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7-29-2020

In Adults with Difficult Intubations, What Is a Gold Standard Method for Success?

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In Adults with Difficult Intubations, What Is a Gold Standard Method for Success?

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Paper Submitted in Partial Fulfillment

Of the Requirements for the Degree

Of Master of Science

Physician Assistant Studies

Augsburg University

7/29/2020

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ABSTRACT

The objective of this thesis is to analyze existing literature and guidelines for difficult intubations and provide clinical recommendations. This paper is a retrospective analysis of human trials focusing on preparation, medication, and tools in the field of emergency airway management. Techniques will be described and discussed. A large portion of intubations are described as difficult and have the potential to fail. Articles retrieved from databases PubMed, Medline, and PLOS ONE and the search engine Google Scholar were reviewed. Websites for the institutions of the American Society of Anesthesiologists and Difficult Airway Society were used in guidance. Currently, many guidelines exist for difficult intubation, and traditional bedside prediction has proven to be unreliable. Techniques such as preprocedural checklists, preoxygenation, proper positioning benefit all intubations. In addition, practicing the failed intubation protocol including a standardized tracheotomy procedure is recommended. The paralytic rocuronium may be superior to succinylcholine in critically ill or those likely to have difficult airways. Technologies such as video laryngoscope, supraglottic airway devices, and bougie-first intubation should be included in training and implemented in practice. The obese population may have specific changes to technique to reduce the risk of complications. Finally, cricoid pressure is theoretically beneficial but practically challenging to replicate and recommendations will be given regarding its implementation.

INTRODUCTION

Airway, breathing, and circulation are the primary considerations for emergent medical decision-making. Without first completing these ABCs of medicine, a provider is likely to find themselves with an unstable patient and poor outcomes. Roughly 50 million intubations occur globally each year and up to 17% of these are deemed difficult.[1,6] At present, the arrival of the

COVID-19 pandemic has only increased intubation numbers.[2] This necessitates a standard protocol and in-depth knowledge for dealing with challenging scenarios and techniques for avoiding adverse outcomes.

For the purposes of this paper, difficult intubation will be a clinical situation where a trained provider has difficulty with tracheal intubation.[4,5] Unfortunately, the difficult airway is a subjective description and a straightforward definition is not freely available.[5] There have been attempts at objectively comparing the complexity of intubations through a variety of scales, however, these are numerous, and none have been widely accepted.[5,6] In practice, the difficult airway represents a complex interaction of clinical setting, skills of the provider, and patient characteristics. An unanticipated difficult intubation with multiple provider attempts has been implicated with poor patient outcomes in emergency and intensive care scenarios.[6] Trauma to the airway, damage to teeth, cardiopulmonary arrest, hypoxic brain injury, and death are all adverse events associated with multiple intubation attempts and prolonged hypoxia.[6]

There have been many iterations of difficult intubation guidelines that are continually revised to fit modern technologies and medical standards. Preference will be given to studies in the field of emergency and intensive care. However, information from the field of surgical anesthesia will be used in areas that are lacking adequate human trial data. The intent of this paper is to address aspects of modern guidelines specific to difficult intubations, describe new techniques, and discuss how a changing population base may alter modern-day protocols for difficult intubations. It will outline current discussion topics and clinical recommendations in the field with focus on those that have potential to lower complication rates and maximize success.

LITERATURE REVIEW

PREPROCEDURAL CHECKLISTS

For many emergency departments, endotracheal intubation is a high-acuity, low-opportunity procedure that is psychologically demanding on both the provider and staff involved. One recent system-wide development has been an implementation of a standardized, preprocedural checklist.[7,8] This relatively simple adjunct has been shown to improve the safety of high-risk procedures and can be applied to the unanticipated difficult airway in emergency department trauma patients.[7,8,9]

Research suggests that the implementation of surgical safety checklists can reduce mortality and postoperative complications. Eight diverse cities across the world employed a 19-item safety checklist founded on the World Health Organization's (WHO) Guidelines for Safe Surgery.[7] This WHO checklist was designed to be universally applicable, benefit communication, and improve consistency of practice.[9] In one study, mortality rate was found to be 3.7% before a checklist was introduced and declined to 1.4% after checklist.[7] In addition, inpatient complications occurred in 18.4% of surgical patients pre- and 11.7% post-checklist. A summary of these results and complications are available in Table 1.[7] The authors concluded that the implementation and use of the WHO Surgical Safety Checklist could be considered in urgent or emergent medical procedures.[7]

In a later study, 141 trauma patients were intubated in the emergency department. A preprocedural checklist was used in 65 patients and 76 without its use.[8] A lower proportion of patients were found to have complications in the checklist population at 1.5% when compared to the non-checklist group at 9.2%.[8] The study found a decreased paralysis-to-intubation time in the post checklist group (median of 94 seconds before and 84 seconds after) and increased safety adherence (17.1% before and 69.2% after).[8] The first-pass intubation success was found to be slightly higher in the post-checklist period, however, these results were similar and nonsignificant (79% before and 86% after, p-value of 0.28).[8]

The preprocedural checklist has been suggested to help make decisions, limit interventions, and prompt calls for help in critically ill adults.[7,8,9] They can be provided for staff at orientation with regular refreshers at training headed by team leaders likely to perform future intubations. These preprocedural checklists can be incorporated in airway simulation training with every level of staff to develop skills and could detect mistakes before they occur, potentially lowering mortality and morbidity of unanticipated difficult intubation.[7,8,9]

PREDICTING DIFFICULT AIRWAYS

The "difficult airway" is a subjective description, a standard definition is not freely available and current scoring systems are undependable.[4,10,11] Prediction and identification of a difficult intubation has been an ongoing struggle for researchers and clinicians alike. Overall, the difficult airway is a complex interaction of clinical setting, provider skills, and patient characteristics.[10,11] An unanticipated difficult intubation has been implicated with poor patient outcomes in emergency and intensive care scenarios. Death, brain injury, cardiopulmonary arrest, airway trauma, and teeth damage can all be associated with multiple intubations.[6] Consistent predictions of high-risk adults using bedside airway assessment tests would be invaluable to lower complication rates and save lives.[11]

Traditionally, providers have attempted to predict difficult intubation characteristics using bedside physical exam techniques and perhaps most notably done by Mallampati et al. The team produced a well-known screening test in 1985 that attempted to classify visualization of oropharyngeal structure and has been modified in recent years.[13] This modified Mallampati score, as seen in Figure 1,[11] was developed along with other bedside tests to accurately predict difficult intubations. However, as recent data suggests, none have been entirely successful.[10,11]

Upon a systematic review of 24 studies involving 20,582 patients, bedside airway screening tests were evaluated. The most commonly used tests are the modified Mallampati score, upper lip bite test, gap between the incisors, as well as thyro-mental and sterno-mental distance.[10] Although the evaluation of airway is a basic first step in planning airway management, the authors of this study found that accurate prediction of difficult airways using these current bedside tests have limited predictive value and varied performance across populations.[10] In a 2019 Cochrane systematic review of screening tests for identifying difficult intubations, Roth et al. found similar results across varied populations.[1] Number of participants, number of difficult laryngoscopies, sensitivity, and specificity of this meta-analysis can be seen in Table 2.[1]

Because current methods to assess an airway are unpredictable, there have been investigations in recent years surrounding the potential benefit of bedside ultrasound for the purpose of better predicting difficult intubation. In one pilot study, researchers sought to determine the feasibility and accuracy of sublingual ultrasound examination of the hyoid bone correlating with an obscured laryngoscope view and difficult intubation. In the 100 patients included of this study, all 100 were able to place the ultrasound probe correctly, without adverse effects, and the exam took less than one minute.[12] Figure 2 displays how Hyoid images were viewed in 96.6% (86/89) of “easy” intubations (those with grade 1-2) with a specificity 97% and sensitivity of 73% for predicting a difficult intubation via laryngoscopy.[12]

Contrasted with sublingual ultrasound, traditional methods for assessing the airway were less successful at predicting the grade of laryngoscope view.[1,10,12] In addition, ultrasound imaging might be beneficial in assessing airways in unconscious patients in emergency or intensive care settings where modified Mallampati cannot be done.[11] Ultrasound could be used by the emergency provider as part of a bedside arsenal for predicting difficult intubations in addition to traditional methods.[12]

PREOXYGENATION

Patients that require airway management are at an increased risk of hypoxia. Tracheal intubation with the delivery of high-flow oxygen is required to correct this state.[15,16] Preoxygenation is the technique of inhaling large quantities of pure oxygen before a medical procedure for the purpose of minimizing nitrogen and maximizing oxygen in the patient's blood.[15,17] It has been shown to extend the period known as "safe apnea" and can be used as a buffer of safety during periods of hypoventilation before the placement of a final airway.[16]

In patients breathing room air before intubation, desaturation has been shown to occur in the period roughly 45-60 seconds from the administration of a sedative.[15] If the patients were to receive 100% oxygen rather than room air, results show a marked increase in time to desaturation.[15] The goals of preoxygenation are to denitrogenate as well as maximally oxygenate blood to 100% if possible and there is evidence showing ideal methods of attaining these goals in emergency settings. Research suggests that standard nonrebreather masks at 15 Liters/minute (L/min) flow rates deliver only 60-70% fraction of inspired oxygen (FiO_2).[15,16,] This method does not meet the goals of complete denitrogenation and would not maximize safe apneic time. Instead, by increasing flow rates of common nonrebreather masks to 30–60 L/min, the provider can deliver FiO_2 of 90% or higher and extend safe apnea to about 9.5 minutes in lean patients.[16,18]

In one study, to properly denitrogenate the functional residual capacity and achieve 90% FiO_2 or greater, three minutes of tidal volume breathing with high flow oxygen was found to be acceptable.[15,18] However, this approach must include a conscious patient that is able to follow instructions and can be improved by having the patient fully exhale before the time period is complete. Eight maximal exhalation followed by maximal inhalation breaths was also shown as a viable method to reduce preoxygenation time to close to 60 seconds and could be used in situations where time is scarce.[15,18]

There are scenarios where patients do not achieve proper saturation within the three-minute period of adequate tidal-volume breathing. This event is likely due to shunt physiology, the state where alveoli are perfused but not ventilated. Shunting occurs in disease states such as pneumonia or pulmonary edema when alveoli are filled with fluid or collapsed.[16] The method of correction in these shunt scenarios is positive pressure to help push fluid out and expand collapsed alveoli.[15,16] In a study by Baillard et al., it was observed that noninvasive positive-pressure ventilation had a mean oxygen saturation (SpO_2) of 98% where the standard group had an SpO_2 of 93%.[20] In addition to smaller drops in SpO_2 during intubation, no cardiovascular effects or significant gastric distention was observed below pressures of 25 cm H_2O.[20]

Maintaining hemoglobin saturation during endotracheal intubation is critical in all patients and especially important in difficult airways. Multiple attempts at intubation prolongs apneic time and can ultimately lead to hypoxic brain injury and death. Maximizing safe apnea through preoxygenation is one critical way to lower complication rates and minimize adverse effects of difficult intubations.[16,18]

POSITIONING

When training for intubation, the provider often practices on a mannequin lying flat on its back. In most patients and those with difficult airways, this supine position has not been shown to be ideal.[15] The technique of head elevation benefits preoxygenation and optimizes views for intubation.[15,16,21,22]

When a patient is flat on their back, it is harder to take full vital capacity breaths. This event in turn lowers the lung's oxygen reservoir and reduces the period of safe apnea.[15] In one randomized controlled study, 40 female patients preparing for surgery underwent preoxygenation in the supine and 40 in the 20-degree head-up position.[20] The head-up group took 364 seconds to decrease saturation from 100% to 95% SpO_2 where the supine group took 283 seconds.[20] Time to desaturation was increased in the inclined position across many populations including obese (BMI >30) and those immobilized due to possible spinal injury.[15] For those with suspected or confirmed spinal cord injury, the reverse Trendelenburg position, where the head of the bed is 30 degrees higher than the foot, can improve preoxygenation while maintaining proper spinal immobilization precautions.[15] After preoxygenation, the provider must next consider laryngoscopy views and improved exposure has been shown with head elevation.

Visualizing the glottis is an integral part of airway management. Elevation of the patient's head has been shown to improve glottic views and decrease complications such as hypoxemia, hypotension, esophageal intubation, and aspiration in the intensive care setting.[22,24] In a retrospective study by the University of Washington, the complication rates of 528 patients undergoing emergent endotracheal intubation using direct laryngoscopy were observed.[22] It was found that 22.6% of patients managed in the supine position resulted in at least one complication and 9.3% occurred in the back-up head-elevated position.[22]

PARALYTICS

Paralytics have long been used to help rapid sequence intubation as a neuromuscular blocking agent. Their purpose is to be given immediately following the induction agent, usually propofol, to antagonize certain neuromuscular transmissions and relax the recipient's airway muscles.[27] This medication allows intubation to take place without unwanted physiologic responses to laryngoscopy and lowers risk of aspiration.[26,27]

For many years, succinylcholine has been the main paralytic agent recommended and used for endotracheal intubation. This medication has a very fast onset, less than one minute after intravenous administration, which optimizes conditions for rapid intubation.[25,26,27] Rocuronium, another paralytic agent, has been shown to display similar characteristics if administered in a dose that is at least 1 mg/kg and is a potential alternative in rapid sequence intubation.[15,26,28] The choice of paralytics may benefit difficult airways and influence time to desaturation.

In one study, the time to desaturation was compared for the commonly used the paralytics succinylcholine and rocuronium.[29] It was found that the time to desaturation to 95% was 242 seconds in the succinylcholine group versus 378 seconds in those given rocuronium.[29] The study suggests that muscle fasciculations, a common adverse drug reaction in succinylcholine, may be the cause of increased oxygen consumption. Furthermore, pretreatment with medication that prevents fasciculations were shown to lessen the gap in desaturation times.[15,29]

In another randomized clinical trial, rocuronium and succinylcholine were studied to assess the noninferiority of rocuronium for rapid sequence intubation in an emergency setting. In a population of 1248 adult patients, Guihard et al. found the number of successful first-attempt intubation was 74.6% with rocuronium and 79.4% in the succinylcholine.[27] This difference of 4.8% did not meet the study's criterion of 7% for noninferiority. In addition, the most common adverse events for the group receiving succinylcholine was hypoxemia occurring in 9.9% of patients and hypotension at 10.1%. The rocuronium group had hypoxemia occurring at 9.0% and hypotension at 6.4%.[27]

As discussed, investigators have compared succinylcholine and rocuronium in endotracheal intubation. Some researchers have found improved success with succinylcholine while others have found that 1.2 mg/kg of rocuronium matches at least the speed of onset and intubation conditions.[16,27,29] However, the ability to reverse effects of rocuronium swiftly with sugammadex, a neuromuscular agonist, is beneficial in the case of unanticipated difficult airway management.[17] Due to the rapid antagonism in the form of sugammadex at 16 mg, rocuronium could be part of a failed intubation plan that can safely and effectively wake up the patient.[17]

PROPER TOOLS

Providing a path to oxygenation is the essence of airway management and intubation. That pathway and the tools used to create it have developed tremendously since early days when tracheotomy was one of the few options available to providers.[3] In modern times, instruments such as the videolaryngoscope (VLS), bougie, and supraglottic airway device have been critical to the continuing advancements in difficult intubations.[30,31,32,34] As discussed, difficult airways cannot always be accurately predicted and research suggests that each successive failed intubation attempt incrementally increases the risk of hypoxia and lowers possibility of future success.[6] For this reason, it is critical for a provider to optimize first-pass success in every possible way. VLS has been a recent development in the field and its role in difficult intubations is well recognized. They offer better views when compared to conventional direct methods and are becoming the standard of care for many institutions.[17,30,31]

In a 2016 Cochrane systematic review, investigators considered 64 randomized controlled trials including a total of 7044 adult participants that underwent laryngoscopy with VLS or direct Macintosh laryngoscope.[30] Fewer failed intubations occurred with VLS (38 studies, 4127 participants, 95% CI 0.19 - 0.65) and fewer failed intubations were seen in anticipated difficult airways with the use of VLS. The data suggests that significantly less incidence of airway trauma (29 studies, 3110 participants; 95% CI 0.48 – 0.96) and postoperative hoarseness (six studies, 527 participants; 95% CI 0.36 – 0.88) occurred when VLS was used over direct. Views of the glottis were more complete in a larger number of VLS (22 studies, 2240 participants, 95% CI 4.17 – 10.98) and it was observed that a smaller number of laryngoscopies with VLS attained no view of the glottis (22 studies, 2240 participants, 95% CI 0.13 – 0.27) when compared with direct. The study also found that the VLS was easier to use for most providers (seven studies, 568 participants, 95% CI 3.12 – 16.31).[30] Across many trials, VLS was shown to likely improve success and lower complication, especially in those with difficult airways.[30]

Tracheal tube introducers or "bougies" are long, stiff plastic sticks that provide a guidewire for the endotracheal tube to advance into a patient's airway.[32] First described in 1949, they have been traditionally used only as a rescue device after one or more failed attempts when an airway is deemed challenging.[32,33] However, due to complication rates rising with increasing attempts, researchers have suggested that using bougies on every first attempt may improve success.[32,33] Driver et al. attempted to answer the question whether a bougie aided first-pass intubation success compared with endotracheal tube and stylet in patients with difficult airway characteristics.[32] Of the 757 patients intubated through September 2016 through August 2017 in Minneapolis, Minnesota's Hennepin County Medical Center, 381 patients were randomly assigned initial intubation attempt facilitated by bougie and 376 were performed via endotracheal tube and stylet.[32] Investigators found that in the 380 patients with one or more difficult airway characteristic (obesity, obstructed airway, short neck, small mandible, large tongue, immobilization of the cervical spine, facial trauma, and body fluids obscuring view), 96% had first-attempt success. This is higher than the endotracheal tube and stylet group with 82% first-pass success in patients with the same characteristics.[32] When including the entire population, the bougie-first group still outperformed with 98% success versus 87% in non-bougie patients.[32]

Supraglottic airway devices (SADs) are a group of airway tools that, once inserted into the pharynx, allow ventilation and oxygenation without necessarily entering a patient's trachea. These airway adjuncts include categories referred to as first-generation SADs (including the traditional laryngeal mask airway) and second-generation SADs.[34,35] Indication for this airway management tool have widened in recent years and may be used as rescue options as part of the difficult airway algorithm.[17,34,35]

Limiting the number of airway interventions and intubation attempts is essential to patient safety, SADs may be beneficial in patients with difficult airways.[18] There are many varied types SADs, however, second-generation appear to be superior due to their increased safety and efficacy.[34] Ideal characteristics of these devices in managing difficult airways include high seal pressure, reliable first-time placement, and compatibility with tracheal intubation.[17,34] This latter characteristic of compatibility with direct fiberoptic guided intubation is associated with several newer second-generation SADs and been reported with higher success rates.[35] Although data is limited and their relative new development has made the technique difficult to master, guided technique using this fiberoptic guidance might benefit those with difficult airways.[35,36]

Both difficult airway protocols from the 2015 Difficult Airway Society Guidelines in the United Kingdom and American Society of Anesthesiologists support the use of supraglottic airways.[4,17] Although not necessarily definitive management, they provide a pathway for oxygenation while the provider considers their options and newer SADs have the potential as an intubating conduit with a higher chance of success.[4,17,34]

SURGICAL AIRWAY

Emergency surgical intervention is performed when other methods of establishing and securing an airway have failed.[17,37] Understandably, most of the evidence surrounding this technique comes from data based in manikin, cadaver, and emergency cases. None of these can replicate the blinding of a randomized control trial.[40] Even so, evidence has shown that scalpel cricothyroidotomy and use of a cuffed tube in the trachea is a fast and reliable method of establishing a surgical airway.[37,38,40,] In stressful crisis scenarios, cognitive processing and fine motor skills decrease quickly.[40] Standardization is invaluable in situations such as these and a technique described by the Difficult Airway Society involving specific equipment, patient positioning, palpation, and scalpel techniques shows success.[17]

Firstly, 100% oxygen should continue to be used for preoxygenation through a nasal cannula or tight-fitting facemask. In addition, the provider must consider whether the patient is adequately sedated with neuromuscular blockade after multiple intubation attempts have been performed.[37,38] Equipment includes a number ten blade scalpel, a 6.0mm, cuffed cannula, and bougie with angled (coude) tip.[17,39] Guidelines suggest that optimal positioning for scalpel cricothyroidotomy is in a neck extended position, not the sniffing or ramped position suggested for regular intubation.[39] This technique can be achieved by pushing pillows or blankets underneath the patient's shoulders and allowing for neck extension.[17] Palpation of the cricothyroid membrane via the "Laryngeal Handshake" technique described by Dr. Richard Levitan and shown in Figure 3.[17] This technique should be done before incision and allows the provider to confidently palpate the laryngeal anatomy and find important landmarks. If an ultrasound machine is on hand and the provider is trained, it has been found to be useful in identifying midline and major blood vessels for this procedure.[17,39] The provider should then make an 8 to 10 cm midline vertical incision and use fingers to then separate tissues. Afterward implement the scalpel technique summarized in Figure 4 as "stab, twist, bougie, tube".[17]

Emergency front-of-neck access should be used in crisis scenarios if a patient cannot be intubated or oxygenated and other methods have failed.[4,17] Complications may be severe including hemorrhage and long-term airway stenosis.[38] However, some difficult intubations will inevitably fail and death from hypoxia will result if oxygenation is not quickly resolved.[6] Regular standardized training must be available for when emergent management of a difficult airway turns to surgical options. Success depends on reinforcement and retention of these skills as well as fast decision-making, planning, and preparation with repeated practice.[40]

PATIENT ANATOMY

The patient population in the United States is changing and medical practice must change with it. Prevalence of adult obesity in the US was 39.8% and 18.5% among children in 2016 and trending upwards.[41] Excess adipose tissue, increased oxygen consumption, and reduced lung volumes may put obese patients at higher risk for difficult tracheal intubation and adverse outcomes.[42,45]

In a study of 6,889 patients that underwent emergency endotracheal intubation, the association between obesity (measured using body mass index, BMI), difficult intubation, and adverse events was studied.[42] First-pass success was used as the indirect marker for intubation difficulty. Adverse events were defined as cardiac arrest, dysrhythmia, post-intubation hypoxemia (<90%), hypotension (<90 mmHg systolic blood pressure), airway trauma, dental trauma, aspiration, allergic reaction, and esophageal intubation. Researchers found a negative relationship between the first-pass success rate and BMI as seen in Figure 5.[42] The study reports first-pass success of 70.9% in "lean" BMI (<25.0 kg/m2), 66.4% in the overweight patients (BMI 25.0 to 29.9 kg/m^2), and 59.3% in the obese population (BMI $\geq$ 30.0 kg/m^2).[42] In addition, this study found an overall positive correlation between BMI and adverse events seen in Figure 6.[42] In the lean population, adverse events were found in 15.8% in the overweight population 18.1%, and 24.2% in the obese group.[42] The findings highlight the importance of recognizing potential characteristics of difficult intubations such as obesity and necessitate provider knowledge of optimizing obese patient's chances of success in a high-risk environment.

Obese populations may require specialized positioning and preoxygenation techniques to optimize success. Preoxygenation increases the amount of safe apnea in patients about to undergo intubation.[17] In obese patients, time to desaturation is lessened as demonstrated by a drop of hemoglobin oxygen levels after 3.5 minutes compared to approximately 9.5 minutes in normal adults, graphically represented in Figure 7.[45] Preoxygenation with a ramped, 25-degree position and continuous positive airway pressure could delay hypoxia in the obese patient.[17,47] Furthermore, a technique described as Nasal Oxygenation During Efforts Of Securing A Tube (NO DESAT) can also extend the safe apneic period in obese populations and in those with difficult intubations.[17] This technique includes giving 15 L/min of oxygen through nasal cannula during intubation. After the induction agent is given and the patient becomes apneic, the nasal cannula continues to diffuse oxygen down the patient's trachea and is absorbed across alveoli.

Small FiO2 changes result in dramatically increased availability of oxygen at the alveolus and likely result in significantly higher oxygen reservoir. This NO DESAT model made available by Dr. Richard Levitan does not seem to affect oral intubation technique and will likely extend safe apnea time in obese patients.[17]

In addition to a shorter period to desaturation, obese populations may have more obstructed laryngoscopy views correlating with difficult intubations.[46,47] Views have been best achieved with the ramped position and video laryngoscopes may be especially helpful to improve glottic views and success of intubation.[31,44] If an obese patient fails intubation attempts and needs emergency cricothyroidotomy, this may be challenging due to obscured anatomical landmarks. In one study, researchers investigated the ability of physicians to correctly identify landmarks in obese and non-obese patients whose landmarks were found previously and verified with ultrasonography. The cricothyroid was found correctly in 12/41 of non-obese patients and 1/15 obese patients.[43]

Although several studies have reported increased association, controversy exists, and it is unclear whether BMI alone is an independent predictor of difficult intubation. This lack of agreement may be due to variation in the exact definition of difficult intubation and difficult laryngoscopy, patient position, provider experience, and technique used for laryngoscopy.[42,45]

PRESSURE

Cricoid pressure has been used in medical practice as early as 1774 and historically employed during intubation for two main reasons: it prevents gastric distension during bag-valve-mask respirations and helps control the regurgitation of gastric contents during anesthesia.[48] Research has also suggested that cricoid pressure may also improve views on direct laryngoscopy and could be used in the management of difficult intubations.[17,49] However, varied implementation of this technique has been associated with scattered results and worse patient outcomes.[15,49]

Coupled with intubation positioning, cricoid pressure has been shown to be just as effective in the head-up position. However, anatomy changes tend to move the cricoid cartilage closer to the sternum thus making it less accessible to the provider's hand attempting to apply force.[49] Although there is data showing improved conditions for intubation, a force of 30 Newtons is needed for appropriate airway protection from regurgitation.[49] This amount of force is not well-tolerated by awake patients and should be around a force of 10 Newtons while conscious, increasing to 30 when unconscious.[49] Evidence shows that cartilage pressure is common to be improperly applied and may even make intubation attempts more difficult.[15,49] In addition, inappropriate pressure may reduce lower esophageal tone and increase risk of aspiration.[49] Hence, a provider must consider both the potential risks and benefits associated with applying cricoid pressure while performing intubations.

METHODS

An independent literature review was completed using the databases, PubMed and PLOS ONE, and one search engine, Google Scholar, in order to complete this thesis. Websites from the American Society of Anesthesiologists (http://www.asahq.org) and Difficult Airway Society (http://www.das.uk.com) were used for guidance on recent protocols. Search terms included the following: "airway emergency management", "bedside predictors", "bougie", "cricothyroidotomy", "difficult airway", "difficult intubation", "failed intubation", "laryngoscopy", "obesity", "paralytics", "positioning", "glottic visualization", "preprocedural safety checklists", "rapid sequence intubation", "rocuronium vs succinylcholine", "supraglottic airway device", "ultrasound", "unanticipated difficult intubation", and "video laryngoscopy". Studies were sorted by the best match and further filtered using most recent publication dates.

Articles accepted for review were read, quality of the studies assessed, and pertinent information obtained for use in this review. Intentional effort was made to include a variety of study models including randomized controlled trials, systematic reviews, and meta-analyses. Research articles referenced in this thesis were human studies, peer-reviewed, and written in English. Resources that were not accessible through databases and search engine were requested through Augsburg University's Lindell Library interlibrary loan.

DISCUSSION

This paper sought to conduct an evaluation of current techniques in difficult intubation management and give clinical recommendations. The obese population was specifically analyzed due to the rising prevalence and likely association with a challenging intubation. This thesis came to several conclusions surrounding aspects and techniques of difficult intubation and will be discussed so that the research question may be fully answered.

Since investigation from the WHO Surgical Safety Checklist in 2009, there has been a significant move to adopt a similar model in emergent procedures. As seen in Smith et al. and other studies, implementation of emergency department checklists was associated with decreases in complication rates with corresponding increases in safety adherence.[7,8,9] However, possible negative effects of a cumbersome checklist could lead to needless delays in patient care.[7] For a patient in critical condition, delay in oxygenation could mean hypoxia and brain death.[6] Smith et al. also measured time between giving a paralytic agent and confirmation of tube placement.[8] There was not an increase in apneic time for the postchecklist population, in fact, they found that procedural checklists correlated with a small decline in paralysis to intubation time.[8] This reduction suggests that checklists did not cause increased apnea time and likely aided to create a more efficient procedure.[7,8]

Unanticipated difficult intubation could occur at any time. Current bedside tests for predicting difficult intubations are inconsistent regarding sensitivity and specificity.[1,10,11,12] As seen in the review of literature, all traditional tests have limited predictive capabilities. This is quite concerning when considering their ubiquitous use in the physical assessment of the potential for difficult airways. In a comprehensive Cochrane review, specificity was relatively high, however, sensitivity was found to be varied.[1] The risk of high false-negatives could lead to false confidence in interpretation and poor patient outcomes.[1,10] In addition, many of these tests, such as the modified Mallampati score, are not useful in emergency situations because the patient must be awake and cooperative.[10,12] A novel bedside prediction test of high sensitivity, specificity, and consistency is sorely needed.

Bedside ultrasound is a potential answer, however, its use in predicting difficult airways is a relatively new application. A pilot study found that sublingual ultrasound is feasible and adverse effects were non-contributory.[12] In addition, this technique could be valuable in the emergency department and intensive care units where patients may be obtunded or uncooperative.[12] Access to a bedside ultrasound, training, and time restraints of emergency scenarios may limit its feasibility.[12] However, this paper argues that the technology has exciting potential in reducing the morbidity and mortality in difficult airway management and more data in the field of emergency medicine is needed concerning its efficacy.

While preoxygenation has become standard in many airway procedures, this practice is especially important in unanticipated difficult intubations. In these scenarios, the patient will undergo multiple attempts. This transmits to increased opportunities to desaturate and decompensate.[6] Evidence suggests implementing a nonrebreather mask at high flow rates of 30-60 L/minute for at least three minutes. Alternatively, eight maximal exhalation and inhalation breaths can be used to shorten this time to about 60 seconds.[15,18] However, it is worth noting that many critically ill emergency department and intensive care patients will not be able to take adequately full vital capacity breaths. In any situation, a tight seal must be present on the mask and the patient must generate enough inspiratory force to fully denitrogenate and adequately preoxygenate the bloodstream.[15] If the patient does not seem to be oxygenating even while high flow preoxygenation is performed, the provider must also consider shunting and associated pathology.[16] Though over-oxygenation and comfort of the patient are valid concerns, preoxygenation is a safe technique with many benefits to difficult intubations and should be implemented in every attempt.[15,17,19]

Preparation is critical to success in all procedures and can prevent airways from ever crossing the threshold to becoming “difficult”. This thesis argues that positioning patients for optimal preoxygenation and visualization is integral to the groundwork for successful intubations. Research has shown that head elevation is a beneficial technique that can lower complication rates.[15,20,22,24] Regarding preoxygenation, the supine position increases workload and lowers the lung’s potential oxygen reservoir.[16] With head elevation patients can breathe easier and, due to the assistance of gravity, have a lower chance of aspiration and postural hypotension.[16] In addition, positioning with head elevation aligns anatomic structures creating a clearer path for visualization of the glottis.[15] Improving the laryngoscope view is one pivotal aspect of lowering rates of difficult intubations.

There are special populations where positioning may be modified for increased success. In trauma patients wearing a cervical spine collar, moving the head independently is not advisable. Instead, the reverse Trendelenburg position, where the head is elevated 30 degrees and feet lowered, can be implemented while adhering to spinal precautions.[15] In obese patients, using increased elevation of the back and shoulders in a ramped position can be used.[15,24] Every provider should have a strong focus on optimizing for success, no matter the practice. Preparing for challenges is good, however, this paper argues that true success is preventing adverse outcomes before they ever occur.

By relaxing patient's airway muscles, paralytics such as succinylcholine and rocuronium allow intubation to occur without the gag reflex.[26,28] This is important in lowering risk of aspiration and optimizing conditions for rapid sequence intubation. Succinylcholine has been used as the standard of care for many years and works very well for emergent procedures.[26] However, without a rapid antagonist available, the provider is forced to wait for effects to wear off before waking the patient.[17] In addition, muscle fasciculations, a common adverse effect in succinylcholine, likely cause increased oxygen consumption and faster desaturation.[17,26] This paper argues that rocuronium may be superior to succinylcholine in critically ill patients and those with high potential for complications.[15,17,26,28,29] Rapid antagonism with sugammadex can be used if the situation presents itself.[17] Having the option of aborting the intubation and waking the patient quickly is beneficial as a part of the failed intubation plan.[17]

Technology is the great engine of change and improvement. Tools such as VLS, bougie, and SAD may be used to improve patient outcomes in a variety of situations. This thesis does not make a case for throwing away traditional techniques such as direct laryngoscopy, it is a skill that should not be lost. Studies have shown VLS to make difficult intubations easier and reduce failure.[30,31] It will likely improve glottic visualization and reduce the incidence of difficult airways altogether.[17,30,31]

Supraglottic airway devices have shown benefit in patients resistant to intubation. These airway adjuncts can allow ventilation and oxygenation without entering the patient's trachea.[34] What is more, newer second-generation SADs can be used in conjunction with fiber optics to guide intubation while providing airway support.[34,36] Bougies have been traditionally used as only rescue devices. Higher first-pass success and lower difficult intubation rates have been seen with bougie-first techniques.[32,33] In medicine, it is our duty to always be willing to adapt and implement new technology such as these for the patient's benefit.

Unfortunately, due to the nature of tracheotomy, data surrounding this topic is mainly collected in retrospective analysis. It is nearly impossible to blind or control many variables in a technique that is both emergent and lifesaving. This leads to the issue of practice for providers that may find themselves in this crisis scenario.[40] Although manikins, cadavers, and animal labs are useful, none completely replicate the stress and demands of clinical application.[38,40] Complications such as massive hemorrhage and further airway obstruction are serious, and every attempt should be made to avoid these outcomes.[37,38] Ultrasound may be useful if immediately available in identification of the midline and blood vessels, but should not delay the procedure.[17,39] This paper argues that emergent front of neck access should be used as part of the failed intubation protocol. There should be a widespread, standardized technique that focuses on simplicity and preparation to combat stress-induced decline of fine motor skills.[40] In addition, this technique should be part of regular training and normalized as an option for failed intubations.

This paper maintains that with the increasing prevalence of obesity throughout the world, the correlation with difficult intubations cannot be ignored.[41,42] It is unclear whether BMI by itself is a prediction of difficult intubation.[45] However, anatomical differences such as increased oxygen consumption, adipose tissue obscuring palpation landmarks, and decreased lung volumes puts this population at risk of adverse events during airway management.[42,43] It is important for a provider to recognize the potential for challenging airways in all patients, however, it is especially critical in the obese population. Furthermore, there are differences in technique for this patient group. As discussed, preoxygenation is important in all cases of intubation, however, positioning and palpation technique may differ in those with higher BMI.[44,46] Excess adipose tissue may obscure landmarks making palpation with the "Laryngeal Handshake" method challenging.[17,43] Ultrasound has been offered as a potential option for distinguishing the cricothyroid membrane and blood vessels previously and this technique has great potential to be helpful in finding landmarks in the obese population.[17]

Cricoid pressure during intubations has come under scrutiny in recent years. There is continuing controversy whether the risks of airway obstruction outweigh the benefits of preventing aspiration.[49] The technique of applying 30 Newtons of pressure to compress the patient's esophagus while keeping airway patency is theoretically viable, but practically difficult.[15] Without a consistent and effective method of quantifying this force, pressure on the cricoid may oscillate on a spectrum of too little for benefit and too much causing complications.[49] Alleged complications include lower esophageal sphincter relaxation causing aspiration and airway obstruction leading to difficulty in manual ventilation, placement of SAD, and glottic visualization.[49] This paper argues that the risks of cricoid pressure outweigh the benefits and unless specifically trained, this technique should not be attempted.

CONCLUSION

The exact definition of difficult intubation is unclear. Factors such as patient characteristics, provider experience, and clinical setting plainly influence the failure of airway management.[4] Quantification using bedside physical exam tests may be potential predictors, but analysis has shown them to be inconsistent.[1,10] In emergency and intensive care scenarios there is precious little time for measurement and history taking, therefore, the best practice for the unanticipated difficult intubation is to be prepared and have a practiced protocol in place. **Recommendation:** The current bedside airway assessment tests are useful but limited in diagnostic value.[1,10] Bedside ultrasound may be valuable in unconscious patients.[12] Providers should always be prepared for unanticipated difficult intubations due to high false-negative rates in bedside tests.

Preparation can take many forms; however, this paper analyzed promising techniques that are designed to be implemented in every intubation for the purpose of avoiding adverse events altogether. Preprocedural checklists, proper positioning, and preoxygenation are relatively simple methods that have been shown to optimize success during this high-acuity, low-opportunity procedure. **Recommendation:** Implementation of an existing preprocedural checklist for every emergency intubation.[8] **Recommendation**: Preoxygenate every intubation patient using a standard, tight-fitting reservoir face mask with flow rate set as high as possible for at least three minutes. Alternatively, if the patient is conscious and cooperative, have them take eight full breaths.[15] If preoxygenation is not achieving saturations of more than 93% to 95%, shunt physiology should be considered, and positive pressure implemented.[15,19] **Recommendation**: Providers should implement head elevation during preoxygenation and intubation of roughly 25 degrees.[15] The reverse Trendelenburg position can be used for trauma patients that require cervical spine precautions.[15]

Medication is an important aspect of intubation. By dampening physiologic responses through paralytics, first-pass success is more likely. Rocuronium is at least as good as traditional succinylcholine, however, for the critically ill and those with difficult intubations it may be superior.[25,27,29] Sugammadex is a fast antagonist of rocuronium and gives the additional option of aborting difficult intubations if necessary.[17] **Recommendation**: In critically ill or patients with a high risk of difficult intubation, the paralytic rocuronium should be used.[17]

Technology and medicine are intertwined. Tools such as the videolaryngoscope and supraglottic airway device are advancements in the field of airway management providers cannot afford to ignore. Compared to traditional direct laryngoscopy, VLS has shown to lower complication rates and maximize first-pass success.[30] SADs that allow patients to be ventilated above the glottis allow providers time to consider the next step in airway management.[34] These should be understood as part of the failed intubation protocol. Bougie-first intubation is not useful for VLS but could be implemented if not accessible.[32] **Recommendation**: If available, videolaryngoscopy should be implemented into airway management.[17,30] Bougie-first and supraglottic airway devices are techniques available in the difficult intubation protocol and the provider should be aware of the benefits to difficult airways.[17,33,34]

Sparse objective data creates challenges when considering an evidence-based approach to surgical airways. However, scalpel cricothyroidotomy is a valuable, life-saving technique.[37] The airway provider should have ample practice and established backup plans for crisis scenarios before they happen. **Recommendation**: Regular training and implementation of a standard surgical airway technique for crisis scenarios.[40] Preparation should include: equipment (number ten blade, bougie with coude tip, and a cuffed cannula), positioning in neck extension (note difference from head elevated position), palpation (done by the "Laryngeal Handshake" method), and standardized scalpel technique ("stab, twist, bougie, tube").[17]

If the population a provider cares for changes, so too should medical practice. A significant proportion of patients that require intubation will be obese and it is important to consider anatomic risk factors for difficult intubation in the care of this group.[42,43,46] **Recommendation**: Preoxygenate and intubate obese patients (BMI over 30.0 kg/m^2) in the ramped position using available pillows or towels.[15,46] In preparation for scalpel cricothyroidotomy, palpation of landmarks may be more difficult in obese patients.[43] Consider training and implementing ultrasound where appropriate.[17]

Cricoid pressure has shown benefit for intubation, but studies have also shown the technique to be practically hard to replicate.[15,49] Mixed results surrounding the efficacy of cricoid pressure are concerning. If done improperly, airway obstruction caused by the provider is the antithesis of what is trying to be accomplished with intubation. It is unclear whether improper technique alone is responsible and more objective data is needed to definitively determine its practical application in emergency medicine.[49] **Recommendation**: Cricoid pressure is theoretically beneficial, but practically difficult to correctly perform. Unless extensively practiced, airway obstruction induced by cricoid pressure may cause harm to the patient and this technique should be avoided.[15]

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APPENDICIES

Table 1. Outcomes During the Precheclist and Postchecklist Periods.[7]

Outcome	Prechecklist Period (n = 76)	Postchecklist Period (n = 65)
Intubation-related complications		
Oxygen desaturation	6 (7.9)	1 (1.5)
Emesis	2 (2.3)	0
Esophageal intubation	0	0
Severe hypotension	2 (2.6)	0
Cardiac arrest	0	0
Any intubation-related complication	7 (9.2)	1 (1.5)
Median paralysis-to-intubation time (paralytic medication to tube confirmation), seconds (IQR)*	94 (78–115)	82 (68–101)
First-pass intubation success	60 (79)	56 (86)
All 15 predefined safety measures completed	13 (17)	45 (69)

Data are presented as n (%) unless otherwise noted.
IQR = interquartile range; RSI = rapid sequence intubation.
*Two patients intubated in the prechecklist period without the use of RSI medications were not included in this analysis.

Table 2. Meta-Analysis of Screening Tests for Identifying Difficult Intubation.[1]

Screening test	Number of participants (studies)	Number of difficult intubations	Summary sensitivity (95%CI)	Summary specificity (95%CI)
Mallampati	500 (1)	40	0.42 (0.27–0.59)	0.93 (0.90–0.95)
Modified Mallampati	191,849 (24)	6615	0.51 (0.40–0.61)	0.87 (0.82–0.91)
Wilson risk score	123 (1)	17	0.47 (0.23–0.72)	0.92 (0.84–0.96)
Thyromental distance	5089 (10)	437	0.24 (0.12–0.43)	0.90 (0.80–0.96)
Sternomental distance	864 (2)	115	No meta-analysis performed	
Mouth opening	6091 (9)	607	0.27 (0.16–0.41)	0.93 (0.87–0.96)
Upper lip bite	598 (2)	121	No meta-analysis performed	

Figure 1. Modified Mallampati Classification.[11]

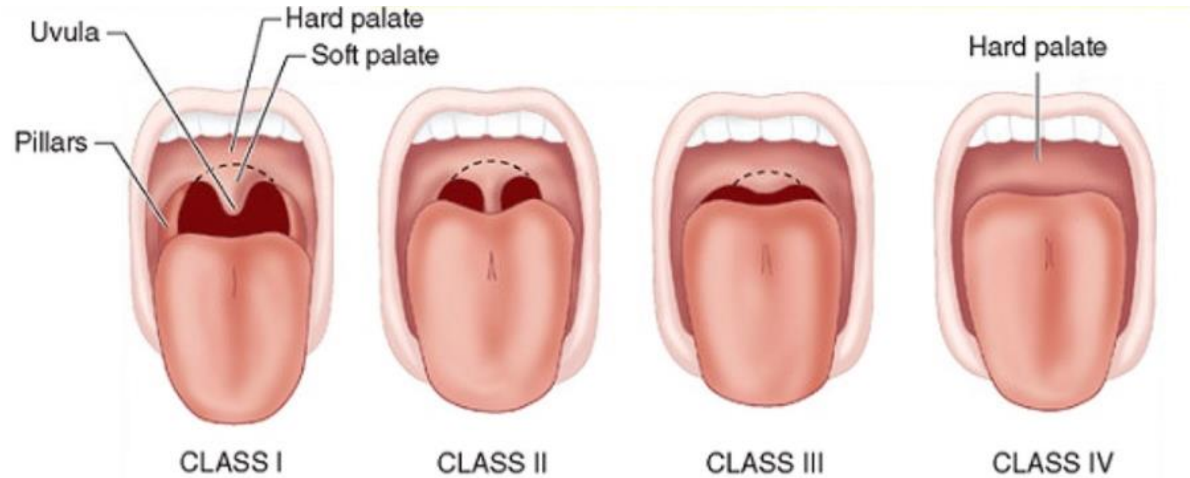


Figure 2. Sublingual ultrasound of the upper airway. (a) Schematic diagram showing placement of the ultrasound probe. (b) Representative ultrasound image showing hyoid bone.[12]

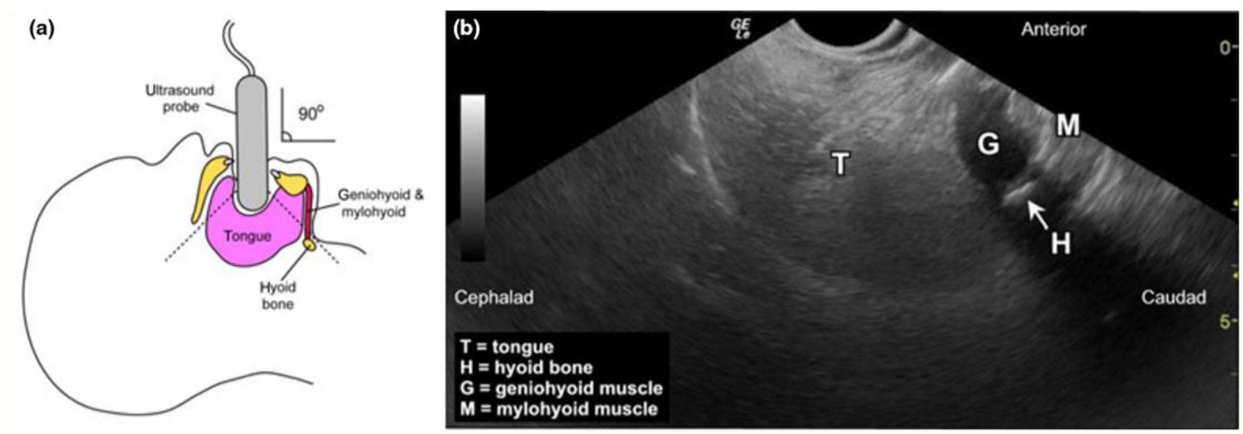


Figure 3. The laryngeal handshake. (A)The index finger and thumb grasp the top of the larynx and roll it from side to side. The bony and cartilaginous cage of the larynx is a cone, which connects to the trachea. (B) The fingers and thumb slide down over the thyroid laminae. (C) Middle finger and thumb rest on the cricoid cartilage, with the index finger palpating the cricothyroid membrane.[17]

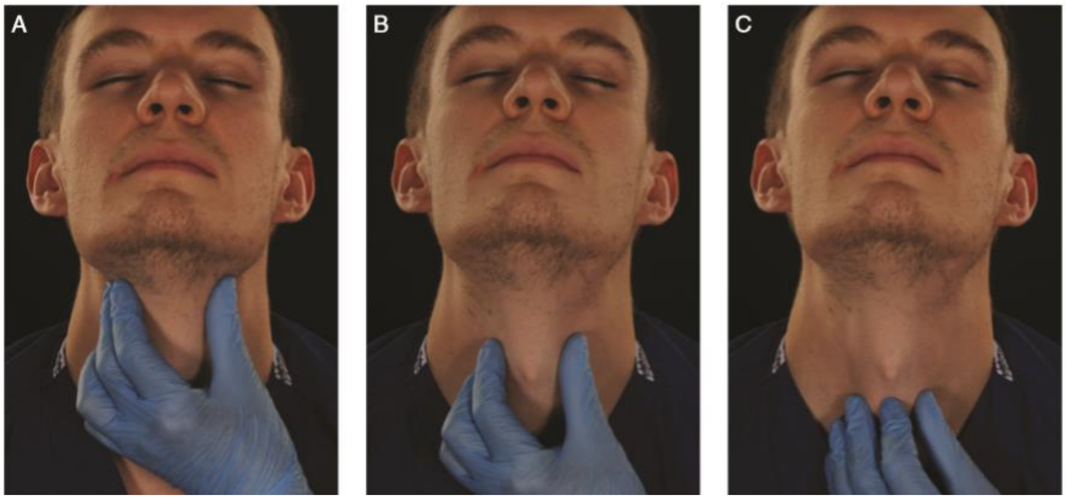


Figure 4. Cricothyroidotomy technique, "stab, twist, bougie, tube". (A) Identify cricothyroid membrane. (B) Make transverse stab incision through cricothyroid membrane. (C) Rotate scalpel so that sharp edge points caudally. (D) Pulling scalpel towards you to open up the incision, slide coude tip of bougie down scalpel blade into trachea. (E) Railroad tube into trachea.[17]

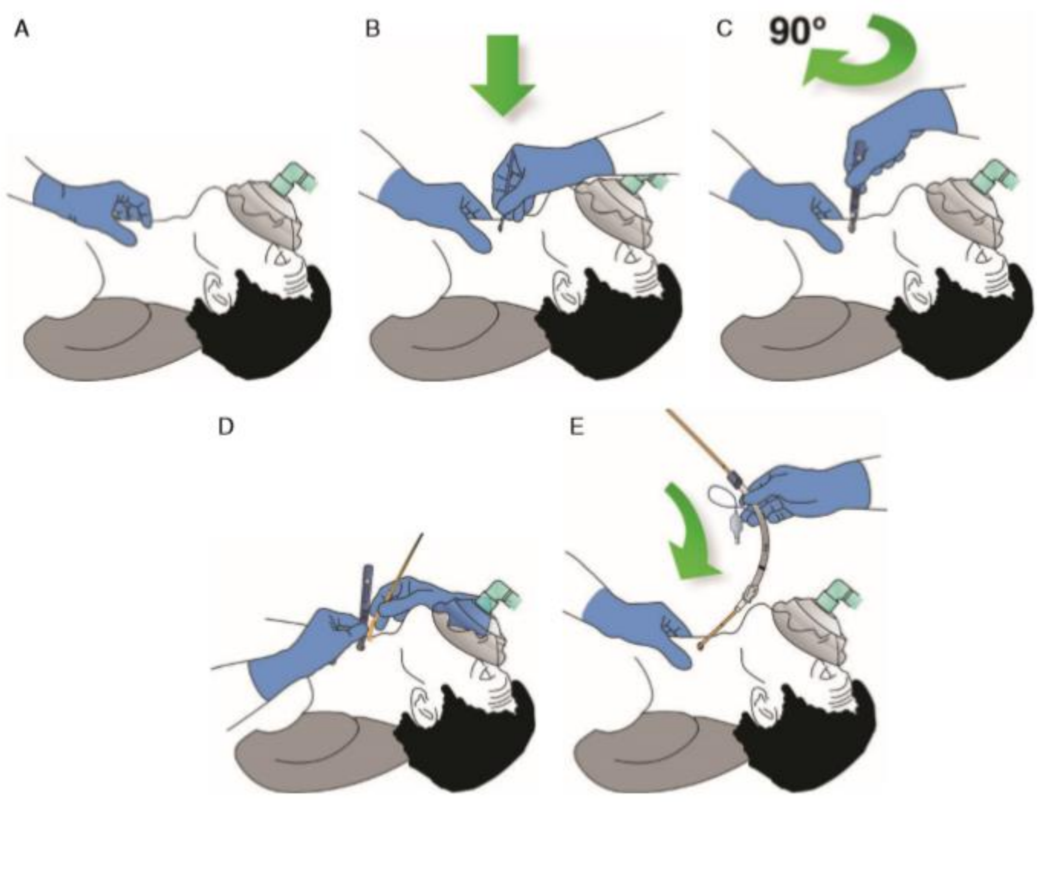


Figure 5. Association of body mass index with the success rate on first intubation attempt.[42]

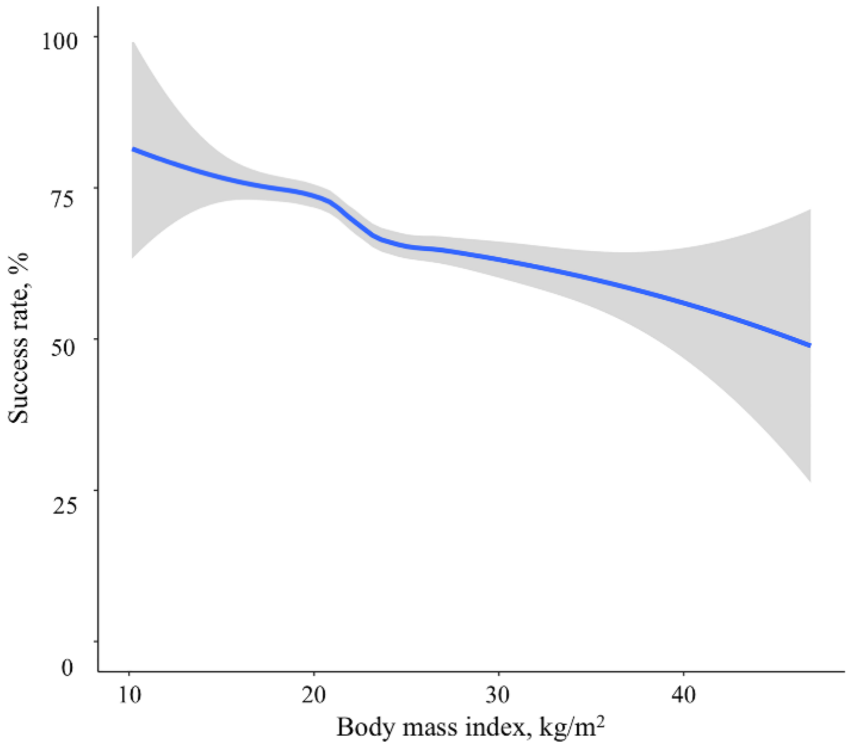


Figure 6. Association of body mass index with rate of adverse events.[42]

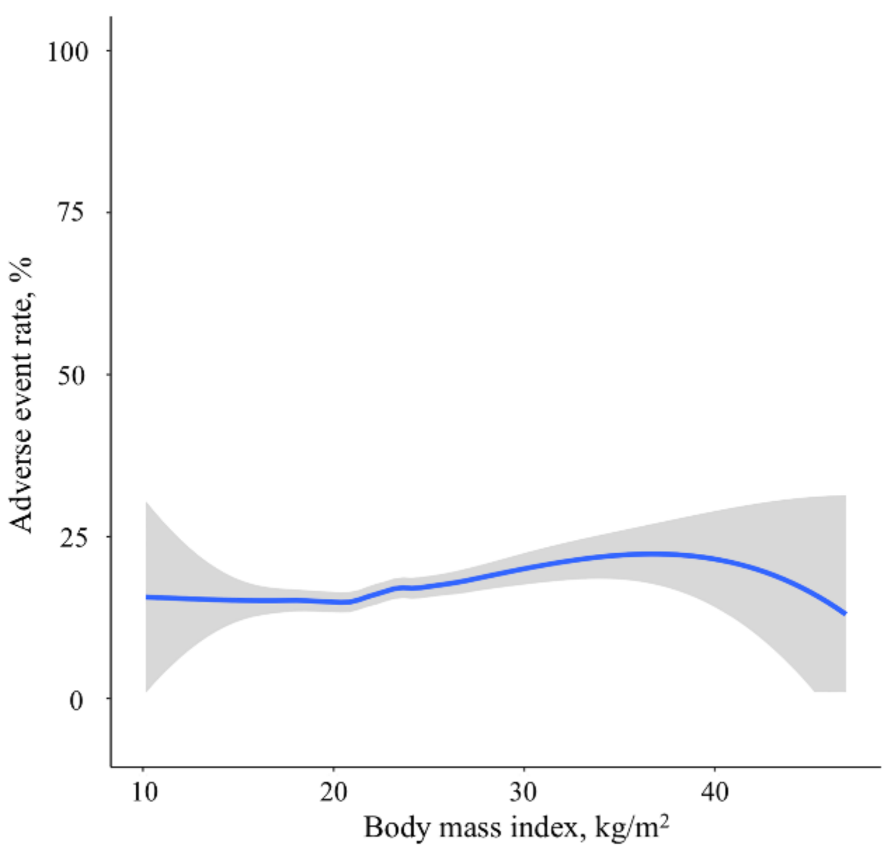
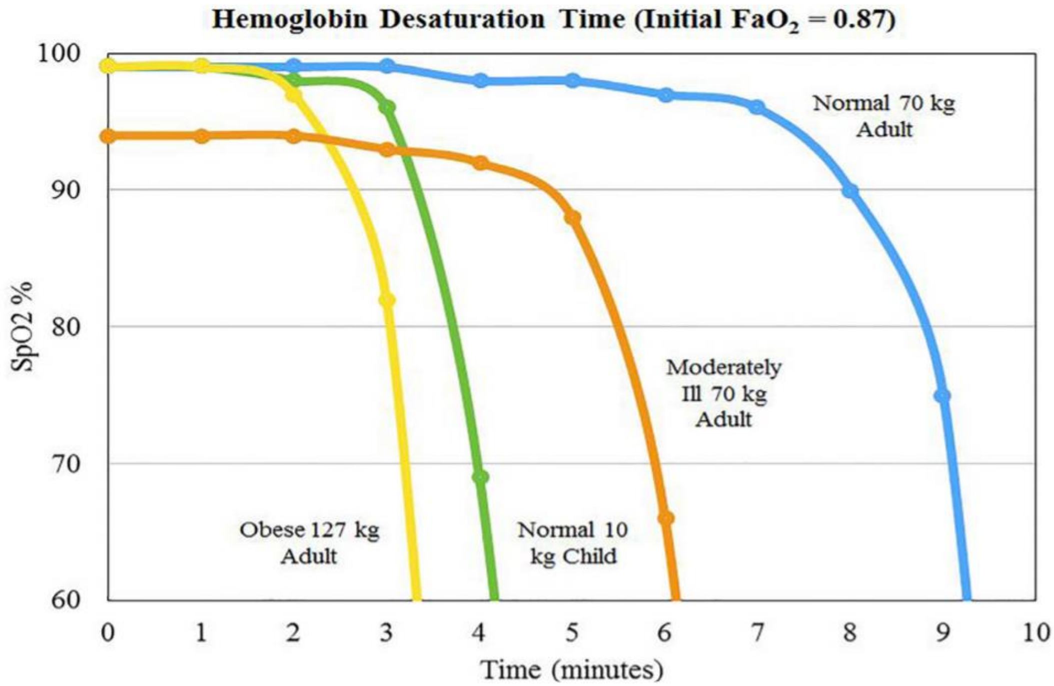


Figure 7. Hemoglobin desaturation time (initial $FaO_2 = 0.87$). $\%SpO_2$ vs. time of apnea for various types of patients. FaO_2 = alveolar oxygenation fraction; SpO_2 = oxygen saturation.[45]



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