAD) is also appropriate (Ramachandran et al., 2012).

The insertion of a supraglottic airway device (SAD) is considered the backup plan when faced with a failed orotracheal intubation or failed mask ventilation. It also serves as an alternative method for immediate gas exchange in a “cannot intubate and cannot ventilate” situation. While SAD are used as a backup plan and part of the DAA, there are clinical studies that show difficult placement of the SAD such as a Laryngeal Mask Airway (LMA). Although the estimated risk of life-threatening adverse respiratory events

during SAD use is rare, the reported rate of events leading to failure of the airway device is 0.2-8% (Ramachandran, Mathis, Tremper, Shanks, & Kheterpal, 2012). Additionally, the estimated incidence of life-threatening complications with SAD use for anesthesia was 1 in 46,174 patients according to The Fourth National Audit Project Report (Cook et al., 2011).

Ramachandran et al. (2012) reviewed 15,795 cases which identified LMA failure. Of the 15,795 cases, 170 (1.1%) experienced the primary outcome of LMA failure. Additionally, more than 60% of those patients with LMA failure experienced significant hypoxia, hypercapnia, or airway obstruction, and 42% presented with inadequate ventilation related to a leak around the LMA. Among the outpatients with LMA failure, 13.7% had unplanned hospital admission, and 5.6% of whom needed intensive care for persistent hypoxemia (Ramachandran, Mathis, Tremper, Shanks, & Kheterpal, 2012). In an effort to help identify a difficult SAD placement, an evaluation can be determined using the pneumonic “RODS” (Murphy & Crosby, 2011) (see Figure 5).

- **R** = Reduced or restricted mouth opening.
- **O** = Obstruction such as Supra- or Extraglottic pathology, (e.g. Neck radiation, lingual tonsillar hypertrophy)
- **D** = Disrupted or distorted airway, seat and seal of the SAD , Fixed cervical spine flexion deformity
- **S** = Stiff Lungs, Stiff cervical spine, ankylosing spondylitis

*Figure 5.* Difficult SAD placement predictor pneumonic “RODS”.

## Difficult Cricothyrotomy

In an emergent setting and a “CICV” event, a cricothyrotomy is recommended according to the ASA DAA as the last resort. Performing a cricothyrotomy during an emergent situation may have many challenges. Some conditions may make it more difficult or impossible to perform a cricothyrotomy procedure. Studies and case reports have identified situations associated with difficulties. Case report conducted by Morishima et al. (2013) describes a 69-year-old woman with rheumatoid arthritis whose airway failed immediately after extubation. The patient had a posterior occipito-cervical fusion and upon extubation, her upper airway obstructed resulted from pharyngo-laryngeal edema. The second case was a 59-year-old man with diabetes mellitus undergoing anterior cervical fusion. On the day of surgery, he complained of dyspnea and his neck was swollen with hematoma. Although, both cases presented with abnormalities of the airway and neck, both cases resulted in cricothyrotomies and were successful (Morishima et al., 2013). A number of clinical reports have identified situations associated with surgical airway difficulties, therefore a commonly use pneumonic “SHORT” is used to quickly identify predictors that may indicate a difficult cricothyrotomy (Murphy & Crosby, 2011) (see Figure 6).

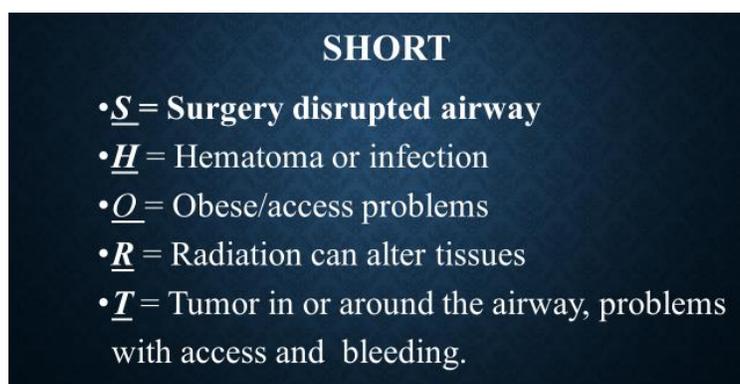


Figure 6. Difficult cricothyrotomy predictor pneumonic “Short”.

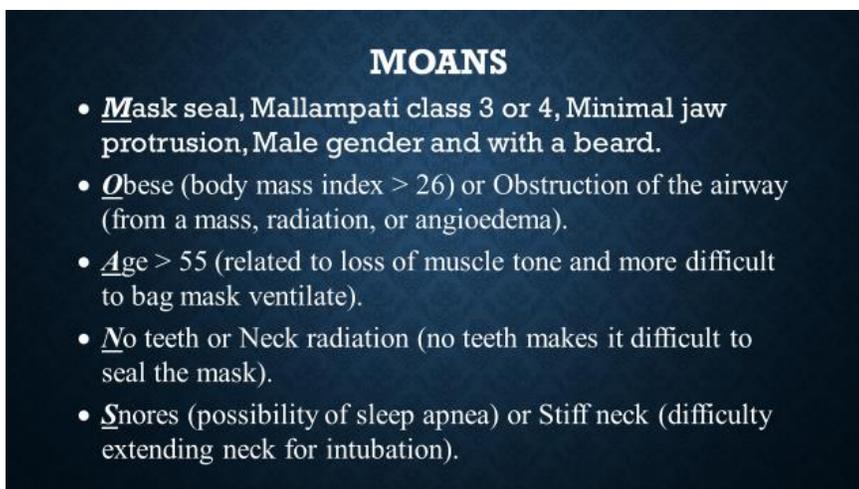
## **Prediction Power**

### **Screening Tools**

Airway management problems can start with difficulties associated with eliciting the predictors, formulating alternative plans, and preparing the proper equipment, helps to determine which patients may be most at risk for difficult airways. Above all, increased awareness of the problem, will ultimately increase patient safety and improve outcome after DMV. Researchers have recommended several screening tests designed to predict a difficult laryngoscopy intubation in patients. However, due to inconsistencies and controversies in many studies, Law et al. (2013) and Murphy (2011) have argued that one screening tool is not sufficient and no one tool is superior to another for predicting a difficult laryngoscopy. Therefore, multiple screening tools are the best method for enhancing the predictive power for determining possible difficult airway (Cattano et al., 2013; Murphy, 2011; Shiga et al., 2005). Failure to evaluate the airway and predict difficulty has been identified as the single most important factor leading to a failed airway (Law et al., 2013; Murphy, 2011). Therefore, it is vital that anesthesia providers evaluate the patient's airway in order to be prepared to manage a failed airway. Since current screening tools do not have absolute significant predictive value it is important to use multiple tools in determining risks.

### **Mask Ventilation Predictors**

Many researchers have validated the anatomical features that have implications to predict DMV. These features can be grouped into five indicators that can easily be recalled using the mnemonic "MOANS" (Murphy, 2011).



*Figure 7.* Difficult mask ventilation predictor mnemonic “MOANS”.

### **Cormack-Lehane (CL) Classification**

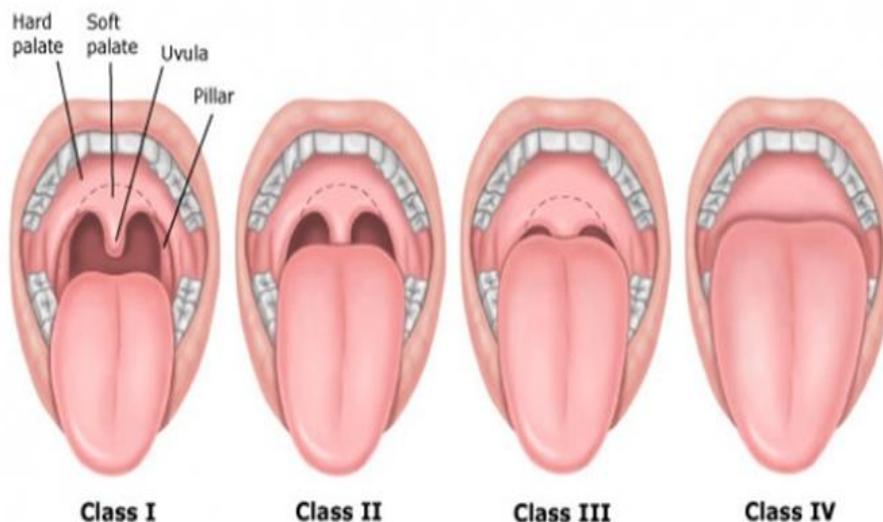
Tracheal intubation is most commonly performed using a direct laryngoscopy technique. Visibility of the glottis is often documented to describe predicted ease of intubation. When a patient is prepared for intubation, a laryngoscope is used to visualize the airway at which point the endotracheal tube is inserted. The Cormack-Lehane (CL) classification (See Figure 4) as previously discussed is a grading system commonly used to describe the view of the larynx during direct laryngoscopy. The grading system begins with grade 1 to grade 4. Grades 3 and 4, in which the glottis is not visualized, are considered possible difficult intubations. Despite widespread use of the CL classification, researchers have questioned its reliability due to its subjectivity. Krage et al. (2010) evaluated knowledge of the CL classification among anesthesiologists and its reliability in a simulated clinical setting. A survey of 120 anesthesiologists showed that 3 out of 4 anesthesiologists claimed to know the CL classification, yet only 1 out of 4 was able to define all grades correctly. Intra- and inter-observer reliabilities were tested with a patient simulator. The CL classification showed fair inter-observer reliability and poor intra-

observer reliability. This indicates that the providers believe they understand the classification system. However, upon the external examination of the patient by the evaluator indicated that the provider was not able to demonstrate understanding of the components of CL classification system.

### **Mallampati Score**

Another commonly used predictor of a difficult intubation is the Mallampati score. This is an estimate of the size of the tongue relative to the oral cavity and the ability of the patient to open their mouth. This system graded the patient 1 to 4 based on the structures visible in the oropharynx with maximal mouth opening (see Figure 5). Grade 3 or 4 suggests that there is a significant chance the patient will be difficult to intubate. In a series of 1,956 patients undergoing elective general anesthesia, Cattano et al. (2014) determined that there was a significant correlation between the Mallampati scale and the CL classification. A difficult laryngoscopy correlated with both a grade of 3 and 4 for CL glottic classification (DL) and Mallampati. Although the Mallampati scale lacked the sensitivity to be predictive when used alone. However, when used along with the CL classification, the Mallampati score becomes a better predictor of a DL.

Another common approach to predicting difficult intubation is an evaluation guided by the mnemonic “LEMON” (Murphy & Crosby, 2011; see Figure 9).



*Figure 8.* Illustration of Mallampati Classification. Class I: Soft palate, uvula, fauces, pillars visible; Class II: Soft palate, uvula, fauces visible; Class III: Soft palate, base of uvula visible; Class IV: Only hard palate visible.

## LEMON

- **L** = Look externally for anatomic features that may make intubation difficult.
- **E** = Evaluate the 3-3-2 rule. Mouth opening (3 finger-breadths)  
Hyoid-chin distance (3 finger-breadths)  
cartilage-floor of mouth distance (2 finger-breadths)
- **M** = Mallampati score.  
Class 1: soft palate, uvula, pillars visible  
Class II: soft palate, uvula visible  
Class III: soft palate, base of uvula visible  
Class IV: hard palate visible
- **O** = Obstruction: examine for partial or complete upper airway obstruction.
- **N** = Neck mobility.

*Figure 9.* Difficult intubation predictor mnemonic “LEMON”.

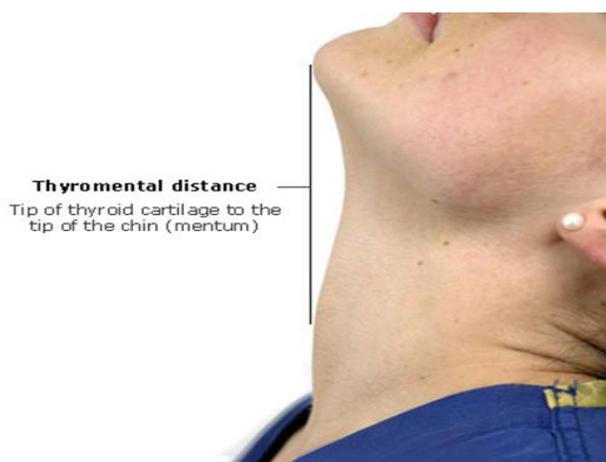
Although many studies have been conducted to test bedside screening tools designed to predict patients with difficult airways, very few are considered reliable (Murray, 2011). In a meta-analysis of 35 studies, Shiga et al. (2005) concluded that no single screening test alone was sufficiently sensitive or specific enough to predict patients at risk. These authors stipulated that a combination of multiple screening tools would be the best method to enhance prediction. They found that a combination of both the Mallampati Test (MP) and Thyromental Distance Test (TMD) were the most accurate in predicting difficult intubation. Similarly, a systematic review of forty-two studies which included 34,513 patients were reviewed testing the accuracy of the Mallampati Test. The accuracy of the original and modified Mallampati score when used alone was insufficient to predict a difficult intubation (Lee et al. 2006).

In anesthesia, the Mallampati Classification is an indirect method of assessing a difficult intubation. It is often used singly or in conjunction with other tools. With the Mallampati test, providers assess the height of the mouth and the distance from the tongue base to the roof of the mouth. This examination allows the anesthesia provider to assess the amount of space available to work within the laryngoscopy. The risk is based upon the level of obstruction from the tongue within the oral cavity (see Figure 8). A Mallampati score of class 3 or 4 is associated with more difficult intubations (Murray, 2011; Honarmand et al. 2014).

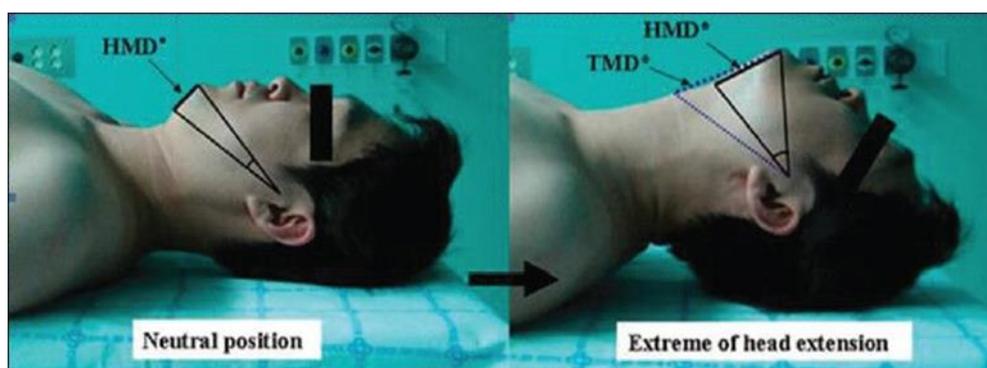
### **Thyromental Distance**

Measuring the thyromental distance (TMD) is another method used to predict a difficult intubation (see Figure 10). Anatomically, the distance from the thyroid notch to the tip of the jaw when the head is extended is the thyromental distance (Cattano et al.,

2013; Shiga et al., 2005). If the TMD is less than 7.0 cm, there is a risk for a difficult intubation (Murray, 2011). Honarmand et al. (2014) indicated that hyomental distance (HD) and the TMD were the preferred screening tools for predicting a difficult laryngoscopy. The HD is based upon the extension of the head at its most extreme tilt (see Figure 7).



*Figure 10.* Illustration of measuring thyromental distance for predicting a difficult intubation.



*Figure 11.* Head and neck position to show hyomental distance and thyromental distance in relation to thyromental distance (ratio).

## Prediction Tools Overview

Despite different findings in all the systematic reviews for which predictor screening tool was most reliable, there was one common finding. One common finding was the use of multiple tools to enhance prediction powers. Therefore, it is recommended that airway screening tests should still be used to predict difficult airways.

The Mallampati test has a sensitivity of 49% and specificity of 86%; the TMD Test has a sensitivity of 20% and specificity of 94% (Cattano et al., 2013; Shiga et al., 2005). Together, these tests showed a higher discriminative power than when used alone. Within this study, it was determined that the use both screening tools were effective for predicting difficulty with intubation (Cattano et al., 2013; Shiga et al., 2005). Furthermore, Honarmand et al. (2014) found using four tools was a better a predictor of difficult airway than two.

A systematic review conducted by Vannucci & Cavallone (2015) included 24 studies involving 20,582 patients in which numerous airway screening tests were evaluated. The most frequently performed tests were: Mallampati score (MP), measurement of Thyro-Mental Distance (TMD), Upper Lip Bite Test (ULBT), Inter-Incisors Gap (IIG), and Sterno-Mental Distance (SMD). The results indicated that individual and combined tests were characterized by limited discriminative capacity, sensitivity, specificity, and positive likelihood ratio. The review results concluded that current bedside tests have limited and inconsistent capacity to discriminate between patients with difficult and easy airways. Most studies were characterized by high risk of bias and concerns of applicability. Thus, despite these bias and concerns it is still recommended that airway screening tests should still be used to predict difficult airways.

## **Protocols for Managing a Difficult Airway**

### **Difficult Airway Algorithm**

The Difficult Airway Algorithm (DAA) established by the ASA in 1993 with the most recent update in 2013 gave anesthesia providers a systematic approach to manage a difficult airway in clinical situations that are rarely encountered (See Figure 8). It is the first standardized approach to managing the anticipated and unanticipated difficult airway situation (Nagalhout & Plaus, 2010). The ASA Difficult Airway Algorithm (DAA) provides basic recommendations that are based on scientific evidence, current literature, and expert practitioner opinions. Furthermore, the DAA provides a coherent cognitive framework when critical events are presented. It serves as a decision tree for approaching various airway management scenarios encountered in clinical practice.

The DAA provides guidelines for dealing with difficult mask ventilation, difficult laryngoscopy, difficult tracheal intubation, and failed intubation. The DAA guidelines for managing an unanticipated difficult airway are based on a series of escalating management plans: If Plan A does not work, backup plans B, C, or D can be executed (see Figure 8). Although practice guidelines are not intended as the standards or an absolute requirement, adherence to them has been shown to provide the greatest chance for success and positive outcomes (Murphy & Crosby, 2011). The purpose of the guidelines is to minimize variations, conserve valuable time, and reduce the likelihood of adverse outcomes (Apfelbaum et al., 2013).

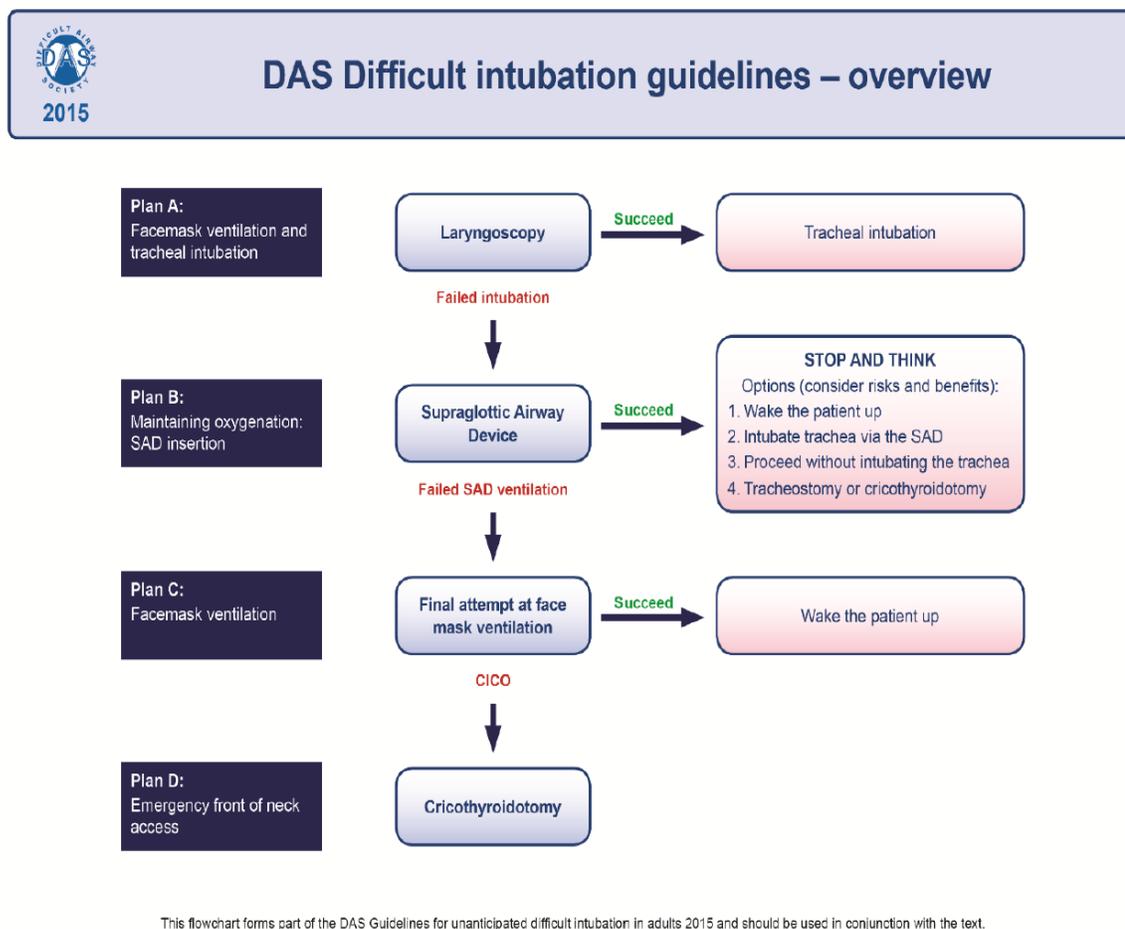


Figure 12. 2015 DAA difficult airway algorithm.

## The Recommendations of DAA

**Evaluation of the Airway.** A preplanned strategy should include the consideration of various interventions should a difficult airway occur. The DAA indicates that first the providers should assess for basic airway management problems. The next step should include an airway evaluation to predict if the airway will be difficult to manage. A back up plan should be available to implement should the primary plan not be successful (Apfelbaum et al., 2013).

**Patient history.** All anesthesia providers should obtain an airway history whenever feasible, before the initiation of anesthetic care and airway management. The intent of the airway history is to detect medical, surgical, and anesthetic factors that may indicate the presence of a difficult airway. Examination of previous anesthetic records, if available may yield useful information about airway management (Apfelbaum et al., 2013).

**Physical Examination.** All patients should receive an airway physical examination whenever feasible, before the initiation of anesthetic care and airway management. The intent of this examination is to detect physical characteristics that may indicate the presence of a difficult airway. This includes conducting screening tools or predictors which were previously discussed (Apfelbaum et al., 2013).

**Basic Preparation for Difficult Airway Management.** Basic preparation for difficult airway management includes: (1) availability of equipment for management of a difficult airway, (2) informing the patient with a known or suspected difficult airway, (3) assigning an individual to provide assistance when a difficult airway is encountered, (4) pre-anesthetic pre-oxygenation by mask, and (5) administration of supplemental oxygen throughout the process of difficult airway management (Apfelbaum et al., 2013).

**Recommendations for Basic Preparation.** There should be a number of items readily available and at the disposal of the anesthesia provider. There should be at least one portable difficult airway cart that contains specialized equipment for difficult airway management. The suggested contents of the portable storage unit for difficult airway management include:

1. Rigid Laryngoscope blades of alternate design and size from those routinely used, this may include a rigid fiber-optic laryngoscope.
2. Video-laryngoscope
3. Endotracheal tubes of assorted sizes
4. Endotracheal tube guides. Semi rigid stylets, ventilating tube exchanger, light wands, and forceps.
5. Supraglottic airways (LMAs)
6. Flexible fiber-optic intubating equipment
7. Equipment for emergency airway access
8. An exhaled carbon dioxide detector.

**Strategy for Intubation of a Difficult Airway.** The quick identification and evaluation of the difficult and failed airway particularly in an unanticipated emergency situation, allows the anesthesia provider to promptly execute the DAA (Murphy, 2011; Law et al. 2013 & Hagberg, 2014. Furthermore, an alternative airway device or technique employed by the anesthesia provider must have the highest potential for successful ventilation (Murray, 2011). The alternative airway device does not dictate the success of an airway rescue. However, the provider's skill in using a particular device will dictate successful airway rescue (Murray, 2011).

Once a patient is identified as a possible difficult airway, there are four issues to consider: (1) awake intubation *versus* intubation after induction of general anesthesia, (2) video-assisted laryngoscopy as an initial approach to intubation, (3) preservation *versus* ablation of spontaneous ventilation, and (4) noninvasive techniques *versus* invasive techniques (surgical or percutaneous airway) for the initial

approach to intubation (Apfelbaum et al., 2013). A consideration of the relative clinical merits and the feasibility of the four methods is necessary prior to implementation. The following are findings related to the four intubation methods.

***Awake intubation.*** Awake fiber-optic intubation is successful in 88–100% patients with difficult airway based on the ASA practice guidelines for management of the DA (Apfelbaum et al., 2013). This include case reports using other methods for awake intubation (blind tracheal intubation, intubation through supraglottic devices, optically guided intubation) also report a high success rate with difficult airway patients (Apfelbaum, 2013).

***Video-assisted laryngoscopy (VL).*** A systematic review of 980 studies that examined the success rate, time to intubation, and several variations of VL including the glidescope and the McGrath found that the success rate was higher and time to intubation was shorter in patients with difficult airways (Jeon et al., 2011 & Mihai, Blair, Kay, & Cook, 2008). A study by Healy, Maties, Hovord, Kheterpal, (2012), concluded that the use of VL increased the success rate of tracheal intubations for the following airway scenarios; (1) patients assessed to be potential or high risk difficult intubation, (2) difficult DL, and (3) failed DLs. Therefore, the use of VL is highly recommended as an alternative technique for the DAA, however, airway injury can occur with VL intubations (Healy, Maties, Hovord, Kheterpal, 2012; Ibinson, Ezaru, Cormican, & Mangione, 2014).

***Intubating stylets or tube-changers.*** Observational studies reported in the ASA Practice Guidelines for Managing the difficult airway showed successful intubation in 78–100% patients with difficult airways when using intubating stylets (Apfelbaum et al., 2013). However, reported

complications from intubating stylets include: mild mucosal bleeding, sore throat, lung laceration, and gastric perforation complications (MacQuirrie, Hung, & Law, 1999).

***SGAs for ventilation.*** Case reports indicate that the use of LMA can maintain or restore ventilation for adult patients with difficult airways (Augoustides, Groff, Mann, Johansson, J., 2007; Fundingsland, Benumof, 1996; Kidani, Shah, 2007). An observational study reported that the LMA provided successful rescue ventilation in 94.1% of patients who cannot be mask ventilated or intubated (Parmet et al., 1998). Additionally, it provides adequate ventilation for 95% of patients with pharyngeal and laryngeal tumors (Parmet et al., 1998).

Reported complications of LMA use with difficult airway patients include: bronchospasm, difficulty in swallowing, respiratory obstruction, laryngeal nerve injury, edema, and hypoglossal nerve paralysis was reported in the ASA Practice Guidelines for managing the difficult airway (Apfelbaum, 2013).

***Intubating laryngeal mask airway (ILMA).*** Observational studies reported successful intubation in 71.4–100% of patients with difficult airway when using the ILMA (Frappier et al., 2003; Fukutome et al., 1998; Kapila, Addy, Verghese, Brain, 1997; Kihara et al., 2000; Nakzawa et al., 1999; Shung et al., 1998). Reported complications from ILMAs include: sore throat, hoarseness, and pharyngeal edema (Apfelbaum, 2013).

***Rigid laryngoscopic blades of alternative design and size.*** Observational studies indicated that the use of rigid laryngoscopic blades of alternative design may improve glottic visualization and facilitate successful intubation for patients with difficult airways (Bell, 1998; Gabbott; 1996).

***Fiber-optic-guided intubation.*** Observational studies using simulated difficult airways, and patients with Mallampati scores of 3–4 reported successful fiber-optic intubation in 87–

100% of patients with difficult airways (Takenaka, Aoyama, Kadoya, Sata, & Shigematsu (1999).

***Lighted stylets or light wands.*** Observational studies reported successful intubation in 96.8–100% of patients with difficult airways when lighted stylets or light wands were used (Watts, 1997; Dimitriou, Voyagis, & Brimacombe, 2002; Holzman, Nargoizian, & Florence, 1988; Hung et al. 1995; Weis & Hatton, 1989)

***Invasive surgical technique: Cricothyrotomy.*** An emergency cricothyrotomy is indicated when patients cannot be adequately oxygenated and ventilated by BMV, SAD, or tracheal intubation (CICV) and who otherwise would face death (Hubert et al., 2014).

According to the ASA DAA, a cricothyrotomy is recommended when an emergent “CICV” event occurs. A cricothyrotomy is an incision made through the skin and cricothyroid membrane. It can establish a patent airway during certain life-threatening situations, such as airway obstruction by a foreign body, angioedema, or massive facial trauma. This procedure is rarely used in the event of CICV or is often utilized too late due to the inexperience of the provider (Boet et al., 2011; Kuduvalli et al., 2008). Therefore, according to Greenland et al. (2011) competency in cricothyrotomy should be mandatory for all anesthesia providers at all institutions. Practicing the skills required to perform an emergency cricothyrotomy is of great importance for all airway practitioners. It can be a challenge for many anesthesia providers to perform a cricothyrotomy due to the pressure of time constraints during a failed airway event. Repeated practice of skills will improve procedure performance of cricothyrotomy (Greenland et al., 2011)

Studies have shown that despite formal training in cricothyrotomy, skill retention is 6 to 12 months (Boet et al., 2011; Kuduvalli et al., 2008). Because this procedure involves the penetration of the skin, Greenland et al. (2011) suggests several surgical procedures in which anesthesia providers can become more familiar. It is recommended that anesthesia providers assist and scrub in for elective tracheostomies in order to become experienced in making incisions. However, this recommendation has not been tested to determine its ability to enhance proficiency.

There are several ways in which this procedure can be performed. All cricothyrotomies involve the penetration of the skin at the cricothyroid area. A systematic review conducted by Langvad, Hyldmo, Nakstad, Vist, & Sandberg (2013) attempted to identify whether there is superiority between available commercial kits versus traditional surgical and needle techniques. The review included 24 studies. The studies selected different starting and stopping points for measurement of success rate and time consumption. The studies found that the open surgical techniques were shown to have higher percentages of success rate in terms of time used to secure the airway. The open surgical technique included: use of a scalpel, a dilator, hemostats, tracheal hook, and tracheostomy tube. Open surgical techniques were found to be statistically faster and have a higher success rate than commercial kits and needle techniques (Langvad et al. 2013).

Cricothyrotomy performed as an open surgical technique was shown to have a 100% success rate compared to a 79% success rate with the Seldinger guidewire technique and needle technique (Helm et al. 2013; National Audit project 4<sup>th</sup>). The

success rate was determined by attaching an ambu bag to the tracheostomy cannula and watching for lung inflation on the manikin (Helm et al., 2013; see Figure 13).



*Figure 13.* Illustration of manikin with a tracheostomy attached to an ambu bag for oxygen ventilation.

Although a cricothyrotomy is considered a last resort emergency procedure, it is not without complications. Acute complications are reported in 15% of cases using an emergent cricothyrotomy (Apfelbaum, 2013). Possible complications included: (1) bleeding from the insertion site, (2) misplaced tube, (3) trauma to surrounding neck structures, and (4) pneumothorax.

### **Teaching Methods**

**Problem Based Learning.** To best facilitate provider training, it is crucial to understand adult learning styles. Selecting a teaching method which results in knowledge and skill retention can be challenging. During a critical and potentially imminent death event, such as dealing with a DA, anesthesia providers must synthesize an enormous amount of complex information and deliver care quickly and in a short period of time.

Thus, using instructional methods that promote rapid, critical thinking, and immediate response time as well as increase long-term knowledge retention are essential.

A problem based learning (PBL) approach has proven to be effective in assisting with long term retention of knowledge as well as promoting rapid decision making during critical events (Chilkoti, Wadhwa, & Kumar, 2015). Numerous studies have found that in medical education settings, relative to traditional, lecture-based learning (LBL) models, the PBL model presents certain advantages with respect to improving student abilities in active learning, two-way communication, clinical thinking, and teamwork.

Additionally, according to World Health Organization data, the PBL teaching model has been used in more than 1,700 medical schools globally, and this number continues to grow (Liu & Fan 2007).

A study by Mehadizadeh et al. (2008) demonstrated that anatomy students that had been instructed via PBL teaching methods not only achieved higher examination scores, but were also highly satisfied with this teaching method. Furthermore, PBL is an active, learner-centered teaching approach in which the learner and the educator act as facilitators (Beers, & Bowden, 2005; McLain et al., 2012). PBL includes a wide variety of educational methods. It incorporates case studies, group discussions, audience response devices, computer based modules, simulations, and other strategies to engage learners to "actively learn." The learning process is aimed at encouraging flexible knowledge, effective problem solving skills, effective collaboration skills, and self-motivation. PBL was developed at the McMaster University Medical School in Canada in the 1960s and has since made a tremendous impact on the process of learning in medicine and nursing (McLain et al., 2012).

The role of the educator in PBL is to facilitate learning by supporting, guiding, and monitoring the learning process. PBL represents a shift from traditional teaching and learning philosophies, which is most often lecture-based and in classroom settings. In a study conducted by McLain et al. (2012), participants who received instruction using PBL had overall higher scores than those who received traditional classroom lectures in a post-test for anesthesia machine check out. This test included identifying and solving malfunctions of the anesthesia machine. Participants in the PBL group performed the anesthesia machine checkout and identified the malfunctions in a shorter length of time than the non PBL group. This suggested that the PBL group was able to quickly apply their knowledge to clinical performance.

In a study conducted by Beers and Bowden (2005), nursing students who received instructions using the PBL method scored significantly higher on the Medical-Surgical Nursing Exit Examination. The study had two groups, a control group and a PBL group, both groups received the same content on diabetes from the same educator, but the PBL group received the content utilizing PBL teaching methods. Both groups were administered a posttest 1 immediately after the lesson and posttest 2, one year later. The results showed a statistically significant difference between the PBL group and the control group for posttest 2 ( $t = -3.38$ ,  $df = 44$ ,  $p = 0.002$ ) with the PBL group outperforming the control group. Furthermore, the study concluded that PBL teaching methods improved knowledge retention (Beers & Bowden, 2005). Additionally, students preferred PBL over lecture-based learning because of a higher quality of education, knowledge retention, class attractiveness, and practical use which lead to higher motivation rate among the students (Khoshnevisasl et al., 2014).

***Computer Based Modules.*** Online education has become increasingly popular across disciplines for providing learning experiences. Despite continued evidence that online learning is at least equivalent to traditional methods, some educators are reluctant to embrace online educational offerings. A study conducted by Palmer et al. (2014) for a 12 lead EKG interpretation course evaluated whether an online class for nurse anesthesia would produce comparable learning outcomes as compared to in class instruction. The in class format for teaching 12 lead EKG interpretation was compared with similar course materials provided in an asynchronous, self-paced, online narrated video format. A pretest/posttest design was used to evaluate concept knowledge change and an analytical skill examination determined student ability to accurately interpret EKG readings. The results were favorable for student satisfaction, attitude toward online learning, and no difference in posttest results from the in class format compared to the online class format (Palmer et al., 2014).

***Educational films.*** Research showed that electronic learning was effective in supporting clinical education. Providing convenient access to learning resources may bring benefits by helping to create learning environments in which learning can take place at any time and location that is convenient for the learner (Hutchinson et al. 2015). Video demonstrations of clinical skills have shown to improve skills. Educational videos provide images to teach procedures requiring skilled techniques (Jang & Kim, 2014). A study of 411 students from 31 medical schools across the nation completed survey questionnaires regarding educational videos. Survey results and interviews pointed out the rich learning resource that video clips bring for teaching clinical skills. It was also

noted that participants appreciated the availability of the learning resources (Jang & Kim, 2014).

Hutchinson et al. (2015), recently evaluated 19 medical students' ability to perform a cricothyrotomy in a simulated CICV scenario. The simulation was judged by two trained observers. The evaluation included the use of rescue airway techniques and the ability to adequately oxygenate. Due to the availability of the online video, the video group outperformed the non-video group the video group. The authors concluded that due to the ability to view the video prior to examination allowed for a more recent airway training and familiarity with the equipment. Educational videos are useful as an adjunct to improve technique and retention after formal instruction such as a classroom lecture or group discussion (Hansen, 2011).

***Safety Checklist.*** The use of a safety checklist has been accepted and utilized as a tool to aid in performance. According to Arriaga et al. (2013), the implementation of a safety checklist increased the effectiveness of lifesaving techniques. For example, 6% of the steps in a simulation study were missed with a checklist when compared to 23% of the steps missed without a checklist (Arriaga et al. 2013). In a retrospective study which consisted of a comparison between two groups before and after implementation of a check list. A group of 842 patients who underwent emergency surgery were compared to a group of 908 patients after a checklist was introduced. The authors found that the complication rate decreased to 36% when a checklist was introduced (Fudickar, Horle, Wiltfang, & Bein, 2012)

In medicine, the use of a checklist for routine procedures and care has been shown to significantly reduce morbidity and mortality. The mortality rate decreased from

3.7% to 1.4% (Arriaga et al., 2013; Fudickar, Horle, Wiltfang, & Bein, 2012). In recent years, checklists and simulations have been considered routine methods of preparing providers for critical events such as Malignant Hyperthermia (MH), local anesthetic toxicity, code blue, pulmonary embolism, and fire in the operating room. However, the use of a checklist in the management of a difficult airway was not found in the current literature review. Checklists are not a new concept and have been successfully used by the aviation industry for decades and they are widely used in the pre-hospital and military environments to improve patient safety in high-risk situations. The aim of using a checklist in clinical practice is to ensure that patient, equipment, and team-related factors are all addressed prior to the procedure and that the principles of crew resource management are used to improve the situational awareness of the team (Wijesuriya & Brand, 2014).

*Simulation.* Although DA management remains one of the leading causes of anesthetic deaths, there has been a reduction in the number of malpractice insurance claims. One reason is due to implementation of simulation experiences for anesthesia providers. The Consolidated Risk Insurance Company (CRICO) is a patient safety and medical mal- practice insurance company. In 2001, they analyzed costs after launching a premium incentive for anesthesiologists that attended simulation training. CRICO concluded the incentive program did reduce the number of malpractice claims and cost after just several years of implementation (Burden, 2011). Additionally, simulations have received increased recognition since the release of “Making Health Care Safer” and seminal Institute of Medicine reports on preventable medical errors and mortality.

Professional organizations such as the American Association of College of Nurses, American College of Surgeons, American Association of Anesthesiologists, and Society for Simulation in Healthcare have all supported simulation training centers (Nehring, 2008; Steadman, 2008). Some of them supported the use of simulations and others through monetary donations to simulation centers. Simulation provides a mechanism for clinicians to practice responding to high-stakes situations without harm to patients. In addition, experienced anesthesia providers must maintain proficiency in a wide array of skills, some of which are known to deteriorate over time without practice (Greenland et al. 2011).

Simulation has gained wide acceptance as an effective teaching method (Zendejas, Brydges, Wang, & Cook, 2013) and is increasingly used for competency-based training (Lorello, Cook, Johnson, & Brydges, 2014). Simulation can serve to maintain clinical skills and may be part of maintenance of board certification, as with the requirement from The American Board of Anesthesiology.

A systematic review and meta-analysis conducted by Lorello, Cook, Johnson, and Brydges (2014) and a systematic review by Zendejas, Brydges, Wang, and Cook (2013) found the majority of studies favored simulation as a teaching strategy compared to strategies which did not utilize simulation. Zendejas et al. (2013) extracted 48 studies which included simulations with health care professionals with topics of airway management, gastrointestinal endoscopy, and central venous catheter insertions. Thirty-one studies involved postgraduate physicians and 17 studies with practicing physicians, nurses, and emergency medicine technicians. The measurement included task completion and patient outcomes. Task completion included airway intubation, fiber-optic intubation,

colonoscopy, and central venous catheter insertions. Patient outcomes were reported either successful or with complications. Complications included esophageal intubation/perforation, inadequate ventilation, bleeding, dental trauma, gastrointestinal perforation, arterial puncture, pneumothorax, and infection. The results suggested that the use of multiple learning strategies and longer duration (time spent training) were associated with improved patient outcomes (Lorello et al., 2014; Zendejas et al. 2013).

A systematic review and meta-analysis of 77 studies examined the effectiveness of simulation in anesthesia. The studies examined training health care professionals and they were categorized in one of the three groups; (1) no intervention group (control group), (2) non-simulation instructional approaches (lecture, small group discussion, instructional videos), and (3) simulation intervention (Lorello et al., 2014). The results showed simulation based training was associated with significant improvement in knowledge, time, skill, behavior process, and patient effect compared to the non-intervention group (Lorello et al., 2014). Hubert et al. (2014) conducted a study of third year anesthesia residents on performing a cricothyrotomy with simulation and without simulation. Residents were trained in two consecutive days during formative simulation on steps and techniques to perform a cricothyrotomy. The times to task completion were significantly shorter with the simulation compared to without simulation (42 seconds compared to 65 seconds) (Hubert et al., 2014). Additionally, the success rate was 100% with simulation training compared to 63% without simulation (Hubert et al., 2014). Furthermore, the majority of the studies conducted on the success rate of cricothyrotomy found that one key to successful emergency surgical management was ongoing training and practice through simulation (Boet et al., 2011; Feng, et al., 2014; Greenland et al.,

201; Green, 2009; Helm et al., 2013; Hubert et al., 2014; Kennedy et al., 2013; Kuduvalli et al., 2008; Lucisano, 2012; Murray et al., 2007). In addition, in a systematic review and meta-analysis the use of a simulation in airway management was reported to be superior in post-test skills retention when compared to no simulation intervention (Kennedy et al., 2013).

In summary, simulation experiences require the learner to utilize effective critical thinking, decision making, and communication skills without the risk of patient harm. Simulation offers learning experiences that mimic real clinical situations, thus providing repeated exposure to rare clinical events to prepare the operating team in an event of an emergency (Kennedy, Cannon, Warner, & Cook, 2014). Simulation allow repeated learning opportunities to build competency, ultimately increasing patient safety and outcomes (Boet et al., 2011; Feng, et al., 2014; Greenland et al., 2011; Green, 2009; & Helm et al., 2013; Hubert et al., 2014; Kennedy et al., 2013; Kuduvalli et al., 2008; Lucisano, 2012; Murray et al., 2007).

As previously discussed, simulation can be used as a teaching strategy to keep the learner engaged and stimulated and it may also function as an evaluation tool. A key aspect in the practice of anesthesia is the ability to perform practical procedures efficiently and safely. Simulation can take place in formative assessment and summative assessment.

*Simulation Formative Assessment.* Simulation can be used as an assessment tool as well as a teaching tool. The teaching aspect is called formative assessment (Wunder et al., 2014). A primary focus of formative assessment is to identify where learners struggle and target areas needing improvement (Wunder et al., 2014). Formative assessment also

provides feedback to the facilitator regarding the effectiveness of the teaching methods used (Wunder et al., 2014). Formative assessment provides on-going feedback during the training and instructional process (Wunder et al., 2014). The goal of formative assessment is to measure the learners' progress. Furthermore, learning through the use of simulation scenario increases the generalizability of the skills taught in simulation to the actual real world setting (Bould, Crabtree, and Naik, 2009).

*Simulation Summative Assessment.* Simulation summative assessment takes place after the learning and training has been completed. The goal of summative assessment is to measure the level of proficiency by a formal evaluation. This evaluation is done by applying a set of standards (Wunder et al., 2014). Furthermore, Murray et al. (2007) concluded that multiple simulation scenario assessments could be used to provide a reliable and valid measure of the anesthesia provider's performance in the operating room.

The development of the simulation component of this project was based upon a literature review conducted by Tetzlaff (2007). Six characteristics were identified which assist the facilitator in determining whether or not the provider can perform the tasks required within the simulation scenario (Tetzlaff, 2007). The six characteristics are as follows:

1. **Reliability and Validity:** Validity of an assessment tool was determined by whether the tool actually measures what it was designed to measure. Reliability is whether the tool can be used repeatedly resulting in similar outcomes.
2. **Flexibility:** Determines if the tool can be used to measure performance in different settings.

3. **Comprehensiveness:** Determined by the assessment tool's ability to measure all aspect of the performance.
4. **Feasibility:** The assessment tool capacity to be used in any program.
5. **Timeliness:** Evaluator provides immediate feedback after the clinical scenario in order to reinforce skills taught during the simulation.
6. **Accountability:** The assessment tool needs to be fair and transparent when applied to all learners.

**Debriefing.** Debriefing is considered a crucial part of simulation (Reed, Andrews, & Ravert, 2013). Debriefing is the process of reflecting on the experiences shared by participants during a simulation scenario. Participants engage in a group discussion in which each participant has an opportunity to share their experience. The goal is for learners to understand what happened in the scenario and what their role should be (Dieckmann, Friss, Lippert, Ostergaard (2009). Dufrene and Young (2013) found that during debriefings facilitators provided constructive feedback and learner's generated discussion regarding the scenarios. The discussion of the experience allowed learners the opportunity to reflect on their actions and learn from both positive and negative aspects of the simulation scenario. Debriefing was also a time to correct any mistakes in thinking or interventions and explore alternatives (Dieckmann, Friss, Lippert, Ostergaard, 2009; Dufrene & Young, 2013). The best time to conduct a debriefing is immediately after the simulation because participants' thoughts and emotions are still fresh and present (Dufrene & Young 2014).

### **Summary Review of Literature**

During a critical, potentially imminent death event, such as dealing with a DA, anesthesia providers must synthesize an enormous amount of complex information and deliver care quickly and in a short period of time. Thus, using instructional methods that promote rapid, critical thinking, and immediate response as well as long-term knowledge retention are essential. The ASA DAA guidelines (Apfelbaum et al., 2013) are designed to be methodical in nature in order to assist in the management of a difficult airway and to reduce the likelihood of adverse outcomes. Researchers have compared several screening tests designed to predict a difficult laryngoscopy intubation in normal patients. However, no single DA predictor was recommended. Anesthesia providers must have the ability to deal with a DA at any given time. This included being proficient in the cricothyrotomy procedure as per the ASA DAA recommendations. Therefore, it is essential for this quality improvement training program to bring awareness, improve practice to existing skills, and enhance professional competencies among anesthesia providers.

## **METHODS**

### **Proposal Project**

In fall 2014, a survey was conducted by the department manager to understand anesthesia provider perceptions of airway management issues. An email invitation was sent to all the anesthesia providers in the hospital and the surgery center to complete an anonymous, 10-item online questionnaire pertaining to difficult airway. The questionnaire was loaded onto Survey Monkey and consisted of questions covering assessment and airway management. Most anesthesia providers who responded (29 out of 50 invited to respond) requested simulation experiences to be focused on difficult airway in the operating room in particular addressing cricothyrotomy. The results from the survey supported the need for this project.

The local quality improvement (QI) committee reviewed cases related to airway mortality and reached consensus that improvement of care was needed. After several meetings where records of difficult airway events were reviewed, members documented that obtaining adequate help and beginning appropriate interventions took longer than expected. Input from the committee led to identified areas for improvement:

1. The need for operating room ASA DA Checklist for Failed Airway
2. The lack of compliance with the ASA difficult airway guidelines, led to a need for a review course/training to be provided via computer modules, education videos, simulations, and debriefing.
3. Lack of procedural skills and lack of confidence to perform a cricothyrotomy led to a need for review and training to perform surgical airway cricothyrotomy.

Based on the needs identified in the survey and from the QI committee, objectives were developed to assist anesthesia providers in reviewing knowledge and attaining skills needed for adherence to the ASA DAA.

### **Objectives for Anesthesia Providers**

The primary purpose of this portion of the curriculum was to provide anesthesia clinicians at KPD an annual review/training curriculum which will allow knowledge enhancement and skills attainment in management of airway crisis. This annual review session aligns with the national American Society of Anesthesiologist Difficult Airway Algorithm guidelines. The training is aimed to teach practical, effective skills and strategies for adult and pediatric intubation that promote patient safety and increase provider confidence. Listed below are objectives for the anesthesia providers to meet at the end of each training.

1. Describe risk factors, physical exam findings, and clinical situations associated with a difficult airway.
2. Classify the various types of equipment used in the management of the patient with a difficult airway and describe their potential use and limitations.
3. Demonstrate a systematic approach to patient, equipment, and drug preparation prior to intubation.
4. Demonstrate effective management of the patient with a difficult airway.
5. Successfully perform direct laryngoscopy in a clinical environment.
6. Employ video laryngoscopes in difficult and failed airways.

7. Use crew resource management principles to effectively utilize an airway management team, maximizing success and patient safety during intubation.
8. The ability to perform a cricothyrotomy

### **Setting**

This quality improvement project was conducted at a hospital, surgery center, and medical office building in Southern California. The hospital has eleven operating rooms in which eight were utilized for simulation training on simulation day. The surgery center has seven operating rooms where four are used during simulation day. The medical office building has 10 procedure rooms where six are used for simulation day. On simulation day, scheduled cases start one hour later so simulation training can occur. This setting allows us training without major interruptions. The simulation took place in the operating/procedure rooms once a month. The simulation was one-hour in length. Simulation training scenarios consist of critical events in the operating room. However, for the current project, a Failed Airway scenario was implemented and evaluated for its effectiveness for improving skills during a critical event.

### **Facilitator/Clinical Expert Committee**

The facilitators consisted of our current department training/education committee which includes four anesthesiologists and four certified nurse anesthetists. Evaluation training for the facilitators was provided in a committee meeting and was based on current literature review on airway management and ASA DAA. The facilitators were trained by the Assistant Chief and myself. After the training session, they demonstrated the ability and skill in evaluating the anesthesia providers for the simulation. I evaluated the CRNA facilitators and the Assistant Chief evaluated the MDAs. The facilitators were

chosen to be on the Training and Education Committee at our facility because they are considered our top performing providers based on knowledge, skills, and patient outcomes.

### **Pre-Simulation Preparation**

**Computer Modules/Educational Films.** Anesthesia providers who participated in the project completed the computer based modules, reviewed the core areas of airway management techniques, and viewed the educational films prior to simulation day. The classroom lecture strategy for the anesthesia department was not feasible. Anesthesia providers do not work daily making it difficult to schedule a classroom type environment. Therefore, computer based modules and educational films provided the flexibility needed when working with diverse schedules. The anesthesia providers are able to learn at their own pace and at a time that was most convenient for them. With the demands of long shifts and 24-hour anesthesia standby in the hospital, providing flexibility in completing the training was essential. Regardless of the shift the anesthesia provider worked, computer based modules and educational films were accessible at any time from any computer in the hospital or at home.

The literature review indicated that computer based modules and educational films were the best methods to teach the PBL strategies. The educational films included in this project were: Identifying a Difficult Airway, The Failed Airway, and The Surgical Airway. The anesthesia providers were to view the educational films prior to simulation day. The film "Identifying the difficult airway", featured Michael Murphy, MD described and demonstrated the mnemonics used to predict a difficult airway. As stated in the ASA guidelines predicting a difficult airway is the single most important step to

preventing the failed airway. The film reviewed the process of an airway assessment and predictor tools used to predict a difficult airway. It emphasized on four basic dimensions of predicting a (1) Difficult ventilation, (2) Difficult laryngoscopy, (3) Difficult placement of the supraglottic external device, and (4) Difficult cricothyrotomy.

The film “The Failed Airway” by Brain Ross, MD focused on the definition, recognition, and the management of the failed airway. The film provided a methodical illustration of the ASA failed airway algorithm where the main focus is oxygenation and ventilation. The film showed a CICV scenario which required a cricothyrotomy using the seldinger’s technique. The last film, “the Surgical Airway” provided step by step on how to perform a cricothyrotomy. The film demonstrated two techniques, the seldinger’s technique and the open surgical technique.

The computer based modules in this project reviewed the differences between various supraglottic airway devices and compare device properties that is advantageous in some situations and limiting in others. The module also provides clinical strategies for routine and emergency airway management based on knowledge of various supraglottic airway devices and their role in the ASA DAA as clinical rescue devices for difficult and failed intubations.

### **Failed Airway Checklist**

The “failed airway” checklist was developed according to the ASA DAA recommendations (Appendix B). The checklist for the ASA DAA was used as a framework for the anesthesia providers as a tool for managing a difficult airway in the operating room. The check list for this simulation listed tasks for providers to perform in the operating room. Currently, each operating room at the facility has a “Crisis Event

Checklist Folder”. The newly developed “Failed Airway Checklist” was included in this program for reference when a difficult or failed airway occurs. A checklist is to confirm an action that has been completed. It is also used to establish a routine for a crisis event. This allows for the cognitive offloading by the anesthesia providers in a crisis event, as well as strengthen team performance. The failed airway checklist was aligned with the ASA DAA recommendations. The reliability of the checklist was verified by a team of 8 (anesthesiologist and CRNAs) experts from the organization who confirmed alignment with the ASA DAA recommendations

### **Skills Proficiency Evaluation Checklist**

The facilitators who evaluated the anesthesia providers as they perform the simulation used a “skill proficiency validation checklist”. A skill proficiency validation checklist was developed by the DNP candidate (Appendix A). The checklist was checked as “pass” or “needs improvement” for each step of the simulation by the facilitator. If the anesthesia provider passed all but one step of the simulation. That step was repeated until the facilitator determined the anesthesia provider was proficient. If the anesthesia provider continued to need improvement, they were scheduled for additional training and simulation until proficiency was met.

The skills proficiency validation checklist consisted of a documentation of start time and time of critical interventions. Time documentation of critical events was important to note because the Quality Improvement Committee identified that a delay in calling for help and the time it took for a second airway team to arrive took an average of 7 to 15 minutes. The documentation of times provided the anesthesia providers awareness of time it took them to request for help. The goal of this process was to assist in the change of practice and raise awareness regarding the call for help. Other times were

documented to identify areas in which any staff in the operating room can assist in decreasing time wasted in a failed airway crisis. For example, how long it took for a difficult airway cart to arrive in the operating room or how long it took to gather other anesthesia equipment such as suction or the cricothyrotomy surgical tray.

This process of identifying time to complete tasks assisted in increasing the awareness of the time constraints within a crisis event. The skill proficiency validation checklist for DA simulation was not to determine whether the anesthesia provider passes or fail an examination or standard, but rather an ongoing training program with the aim of updating and attaining the necessary skills for patient safety during DA scenarios.

### **Development of the Simulation Scenario**

Scenarios were developed using the two endpoints of the ASA DAA pathways; non emergent pathway and emergent pathway needing a surgical airway (see figure 8). The non-emergent pathway consisted of a difficult intubation, but able to mask ventilate. The emergent pathway needing a surgical airway consisted of a CICV, requiring a cricothyrotomy procedure. In each scenario, the anesthesia provider must pass all performance checkpoints. The checkpoints require that the anesthesia providers perform less than 3 direct laryngoscopies, attempt optimal mask ventilation, call for help in an emergency, choose and perform correctly the recommended airway management techniques, carry out ASA DAA guidelines, and successfully perform a cricothyrotomy.

### **Simulation Day**

The day of simulation, eight operating rooms were used to train anesthesia providers. One facilitator was assigned to one operating room. The simulation lasted 60 minutes to complete that was divided into four, 15 minute intervals. The first 15 minutes

consisted of the difficult airway simulation followed by a 15-minute debriefing session. In the debriefing, a discussion occurred regarding what went well and what improvements can be made for the first scenario. The second scenario then followed with implementation of the improvements suggested during the first debriefing. The second scenario included the CICV. At the conclusion of the second simulation, another debriefing session was held and further discussion was allotted for questions and answers.

### **Cricothyrotomy Simulation**

The CICV scenario was the ideal experience for the ASA DAA simulation. The CICV open surgical technique involves horizontal incision made over the cricothyroid membrane in the neck. The anesthesia provider feels for the membrane then using a blunt scapel, a dissection is made in the lower part of the membrane, exposing the larynx. To stabilize the incision, the tracheal hook was placed inferior to the thyroid cartilage. The incision was then dilated before the tracheostomy tube was advanced into the tracheal lumen.

Aho et al (2015) demonstrated that a low fidelity cricothyrotomy simulator has all the major anatomical representations needed for training. It provided a basis of skill level and a step by step approach to perform the task. In order to simulate the airway anatomy on a limited budget, a do it yourself cricothyrotomy task trainer was made for the surgical airway simulation (Appendix C). A homemade moldable silicone airway simulator allowed for cricothyrotomy skills training. The ingredient was basic, a mix cheap silicone caulking (cheap acetic cure) with corn starch and a touch of solvent (such as white spirits) to make it softer. The mixture can cast or mold into shape then is set in less than

an hour. Once the mold is set up, limitless larynxes can be poured from the same mold. A small length of leftover ventilator tubing was placed in the middle mold to provide a trachea that can be cut and replaced. The cost was less than ten dollars to make 10 molds.

**RESULTS: PROJECT MANUSCRIPT**

The product of this quality improvement project was the creation of a manuscript submitted to the *American Association of Nurse Anesthetist Journal*, found in Appendix D.

## DISCUSSION

This project was an implementation of a semi-annual DA refresher course designed to help maintain skills aligned with the ASA DAA guidelines. Research found that difficult airway management as envisioned by the ASA DAA can be systematically taught and performed using the standards outlined in the guidelines. A comprehensive annual training and simulation provided in this project helped to prepare anesthesia providers in managing a DA. They were able to acquire the clinical experience needed in DA situations. Furthermore, the simulation closely replicated real life scenarios, which provided the urgency required when managing a DA. Simulation also provided a realistic setting for skills training when clinical opportunities were limited.

Currently, there is no mandatory airway training at the facility. However, there is a hospital mandate for training concerning the management of malignant hyperthermia. Malignant hyperthermia affects 1 in 100,000 patients who have had anesthesia (Larach, Gronert, Allen, Brandom, & Lehman, 2010). This is significantly lower than the incident rate for a CICV, which is 3 in 100,000 (Hubert, Duwat, Deransy, Mahjoub, & Dupont, 2014). Given the magnitude of incidents of a DA that could lead to a CICV, it is important to provide the training necessary to equip the airway experts with the skills needed to avert patient injury or death.

The chief of anesthesia and the administrators of anesthesia have recognized the importance of the DA training for patient care and thus approved the implementation of the education. Simulation of crisis events such as anaphylaxis, fire in the operating room, and code blues are several education programs available to operating room staff. Thus, the failed airway simulations were included as a crisis event and integrated into the

teaching schedule, which are rotated monthly for 60 minutes during staff meeting/training time.

Funding for this project was minimal. Many of the operating room equipment for simulation were available for use without added cost. Computer modules and educational films were free of charge from organizational websites who train and educate anesthesia providers. Cost for cricothyrotomy simulation materials were paid by the anesthesia department and considered part of the education program.

### **Limitations**

A limitation identified in this project was the terminology used to identify the education purpose. Initially the term competency was used. However, this term was not taken well by the anesthesiologists on staff as they felt that their competency should not be evaluated by a CRNA. The name of the program was changed to better reflect the nature of the training, which was to bring awareness of education, and increase skill sets regarding DA management. The course was presented as a refresher-training course rather than competency for the anesthesiologists and the CRNAs.

Another limitation was the delay of the implementation of the cricothyrotomy simulation. This will be implemented this July 2016. The lack of implementation is due in part to the time constraints allowed for the project and the lack of construction of task trainer models. Currently, the education program involves viewing educational films of the cricothyrotomy procedure. However, the providers have not had the opportunity to practice the skills learned from the educational films on task trainer models.

### **Implications for Care**

The education and the simulation regarding DA management offered an experience that anesthesia providers were seeking, based upon the results of a need assessment. It is recommended by the Difficult Airway Society (2015) that providers take a refresher course every three to five years in cricothyrotomy training. In the present project, the education component was implemented per the difficult airway society recommendations. However, the simulation will be provided to anesthesia providers biannually in order to increase access and retention of the skills taught to manage a DA, this will begin July 2016.

Currently, the QI committee receives all records of adverse patient outcomes for further review related to any airway complications. The electronic medical record is not programmed to extract difficult airway data. The anesthesia provider documents all intraoperative events on paper charting. The anesthetic record is then scanned and filed under the electronic medical record in the “media” tab. This is an image of the record only. It does alert the anesthesia provider that the patient is a DA. Thus the tracking of patients with DAs is difficult to impossible. This information is important to obtain in order to assist anesthesia providers to quickly identify patients that have a DA. Future implications would be to develop a system of documentation of DA. This system of data tracking could begin with a meeting with The Health Connect Software IT department in order to determine the best method to track DAs that would not go to QI.

### **Plan for Evaluation**

The plan for evaluation of the present project will involve measuring patient outcomes through data collected on morbidity and mortality due to DA. Data can be

extracted from the electronic medical record regarding patient outcomes related to airway complications. The QI committee receives all records of adverse patient outcomes, and data regarding airway complications. This data will be compared to the number of cases and the particulars of each case can be compared to data from prior years.

Evaluation of the DAA training program and facilitators are an important component to the identification of areas for improvement. Newly developed programs need constant modifications to meet the growing needs of anesthesia providers and patients. A course/facilitator evaluation form will be distributed immediately after the simulation and collected.

Another evaluation component is the evaluation of the providers. This will be assessed through an evaluation of the procedural skills requires in a DA. The “Skills Proficiency Validation Checklist” will be used in the evaluation. It was developed in alignment with the ASA DAA guidelines as an assessment tool in combination with simulation and debriefing. According to Bould, Crabtree, & Naik (2009), combination of assessment tools is considered the “gold standard.”

## CONCLUSION

The present project was the implementation of a bi-annual difficult airway training program to bring awareness, improve practice to existing skills, and enhance professional competencies among anesthesia providers. The majority of the studies conducted on the success rate of cricothyrotomy found that one key to successful emergency surgical management was ongoing training and practice (Boet et al., 2011; Feng, et al., 2014; Greenland et al., 201; Green, 2009; Helm et al., 2013; Hubert et al., 2014; Kennedy et al., 2013; Kuduvalli et al., 2008; Lucisano, 2012; Murray et al., 2007). The education program provided the recommended training per the Difficult Airway Society (2015). The education program consisted of computer based modules, education films, simulations and debriefings regarding the DA scenarios.

The American Association of Nurse Anesthetists (AANA) Journal was selected as a publication for this project. It is an official scholarly journal that is published bimonthly. This journal was selected because the target audience are Nurse Anesthetists. The information in the manuscript is pertinent to the practice of nurse anesthesia.

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## APPENDIX A

## SKILLS PROFICIENCY VALIDATION CHECKLIST

Evaluator: \_\_\_\_\_ Anesthesia Provider: \_\_\_\_\_

Simulation Start Time @ \_\_\_\_:\_\_\_\_

- Call for expert anesthesiology help and a code cart
- Get difficult Airway Cart and a video laryngoscope
- Bag-mask ventilate with 100% oxygen
- Is ventilation adequate? Yes/no

@ \_\_\_\_:\_\_\_\_

@ \_\_\_\_:\_\_\_\_

@ \_\_\_\_:\_\_\_\_

@ \_\_\_\_:\_\_\_\_

 **Ventilation ADEQUATE**

- Consider awakening patient or alternative approaches Successful@ \_\_\_\_:\_\_\_\_

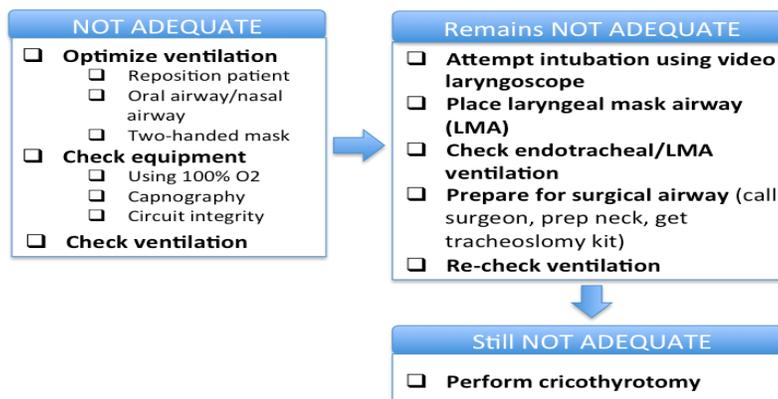
- Video laryngoscope
- LMA as conduit to intubation
- Intubating stylet (Bougie)
- Fiberoptic intubation
- Blind oral or nasal intubation

- If awakening a patient, consider Successful@ \_\_\_\_:\_\_\_\_

- Awake intubation
- Cancel the case

 **Ventilation NOT ADEQUATE**

Call for surgical Tray/@ \_\_\_\_:\_\_\_\_



Airway surgical start@ \_\_\_\_:\_\_\_\_

 **Steps to Perform Cricothyrotomy**

1. Palpate
2. Scalpel
3. Finger
4. Hook
5. Spreader
6. Tube

Surgical Airway Complete/Successful@ \_\_\_\_:\_\_\_\_

Pass or Needs Improvement

## APPENDIX B

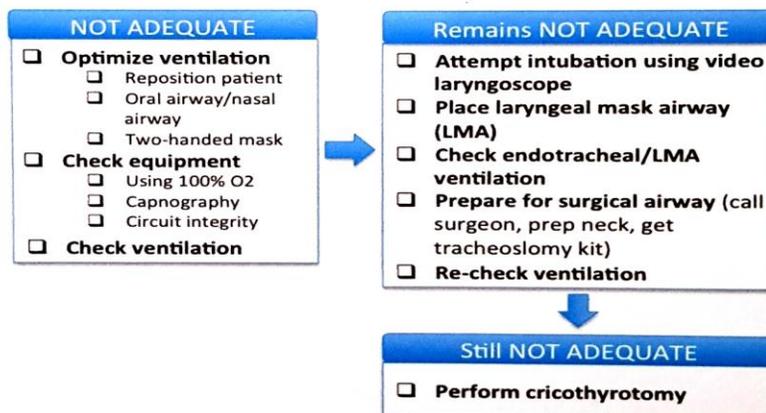
## THE FAILED AIRWAY SIMULATION CHECKLIST

**Failed Airway Simulation Checklist**

- Call for expert anesthesiology help and a code cart
- Get difficult Airway Cart and a video laryngoscope
- Bag-mask ventilate with 100% oxygen
- Is ventilation adequate?

 **Ventilation ADEQUATE**

- Consider awakening patient or alternative approaches to secure airway...
  - Video laryngoscope
  - LMA as conduit to intubation
  - Intubating stylet (Bougie)
  - Fiberoptic intubation
  - Blind oral or nasal intubation
- If awakening a patient consider
  - Awake intubation
  - Cancel the case

 **Ventilation NOT ADEQUATE****Steps to Perform Cricothyrotomy**

- 1. Palpate
- 2. Scalpel
- 3. Finger
- 4. Hook
- 5. Spreader
- 6. Tube

APPENDIX C  
CRICOTHYROTOMY TASK TRAINER SIMULATOR



*Figure. Cricothyrotomy task trainer for simulation training.*

## **APPENDIX D**

### **MANUSCRIPT SUBMITTED TO THE *AMERICAN ASSOCIATION OF NURSE ANESTHETISTS JOURNAL***

#### **Managing a Difficult Airway: A Quality Improvement Project**

#### **ABSTRACT**

The management of a difficult airway is one of the fundamental competencies required for all anesthesia providers. Despite the Difficult Airway Algorithm guidelines developed by the American Society of Anesthesiologists there continues to be high rates of mortality and morbidity related to anesthesia. Commonly found causes to difficulties with poor airway management were poor adherence to appropriate recommendations as well as a decline in retention of knowledge after training (Arriaga et al., 2013). A “Cannot intubate, cannot ventilate” situation in real life is rare, and may be difficult for anesthesia providers to achieve and maintain competency through clinical experiences. Therefore, a semi-annual training program is required to bring awareness, improve practice to existing skills, and enhance professional competencies among practicing anesthesia providers.

#### **INTRODUCTION**

Management of a difficult airway is one of the most challenging tasks faced by anesthesia providers. Difficult airway management is the leading cause of anesthesia deaths and malpractice claims in the United States (Kennedy, Cannon, Warner, & Cook, 2014). Difficult airways are categorized as either difficult or impossible to intubate and ventilate. As many as 6.2% of all intubations are difficult airways (Hubert, Duwat, Deransy, Mahjoub, & Dupont, 2014). Difficult intubation and difficult ventilation occurs in 1.5% of anesthesia cases. Impossible intubation and difficult ventilation occurs in

0.3% of anesthesia cases. “Cannot intubate and cannot ventilate” (CICV) events occur in 0.07% of anesthesia cases (Hubert, Duwat, Deransy, Mahjoub, & Dupont, 2014).

Unfortunately, anesthesia providers cannot always predict which patients will have difficult airways. Therefore, despite advances in technology and improvements in techniques, airway complications can still result in patient deaths.

The American Society of Anesthesiologist (ASA), conducted the Closed Claims Project (ASA-CCP) in 1985 to examine all malpractice insurance claims made in that year. The purpose was to identify the causes of anesthesia-related patient injuries to improve patient safety. The ASA-CCP retrieved data from practice claims of 35 participating malpractice insurance carriers. The latest report in 2010, revealed that 25% of the claims were related to death and 17% were due to respiratory complications (Metzner et al., 2011; Cook & MacDougall-Davis, 2012). In addition, hypoxia was identified as the most common cause of airway- related deaths by the Fourth National Audit Project in 2011 (Cook & MacDougall-Davis, 2012). To improve established guidelines, this project reviewed cases of airway-related deaths to determine risk factors that were either missed or discounted. It was revealed that in half of the claims despite patients being identified as “predicted or anticipated difficult airway,” many anesthesia providers proceeded with the standard general anesthetic practice (Cook & MacDougall-Davis, 2012).

Since the development of the American Society of Anesthesiologists Difficult Airway Algorithm (ASA DAA), the number of claims and severity of outcomes during anesthesia induction have decreased (Cook & MacDougall-Davis, 2012; Law et al. 2013; Metzner et al. 2013). However, studies repeatedly iterate that mortality and morbidity

related to anesthesia is due to inadequate ventilation resulting in hypoxia. This is due to providers not following the ASA DAA guidelines and not executing a cricothyrotomy (surgical emergency airway; Figure 1) in a reasonable time frame (Greenland, et al., 2011).

In an effort to improve outcomes, the ASA adopted a DAA in 1993, with revisions in 2003 and 2013. The DAA provides a coherent cognitive framework for approaching various airway management scenarios encountered in clinical practice. Although the national guidelines exist, providers do not necessarily follow the guideline's recommendations (Hubert et al., 2014). Due to the rarity of CICV scenarios, providers may not recall, thus may miss or skip recommended steps of the guidelines. Commonly found causes of mortality and morbidity with difficult airways are poor adherence to appropriate recommendations as well as a decline in retention of knowledge after training (Arriaga et al., 2013). Additionally, the National Audit report (2014) indicated poor outcomes were associated with extended time patient is hypoxic or anoxic. Therefore, it is important for the anesthesia providers to call for help as soon as airway challenges are identified. In any event, failure to effectively manage these life threatening complications can lead to patient deaths.

During the past 5 years, two deaths occurred at the local facility related to inadequate management of a difficult airway. The local quality improvement (QI) committee reviewed those cases and reached the consensus that improvement of care was needed. After several meetings where records of difficult airway events were reviewed, members documented that providers and staff members took longer than expected to

obtain adequate help and begin appropriate interventions because members of the operating room staff were unsure what to do.

### **Purpose of the Project**

The primary objective for this quality improvement project is to bring awareness and improve practice to existing skills. Furthermore, decreasing the number of mortality and morbidity at the local facility to improve patient outcomes.

The project included specific products and several deliverables:

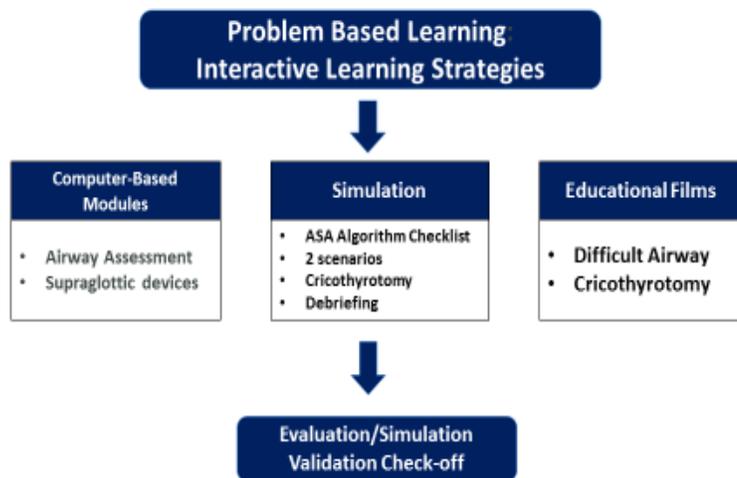
1. Teaching/learning methods that utilize computer modules, education films, check list, simulations, and debriefing.
2. An annual evaluation for DAA simulation and cricothyrotomy procedure.

The objectives for the anesthesia providers at the end of the training session are to improve in the following areas: 1) diagnostic and airway management skills, 2) ability to integrate knowledge, 3) clinical judgment, 4) communication, and 5) teamwork. In order to develop a program that is sustainable and that will promote lasting behavioral change in the management of difficult airways, a thorough review of literature was conducted in addition to consultations with clinical and educational experts.

### **Supporting Framework**

The Competency Outcomes and Performance Assessment (COPA) Model developed by Lenburg (1999) was used for this project. This model serves as a framework that supports competency outcomes and assessment required for practice, along with accountability in practice skills (Lenburg, 1999). As seen in Figure 1, the COPA Model emphasizes “critical thinking over tasks, concepts over cases, integrated actual performance over test results, and performance based expectations over

procedures” (Lenburg, 1999, p. 5). The COPA Model is organized around four concepts that are essential to professional practice: core practice competencies, end-result competency outcomes, practice-driven interactive learning strategies, and objective competency performance examinations.



*Figure 1.* For creating a quality improvement program to keep practicum current. COPA Model adapted from by Lenburg, 1999.

A problem based learning (PBL) approach has proven to be effective in assisting with long term retention of knowledge as well as promoting rapid decision making during critical events (Chilkoti, Wadhwa, & Kumar, 2015). According to World Health Organization data, the PBL teaching model has been used in more than 1,700 medical schools globally, and this number continues to grow (Liu & Fan 2007). The PBL approach is an active learner-centered teaching method in which the learner and the educator act as facilitators (Beers, & Bowden, 2005; McLain et al., 2012). The PBL incorporates case studies, group discussions, audience response devices, computer based modules, simulations, and other strategies to engage learners to "actively learn."

During a critical, potentially imminent death event, such as dealing with a DA, anesthesia providers must synthesize an enormous amount of complex information and deliver care quickly and in a short period of time. Thus, using instructional methods that promote rapid, critical thinking, and immediate response as well as long-term knowledge retention are essential. The ASA DAA guideline is designed to be methodical in nature in order to assist in the management of a difficult airway and to reduce the likelihood of adverse outcomes. Researchers have compared several screening tests designed to predict a difficult laryngoscopy intubation in normal patients. However, no single DA predictor is recommended. Anesthesia providers must have the ability to deal with a DA at any given time. This includes being proficient in the cricothyrotomy procedure (ASA guideline). Therefore, it is essential for this Quality improvement program to enhance provider confidence and update technical skills in managing DA.

### **Literature Review**

A thorough literature search was conducted and many studies were compiled, which focused on the components of difficult airway competency. An invasive surgical technique, cricothyrotomy is indicated when patients cannot be adequately oxygenated and ventilated and would otherwise face death (Hubert et al., 2014). According to the ASA DAA, a cricothyrotomy is recommended when an emergent “CICV” event occurs. This procedure is rarely used in the event of CICV or is often utilized too late due to the inexperience of the provider (Boet et al., 2011; Kuduvalli et al., 2008). Therefore, according to Greenland et al. (2011) competency in cricothyrotomy should be mandatory for all anesthesia providers at all institutions. Practicing the skills required to perform an emergency cricothyrotomy is of great importance for all airway practitioners. It can be a

challenge for many anesthesia providers to perform a cricothyrotomy due to the pressure of time constraints during a failed airway event. Repeated practice of skills will improve procedure performance.

Studies have shown that despite formal training in cricothyrotomy, skill retention is 6 to 12 months (Boet et al., 2011; Kuduvalli et al., 2008). There are several methods to perform this procedure. A systematic review conducted by Langvad, Hyldmo, Nakstad, Vist, & Sandberg (2013) attempted to identify whether there is superiority between available commercial kits versus traditional surgical and needle techniques. The review included 24 studies. The studies selected different starting and stopping points for measurement of success rate and time consumption. The studies found that the open surgical techniques were shown to have higher percentages of success rate in terms of time used to secure the airway. The open surgical technique included: use of a scalpel, a dilator, hemostats, tracheal hook, and tracheostomy tube. Open surgical techniques were found to be statistically faster and have a higher success rate than commercial kits and needle techniques (Langvad et al. 2013). Cricothyrotomy performed as an open surgical technique was shown to have a 100% success rate compared to a 79% success rate with the Seldinger guidewire technique and needle technique (Helm et al. 2013; National Audit project 4<sup>th</sup>).

## **METHODS**

### **Setting**

This quality improvement project was conducted at a hospital and a surgery center in Southern California. The simulation took place once a month. The simulation was one-hour in length. Simulation training scenarios consist of critical events in the operating

room. However, for the current project, a Failed Airway scenario was implemented and evaluated for its effectiveness for improving skills during a critical event.

### **Quality Improvement Project**

In fall 2014, a survey was conducted by the department manager to understand anesthesia provider perceptions of airway management issues. An email invitation was sent to all the anesthesia providers in the hospital and the surgery center to complete an anonymous, 10-item online questionnaire pertaining to difficult airway. The questionnaire was loaded onto Survey Monkey and consisted of questions covering assessment and airway management. Most anesthesia providers who responded (29 out of 50 invited to respond) requested simulation experiences to be focused on difficult airway in the operating room in particular addressing cricothyrotomy. The results from the survey supported the need for this project.

The local quality improvement (QI) committee reviewed cases related to airway mortality and reached consensus that improvement of care was needed. After several meetings where records of difficult airway events were reviewed, members documented that obtaining adequate help and beginning appropriate interventions took longer than expected. Input from the committee led to identified areas for improvement:

1. The need for operating room ASA DA Checklist for Failed Airway
2. The lack of compliance with the ASA difficult airway guidelines, led to a need for a review course/training to be provided via computer modules, education videos, simulations, and debriefing.
3. Lack of procedural skills and lack of confidence to perform a cricothyrotomy led to a need for review and training to perform surgical airway cricothyrotomy.

Based on the needs identified in the survey and from the QI committee, objectives were developed to assist anesthesia providers in review knowledge and attain skills needed for adherence to the ASA DAA.

### **Objectives for the Anesthesia Providers**

1. Describe risk factors, physical exam findings, and clinical situations associated with a difficult airway.
2. Classify the various types of equipment used in the management of the patient with a difficult airway and describe their potential use and limitations.
3. Demonstrate a systematic approach to patient, equipment, and drug preparation prior to intubation.
4. Demonstrate effective management of the patient with a difficult airway.
5. Successfully perform direct laryngoscopy in a clinical environment.
6. Employ video laryngoscopes in difficult and failed airways.
7. Use crew resource management principles to effectively utilize an airway management team, maximizing success and patient safety during intubation.
8. The ability to perform a cricothyrotomy

### **Facilitator/Clinical Expert Committee**

The facilitators consisted of our current department training/education committee which includes four anesthesiologists and four certified nurse anesthetists. Evaluation training for the facilitators was provided in a committee meeting and was based on current literature review on airway management and ASA DAA. The facilitators were trained by the Assistant Chief and myself. After the training session, they demonstrated the ability and skill in evaluating the anesthesia providers for the simulation. I evaluated

the CRNA facilitators and the Assistant Chief evaluated the MDAs. The facilitators were chosen to be on the Training and Education Committee at our facility because they are considered our top performing providers based on knowledge, skills, and patient outcomes.

### **Pre-Simulation Preparation**

**Computer Modules/Educational Films.** Anesthesia providers who participated in the project completed the computer based modules, reviewed the core areas of airway management techniques, and viewed the educational films prior to simulation day. The classroom lecture strategy for the anesthesia department was not feasible. Anesthesia providers do not work daily making it difficult to schedule a classroom type environment. Therefore, computer based modules and educational films provided the flexibility needed when working with diverse schedules. The anesthesia providers are able to learn at their own pace and at a time that was most convenient for them. With the demands of long shifts and 24-hour anesthesia standby in the hospital, providing flexibility in completing the training was essential. Regardless of the shift the anesthesia provider worked, computer based modules and educational films were accessible at any time from any computer in the hospital or at home.

The literature review indicated that computer based modules and educational films were the best methods to teach the PBL strategies. The educational films included in this project were: Identifying a Difficult Airway, The Failed Airway, and The Surgical Airway. The anesthesia providers were to view the educational films prior to simulation day. The film “Identifying the difficult airway”, featured Michael Murphy, MD described and demonstrated the mnemonics used to predict a difficult airway. As stated in

the ASA guidelines predicting a difficult airway is the single most important step to preventing the failed airway. The film reviewed the process of an airway assessment and predictor tools used to predict a difficult airway. It emphasized on four basic dimensions of predicting a (1) Difficult ventilation, (2) Difficult laryngoscopy, (3) Difficult placement of the supraglottic external device, and (4) Difficult cricothyrotomy.

The film “The Failed Airway” by Brain Ross, MD focused on the definition, recognition, and the management of the failed airway. The film provided a methodical illustration of the ASA failed airway algorithm where the main focus is oxygenation and ventilation. The film showed a CICV scenario which required a cricothyrotomy using the seldinger’s technique. The last film, “the Surgical Airway” provided step by step on how to perform a cricothyrotomy. The film demonstrated two techniques, the seldinger’s technique and the open surgical technique.

The computer based modules in this project reviews the differences between various supraglottic airway devices and compare device properties that is advantageous in some situations and limiting in others. The module also provides clinical strategies for routine and emergency airway management based on knowledge of various supraglottic airway devices and their role in the ASA DAA as clinical rescue devices for difficult and failed intubations.

### **Failed Airway Checklist**

The “failed airway” checklist was developed according to the ASA DAA recommendations (Appendix C). The checklist for the ASA DAA was used as a framework for the anesthesia providers as a tool for managing a difficult airway in the operating room. The check list for this simulation listed tasks for providers to perform in

the operating room. Currently, each operating room at the facility has a “Crisis Event Checklist Folder”. The newly developed “Failed Airway Checklist” was included in this program for reference when a difficult or failed airway occurs. A checklist is to confirm an action that has been completed. It is also used to establish a routine for a crisis event. This allows for the cognitive offloading by the anesthesia providers in a crisis event, as well as strengthen team performance. The failed airway checklist was aligned with the ASA DAA recommendations. The reliability of the checklist was verified by a team of 8 (anesthesiologist and CRNAs) experts from the organization who confirmed alignment with the ASA DAA recommendations

### **Skills Proficiency Evaluation checklist**

The facilitators who evaluated the anesthesia providers as they perform the simulation used a “skill proficiency validation checklist”. A skill proficiency validation checklist was developed by the DNP candidate (see Figure 1). The checklist was checked as “pass” or “needs improvement” for each step of the simulation by the facilitator. If the anesthesia provider passed all but one step of the simulation. That step was repeated until the facilitator determined the anesthesia provider was proficient. If the anesthesia provider continued to need improvement, they were scheduled for additional training and simulation until proficiency was met.

The skills proficiency validation checklist consisted of a documentation of start time and time of critical interventions. Time documentation of critical events was important to note because the Quality Improvement Committee identified that a delay in calling for help and the time it took for a second airway team to arrive took an average of 7 to 15 minutes. The documentation of times provided the anesthesia providers awareness

of time it took them to request for help. The goal of this process was to assist in the change of practice and raise awareness regarding the call for help. Other times were documented to identify areas in which any staff in the operating room can assist in decreasing time wasted in a failed airway crisis. For example, how long it took for a difficult airway cart to arrive in the operating room or how long it took to gather other anesthesia equipment such as suction or the cricothyrotomy surgical tray.

This process of identifying time to complete tasks assisted in increasing the awareness of the time constraints within a crisis event. The skill proficiency validation checklist for DA simulation was not to determine whether the anesthesia provider passes or fail an examination or standard, but rather an ongoing training program with the aim of updating and attaining the necessary skills for patient safety during DA scenarios.

### SKILLS PROFICIENCY VALIDATION CHECKLIST

Evaluator: \_\_\_\_\_ Anesthesia Provider: \_\_\_\_\_

Simulation Start Time @ \_\_\_\_:\_\_\_\_

- Call for expert anesthesiology help and a code cart  
@ \_\_\_\_:\_\_\_\_
- Get difficult Airway Cart and a video laryngoscope  
@ \_\_\_\_:\_\_\_\_
- Bag-mask ventilate with 100% oxygen  
@ \_\_\_\_:\_\_\_\_
- Is ventilation adequate? Yes/no  
@ \_\_\_\_:\_\_\_\_

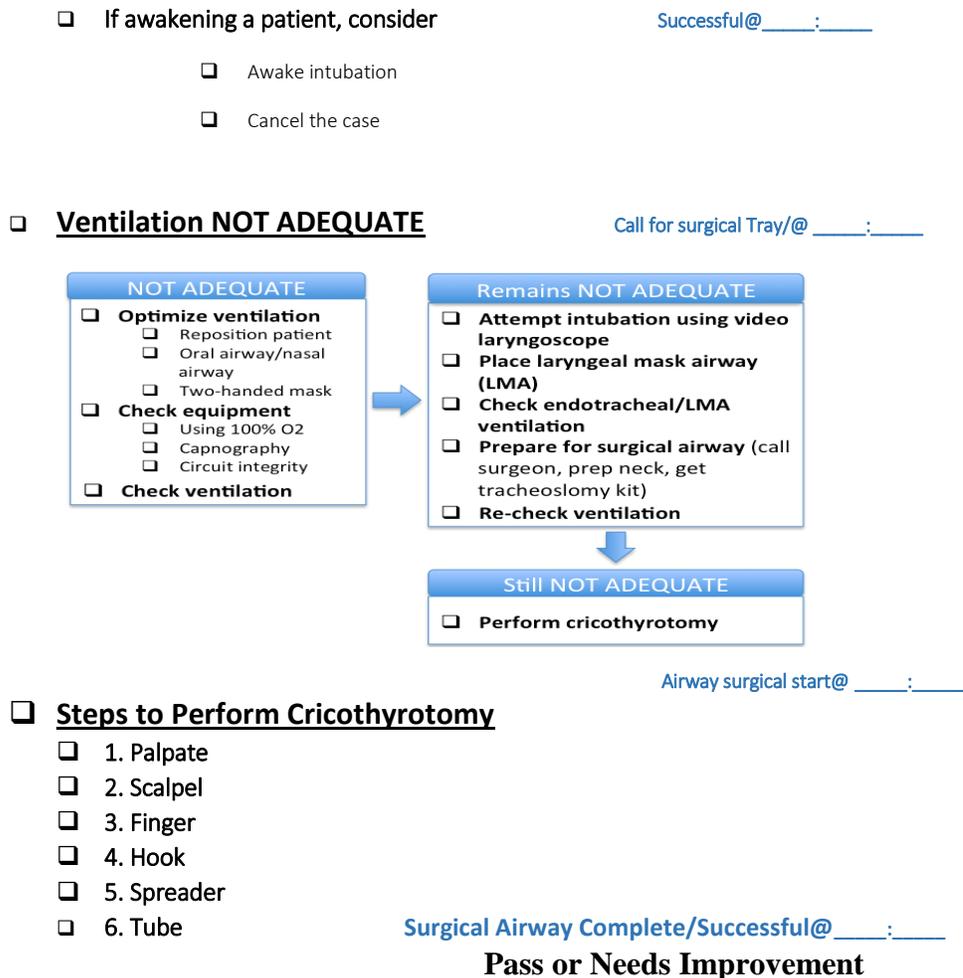
#### **Ventilation ADEQUATE**

- Consider awakening patient or alternative approaches to secure

Airway...

Successful@ \_\_\_\_:\_\_\_\_

- Video laryngoscope
- LMA as conduit to intubation
- Intubating stylet (Bougie)
- Fiberoptic intubation
- Blind oral or nasal intubation



**Figure 2.** Proficiency validation checklist.

### Development of the Simulation Scenario

Scenarios were developed using the two endpoints of the ASA DAA pathways; non emergent pathway and emergent pathway needing a surgical airway (see figure 8). The non-emergent pathway consisted of a difficult intubation, but able to mask ventilate. The emergent pathway needing a surgical airway consisted of a CICV, requiring a cricothyrotomy procedure. In each scenario, the anesthesia provider must pass all performance checkpoints. The checkpoints require that the anesthesia providers perform less than 3 direct laryngoscopies, attempt optimal mask ventilation, call for help in an

emergency, choose and perform correctly the recommended airway management techniques, carry out ASA DAA guidelines, and successfully perform a cricothyrotomy.

### **Simulation Day**

The day of simulation, eight operating rooms were used to train anesthesia providers. One facilitator was assigned to one operating room. The simulation lasted 60 minutes to complete that was divided into four, 15 minute intervals. The first 15 minutes consisted of the difficult airway simulation followed by a 15-minute debriefing session. In the debriefing a discussion occurred regarding what went well and what improvements can be made for the first scenario. The second scenario then followed with implementation of the improvements suggested during the first debriefing. The second scenario included the CICV. At the conclusion of the second simulation, another debriefing session was held and further discussion was allotted for questions and answers.

### **Cricothyrotomy Simulation**

The CICV scenario was the ideal experience for the ASA DAA simulation. The CICV open surgical technique involves horizontal incision made over the cricothyroid membrane in the neck. The anesthesia provider feels for the membrane then using a blunt scapel, a dissection is made in the lower part of the membrane, exposing the larynx. To stabilize the incision, the tracheal hook was placed inferior to the thyroid cartilage. The incision was then dilated before the tracheostomy tube was advanced into the tracheal lumen.

A study conducted by Aho et al. (2015) demonstrated a degree in construct validity in which low fidelity cricothyrotomy simulator has all the major anatomical

representations needed for training. It provided a basis of skill level and a step by step approach to perform the task. In order to simulate the airway anatomy on a limited budget, a “do it yourself cricothyrotomy trainer” was made for the surgical airway simulation (see Figure 2). A homemade moldable silicone airway simulator allowed for cricothyrotomy skills training. The ingredient was basic, a mix cheap silicone caulking (cheap acetic cure) with corn starch and a touch of solvent (such as white spirits) to make it softer. The mixture can cast or mold into shape then is set in less than an hour. Once the mold is set up, limitless larynxes can be poured from the same mold. A small length of leftover ventilator tubing was placed in the middle mold to provide a trachea that can be cut and replaced.



*Figure 2.* Do it your self Cricothyrotomy Task Trainer (retrieved from DYI...)

## DISCUSSION

Future implications for this project include implementation of a semi-annual DA training align with the ASA DAA guidelines. Research found that difficult airway management as envisioned by the ASA DAA can be systematically taught and performed using the standards outlined in the guidelines. Practice and measurement through quantitative simulation has been shown to improve outcomes. A comprehensive annual training and simulation may be the best preparation for the acquisition of the clinical experience needed in DA situations.

Studies indicated that simulation provides the best means of maintaining skills required in dealing with infrequent clinical challenges. Additionally, simulation can closely replicate real like scenarios providing the urgency required in DA management. Simulation also provide realistic setting for skills training when clinical opportunities are limited. Furthermore, the majority of the studies conducted on the success rate of cricothyrotomy found that one key to successful emergency surgical management was ongoing training and practice (Boet et al., 2011; Feng, et al., 2014; Greenland et al., 2011; Green, 2009; Helm et al., 2013; Hubert et al., 2014; Kennedy et al., 2013; Kuduvalli et al., 2008; Lucisano, 2012; Murray et al., 2007). Therefore, implementation of a semi-annual DA training program is necessary for improvement in patient outcomes in any facility providing anesthesia services.

### **Plan for Evaluation**

Clinical process and outcome measurements can be used to determine if indeed implementation of this project improved quality care. Measuring clinical process and outcomes involve: obtaining a baseline of current practices using the selected measures

and reassessing or monitoring the effect of improvement efforts on measure performance. The purpose of this project was to improve the quality of care by decreasing the number of mortality and morbidity at the local facility. Measuring mortality and morbidity patient outcomes would give us data on whether the semi-annual DA training helped improved the anesthesia providers' knowledge and skills. In order to have data that reflects airway complications and patient outcomes. Data can be extracted by the electronic medical record to gather patients' outcomes from airway complications. Additionally, data may also be collected through the QI's data base because the QI committee receives all records of adverse patient outcomes for further review. Therefore, the number of adverse patient outcomes can be compared from the previous years (prior to implementation of the project) to after implementation. This data and or results would demonstrate whether the implementation of a semi-annual training for anesthesia providers improved patient outcomes related to DA.

Implementation of an annual difficult airway training program was to bring awareness, improve practice to existing skills, and enhance professional competencies among the anesthesia providers. Evaluation of the ongoing training program and facilitators are also important. It is essential to identify areas for improvement to modify what is needed to meet the needs of the anesthesia providers and patients. For this reason, an anonymous online survey monkey evaluation was conducted for all the anesthesia providers and the facilitators to voice their opinions and concerns.

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