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Analysis of Current Practices for Measuring Endotracheal Cuff Pressures

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ANALYSIS OF CURRENT PRACTICES FOR MEASURING ENDOTRACHEAL TUBE CUFF PRESSURE

by

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ABSTRACT

The current practice for the measurement of endotracheal tube (ETT) cuff pressure intraoperatively is subjective, potentially leading to negative consequences for patients. The purpose of this best practice project was to examine and synthesize the current evidence-based literature on measuring ETT cuff pressure and developed a policy recommendation for measuring ETT cuff pressure in the intraoperative setting by anesthesia providers. The ACE star model of knowledge transformation guided this best practice project. An extensive literature review was performed to evaluate and synthesize the current evidence-based research that can be used to develop the policy on measuring endotracheal tube cuff pressure. The developed evidence-based policy was emailed to the panel of experts for review and evaluation per secured USM server. The panel of experts utilized the AGREE-GRS tool to evaluate the evidence-based policy recommendations via Survey Monkey.

The panel members assessed the development, presentation, completeness, and clinical validity of the evidence-based policy recommendations. Policy revisions were made as necessary based on the data collected from the AGREE-GRS tool. The findings revealed a highest to high quality (100%) of agreement in all categories. A greater number of panel members strongly agreed on the components included in the policy recommendations and supporting evidence, and furthermore, all agreed the policy should be implemented in the practice setting. The evidence-based policy and supporting evidence were compiled into an executive summary. The executive summary was distributed to the chief Certified Registered Nurse Anesthetist (CRNA) at a hospital in south Mississippi. This project holds the potential to minimize the variation in measuring

ETT cuff pressure while improving patient outcomes and reducing the risk of complications.

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DEDICATION

First, I give honor and praise to God for allowing me to accomplish this goal. For my loving family, I would like to dedicate this doctoral project to you all for the prayers, support, and encouragement. To my husband, James D. Dixon, I am forever grateful for your love, support, being my biggest fan, and making everything possible. To my son, Connor J. Dixon, you are everything beautiful in my life; you keep me inspired.

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LIST OF ABBREVIATIONS

AGREE	Appraisal of Guidelines for Research and Evaluation
CRNA	Certified Registered Nurse Anesthetist
DNP	Doctor of Nursing Practice
ETT	Endotracheal Tube
GRS	Global Rating Scale
IRB	Institutional Review Board
USM	The University of Southern Mississippi

CHAPTER I – INTRODUCTION

Patients undergoing surgery often require the insertion of an endotracheal tube (ETT) for airway management. In anesthesia practice, this procedure is the foundation of traditional airway management and one of the most routinely performed (Nagelhout & Plaus, 2014). According to Grant (2013), intubation with an ETT is performed approximately 20 million times every year in the United States (p. 292). "Management of cuffed endotracheal tubes is routine practice for anesthetists" (Stewart, Seacrest, Norwood, & Zachary, 2003, p. 443). The role of measuring endotracheal cuff (ETT) pressure is to ensure that an adequate seal is formed for ventilation and to prevent complications (Purchon, 2017; Sultan, Carvalho, Rose, & Cregg, 2011).

Measuring the ETT cuff pressure is an important part of providing safe anesthesia care to patients (Grant, 2013). Currently, anesthesia providers utilize several estimation techniques to measure ETT cuff pressure, which often leads to the cuffs being over-inflated or under-inflated (Grant, 2013; Tobias, Schwartz, Rice, Jatana, & Kang, 2012). As a result, patients have an increased risk for postoperative complications (Grant, 2013). The postoperative complications associated with inadequate cuff pressures include; tracheal stenosis, tracheal rupture, recurrent laryngeal nerve damage, aspiration, sore throat, and hoarseness (Stewart et al., 2003; Sultan et al., 2011). Not only do these complications cause an inconvenience to the patient and unanticipated cost to the hospital, but they can also be life-threatening.

Anesthesia providers as well as other surgical personnel are responsible for improving patient outcomes, maintaining patient satisfaction, and decreasing the risk of complications associated with perioperative care. Healthcare providers who utilize the

current best-evidence in practice not only improves the quality of patient care but also reduce variations in the delivery of care (Melnyk & Fineout-Overholt, 2011). Using an evidence-based policy for measuring ETT cuff pressure in the intraoperative setting has the potential to minimize variation while improving patient outcomes and reducing the risk of complications.

Problem Statement

The existing practices of many nurse anesthetists in the intraoperative setting in south Mississippi vary significantly in measuring ETT cuff pressure. Multiple techniques may be observed at an institution since the choice is based on the provider's preference. The most common techniques used in practice to measure endotracheal cuff pressure are the estimation techniques (Sultan et al., 2011). However, researchers have shown that the estimation techniques of measuring ETT cuff pressure are inaccurate (Grant, 2013; Tobias et al., 2012). Thus, the failure to accurately measure ETT cuff pressure increases the incidence of postoperative tracheal morbidity (Grant, 2013). The risk of injury resulting from the current techniques of measuring ETT cuff pressures by anesthesia providers warrants evaluation of current practice. The current practice for the measurement of ETT cuff pressure intraoperatively is subjective, potentially leading to negative consequences for patients.

Needs Assessment

At a hospital in south Mississippi, various methods are utilized by anesthesia providers for the measurement of endotracheal cuff pressures. Currently, the accuracy of measuring endotracheal cuff pressure in clinical practices differs from textbooks. An informal poll was given to 10 anesthesia providers in south Mississippi to assess their

knowledge of evidence-based practice regarding accurate ETT cuff pressure measurement. The two questions asked during this informal poll were: Which technique do you prefer to use for measuring ETT cuff pressure? Are you aware that the current practices of measuring endotracheal cuff pressures are inaccurate? Several stated knowledge of using a manometer, however, admitted that they never used a manometer in everyday practice. The consensus among providers was that estimation techniques were most often used in the clinical setting. In addition, most of the anesthesia providers were unaware that the estimation techniques were inaccurate. The anesthesia providers also demonstrated an interest in learning more about the evidence and other strategies for measuring ETT cuff pressure. Several providers stated that the most common complaint amongst postoperative patients is soreness of throat.

Clinical Question

Currently, the anesthesia practice of measuring ETT cuff pressures in the intraoperative setting is subjective and is based on the provider's preference. Patients may be at risk of being negatively affected by the current techniques utilized by anesthesia providers. The clinical question of this best practice project is, "What is the best practice for measuring ETT cuff pressure in the intraoperative setting?" This project is significant to anesthesia practice, as it is expected to provide best practice recommendations from current literature, decrease the risk of complications, improve patient outcomes, maintain patient satisfaction, and possibly minimize the variations for measuring ETT cuff pressure.

Available Knowledge

Policy

White, Dudley-Brown, and Terhaar (2016) define policy, "as the choices a society, an organization, or a group makes regarding its goals and priorities and how it will allocate its resources to those priorities" (p.138). Advance practice nurses can ensure patients receive the highest quality of care by using evidence-based policies (Melnyk & Fineout-Overholt, 2011). A gap still exists between the policy procedures and current literature (Melnyk & Fineout-Overholt, 2011). However, a policy that provides clear direction and specifies the suggested outcomes increases the success of policy implementation (White et al., 2016).

Cuff Pressure

The monitoring of ETT cuff pressures is essential in anesthesia practice to prevent complications related to the over-inflation and under-inflation of the ETT cuff (Purchon, 2017; Sultan et al., 2011). An ETT cuff is considered over-inflated when the volume of air inside the cuff produces a pressure higher than the tracheal mucosa perfusion pressure, which is approximately over 32 cm H_20 (Knowlson & Bassett, 1970). An ETT cuff is considered under-inflated when the volume of air inside the cuff produces an insufficient seal, which is approximately less than 20cm H_20 (Sole et al., 2009).

Estimation Techniques

The current clinical practice for measuring ETT cuff pressures is attained by the anesthesia provider simply palpating the amount of pressure exerted on the tracheal wall (Sultan et al., 2011). Stewart et al. (2003) categorize this method as an estimation

technique. The minimal occlusive volume technique, minimal leak technique, and the palpation technique are all examples of the estimation techniques (Stewart et al., 2003).

The minimal occlusive volume technique is performed by inflating the ETT cuff with the smallest amount of air that does not produce an audible leak during ventilation (Stewart et al., 2003). Although it has been shown to produce cuff pressures above the recommended range, the minimal occlusive volume technique is recommended to reduce the incidence of tracheal stenosis (Totonchi, Jalili, Hashemian, & Jabardarjani, 2015). Totonchi, Jalili, Hashemian, and Jabardarjani (2015) recommend the utilization of the minimal occlusive volume technique compared to the palpation technique to reduce the incidence of tracheal stenosis.

The minimal leak technique is performed by inflating the ETT cuff with an amount of air that produces a minimum leak during ventilation (Stewart et al., 2003). The minimum leak is measured by observing a 50-100ml decrease in the tidal volume during positive pressure ventilation (Sultan et al., 2011, p. 379). This technique is ineffective for measuring ETT cuff pressure, leading to both over-inflation and under-inflation (Harvie et al., 2016; Stewart et al., 2003). An observational study was conducted over three months on ventilated patients assessing the accuracy of the minimal leak technique. The results showed only 44% of the patients had cuff pressures within the recommended range of 20-30cm H_20.

In addition to the minimal occlusive and minimal leak technique, there is a significant discussion in the literature about the palpation technique. The palpation technique is performed by the provider palpating the pilot balloon after injecting the ETT cuff with air (Sultan et al., 2011). Although, this technique is considered unreliable in

detecting appropriate cuff pressures; it is still widely used in practice (Sultan et al., 2011). For example, Totonchi and colleagues (2015) conducted a cross-sectional study in 101 adult patients requiring mechanical ventilation after open heart surgery. Their primary goal was to determine the accuracy of the palpation and minimal occlusive technique in measuring ETT cuff pressures. The researchers reported that the cuff pressures assessed by the palpation technique had 92 patients (91.1%) out of the permissible range (20–30 cm H_2O) and 9 patients (8.9%) within the range when checked with the manometer. The cuff pressures assessed by the minimal occlusive technique had 79 patients (78.2%) out of the permissible range and 22 patients (21.7%) within the range when checked by the manometer. The researchers concluded that manometer is the most reliable way to measure ETT cuff pressures, but in its absence, the minimal occlusive technique is the next best substitute.

Several researchers have demonstrated that the use of the palpation technique to measure ETT cuff pressure often results in pressures above the recommended range. For example, Tsaousi, Pourzitaki, Chlorou, Papapostolou, and Vasilakos (2016) found that the highest incidence (14.3%) of over inflation was noted in cuff pressures ranging from 18-42 cm H_2O whose method was the palpation technique. Liu et al. (2010) reported the mean ETT cuff pressure of 43 ± 33.3 mmHg with 210 mmHg being the highest in patients whose pressures were determined by the palpation technique. This high cuff pressure produced by the palpation technique causes an increase in the incidence of a sore throat and hoarseness postoperatively (Tsaousi et al., 2016).

Complications

Sultan et al. (2011) suggested cuff pressures are a contributing factor in the development of complications relating to endotracheal tubes (p. 383). Complications can arise from either the provider under-inflating or over-inflating the ETT cuff. The complications include: tracheal stenosis, tracheal rupture, recurrent laryngeal nerve damage, aspiration, sore throat, and hoarseness (Stewart et al., 2003; Sultan et al., 2011). Aspiration and hoarseness are complications that have been associated with the under-inflation of ETT cuff. Jaensson, Gupta, and Nilsson (2012) found that 59% of patients with cuff pressures below 20 cm H_20 presented with hoarseness postoperatively. Bhatti et al., (2010) conducted a cost analysis of intubation-related injuries. The researchers concluded that injuries related to endotracheal intubations significantly increases the average length of stay and readmission rates, thus increasing healthcare cost by 20% (Bhatti et al., 2010).

A sore throat is one of the common postoperative complications reported after intubation with an endotracheal tube, with an incidence of 55% (Liu et al., 2010). Researchers have been able to link this incidence with the over-inflation of the ETT cuff. For example, Tsaousi et al., (2016) found that after 24 hours of removing the ETT, the incidence of a sore throat was 31.4% in patients whose cuff pressures measured the highest. Similar results were reported by Liu et al. (2010) who studied 509 patients and found a 44% incidence of a sore throat in patients with a mean ETT cuff pressure of 43 ± 33.3 mmHg 24 hours after removing the ETT.

Manometer

The use of manometers to correctly measure ETT cuff pressure has been demonstrated by several researchers. For instance, Stewart et al. (2003) implemented a study among anesthesia providers to compare ETT cuff pressures obtained by estimation techniques with the direct measurements using a manometer. The study included 40 participants who could inflate the ETT cuff with their usual technique. The pressures obtained by the estimation techniques ranged from 6 to 60 cm H_20 (mean= 44.5 cm H_2O; SD = 13.07 cm H_20). The investigators found that 65% of the of the providers achieved pressures higher than 40 cm H_20 and only 30% achieved the pressures within the ideal range (25- 40 cm H_20). The investigators concluded that estimation techniques were not accurate and suggested the use of a manometer.

Some researchers have shown the use of the manometer to measure ETT cuff pressure reduces the incidence of post-procedural complications. A group of researchers conducted an observational, randomized, prospective, controlled trial on 509 patients administered general anesthesia (Liu et al., 2010). The patients were randomly divided into two groups. The control group consisted of 273 patients whose ETT cuffs were inflated by the provider using the palpation method. The study group consisted of 236 patients whose ETT cuffs were inflated and adjusted by the manometer. The mean ETT cuff pressure in the study group measured 43 ± 33.3 mmHg after adjustments with the manometer the pressures measured 20 ± 3.1 mm Hg ($P < 0.001$). The researchers found that the control group had an incidence of 11% blood-streaked expectoration, 11% hoarseness, and 44% sore throat. The study group only had an incidence of 4% blood-streaked expectoration, 3% hoarseness, and 34% sore throat.

Another group of researchers demonstrated another benefit of using a manometer to measure ETT cuff pressure. Darvall et al. (2017) found that the use of a manometer is associated with a decrease in antibiotic administration for ventilation-associated pneumonia (VAP). This study was conducted on 178 mechanical ventilated patients whose ETT cuff pressures were either managed by the minimal leak test technique or a manometer. The results of the study showed an 11.4% decrease in the incidence of ventilator-associated complications with the use of manometer compared to 16.3% with the minimal leak test technique ($P = 0.018$).

Sengupta et al. (2004) implemented a blind study to test the hypothesis that the inflation of ETT cuff without a manometer is inadequate. This study consisted of 93 patients undergoing general anesthesia that required placement of an endotracheal tube. The induction of anesthesia and the endotracheal placement were performed by an anesthesia provider. Cuff pressures were obtained 60 minutes after intubation with a manometer. The investigators' findings were that only 27% of the cuff pressures were within the recommended range (20-30 cm H_20). The average cuff pressures were 35.3 cm H_20; 50% of the pressures were above 30 cmH_20; 27% of the pressures were above 40 cm H_20, and 23% of the pressures were less than 20 cm H_20. The study concluded that cuff pressures should be initially set and monitored with a manometer.

Provider-Based

Gilliland, Perrie, and Scribante (2015) performed a study at two academic hospitals. The study consisted of 96 adult patients undergoing general anesthesia without the use of nitrous oxide. The primary outcome of this study was to determine the ETT cuff pressures of patients during anesthesia. The researchers found that 64.58% of the

cuff pressures in patients were above 30 cm H_20. The results showed no statistically significant difference between the facilities or inflation method. The study concluded that the ETT cuff pressures were above the ideal range in the majority of the patients undergoing general anesthesia. The investigators recommended the availability and direct measurement of cuff pressures with manometers.

In a similar study, investigators measured the ability of anesthesia providers to inflate ETT cuffs within the recommended range. The study included 52 anesthesia providers who inflated cuffs on a tracheal model using their normal technique. The investigators found that 55.8% of the cuff pressures were above 30cm H_2O and only 36.5 % within the recommended range (Siamdoust, Mohseni, & Memarian, 2015).

Purchon (2017) conducted an audit on 85 patients undergoing cardiac surgery. After placement of the ETT, the providers inflated the cuffs with their normal technique. The investigator measured and recorded the cuff pressures using a manometer. The results were as followed: 12 under-inflated, 32 over-inflated, 17 extremely over-inflated, and 24 correctly inflated. The author recommended restricting the palpation and minimum occlusive technique from current practice and incorporating the manometer for measuring cuff pressures.

While studies have shown that anesthesia providers are inflating cuffs above the recommended range, it has also been demonstrated in emergency medicine. Hoffman, Parwani, and Hahn (2006) conducted a cross-sectional, prospective, observational study on 41 emergency-medicine attending physicians. Their primary outcome was to determine the capability of emergency medicine physicians to inflate ETT cuffs within

safe ranges. The researchers found the average cuff pressure was greater than 93.2 cm H_20 (16-20 cm H_20; 95 % confidence interval, 82.3-104.2 cm H_20).

Conclusion

Currently, a gap in practice exists amongst anesthesia providers as it relates to the measurement of ETT cuff pressure. Numerous researchers have proven that the measurement of ETT cuff pressures intraoperatively is often not performed according to best-recommended practice (Grant, 2013; Jordan, Van Rooyen, & Venter, 2012; Purchon, 2017). Further, studies have shown a correlation between an increased incidence of postoperative tracheal morbidity and ETT cuffs not properly inflated (Liu et al., 2010). Post-operative tracheal morbidity could contribute significantly to cost for a facility considering that readmission rates and the average length of stay for patients are increased (Bhatti et al., 2010). Post-operative tracheal morbidity can also directly affect the quality of anesthesia care through decreased patient satisfaction (Lehmann, Monte, Barach, & Kindler, 2010).

Rationale

This best practice project was guided by the ACE star model of knowledge transformation. This model is a framework used by researchers to facilitate the process of evidence-based projects (Melnyk & Fineout-Overholt, 2011). The ACE star model was developed to improve the process of implementing the current evidence-based literature into practice, by creating clinical-practice recommendations (Melnyk & Fineout-Overholt, 2011). The unique five-star shape of this model represents each stage in the process. As described by Mclnyk and Fineout-Overholt (2011), the ACE star model consists of five stages of knowledge transformation (p. 307). The five stages include: (1)

knowledge discovery, (2) evidence summary, (3) translation into practice recommendations, (4) implementation into practice, (5) and evaluation (Melnyk & Fineout-Overholt, 2011, p. 397). In the first stage, an extensive literature review was conducted on the different techniques of measuring ETT cuff pressure. In the second stage, an evidence-based policy was developed for measuring ETT cuff pressures from the information obtained from the literature review. In the third stage, the panel of experts evaluated the evidence-based policy. In the fourth stage, an executive summary was created and shared with the Chief CRNA at a level one hospital in south Mississippi. In the fifth stage, the Chief CRNA reviewed executive summary including the policy recommendations. The ACE star model was utilized to transform the current knowledge of measuring ETT cuff pressure into anesthesia practice.

Specific Aims

The current practice for the measurement of ETT cuff pressure intraoperatively is subjective, potentially leading to negative consequences for patients. The purpose of this best practice project was to examine and synthesize the current evidence-based literature on measuring ETT cuff pressure and develop a policy recommendation for measuring ETT cuff pressure in the intraoperative setting by anesthesia providers. While several techniques are utilized to measure the cuff pressures of ETT, this project explored which technique is best recommended for practice. The recommendations for an evidence-based policy on measuring ETT cuff pressure has the potential for the enhancement of more desirable patient outcomes, decreasing the risk of complications, and maintaining patient satisfaction.

Summary

The management of ETT cuffs is routine practice for anesthesia providers. The literature review revealed that current estimation techniques utilized by anesthesia providers are subjective and inaccurate. The findings also communicated that ETT cuff pressures should be set and measured with a manometer. With consideration to these findings, it is hypothesized that an evidence-based policy based on the use of a manometer has the potential to minimize the variation in measuring ETT cuff pressure.

CHAPTER II -METHODS

Observation and review of current literature indicate that the current techniques utilized by anesthesia providers to measure ETT cuff pressure are inconsistent. Evidence-based research does not support the estimation techniques used for measuring ETT cuff pressure. Furthermore, the inaccuracy of measuring ETT cuff pressures has been shown to contribute to post-operative tracheal morbidity. Multiple variations of measuring ETT cuff pressure are amongst the anesthesia providers in south Mississippi. The purpose of this project was to develop evidence-based policy recommendations based on a review of the current best practice for measuring ETT cuff pressure.

Intervention

Upon approval from The University of Southern Mississippi (USM) Institutional Review Board (IRB) (Protocol #18071905, Appendix A), an extensive literature review was performed to evaluate the current evidence-based research available on measuring endotracheal tube cuff pressure. The search was conducted using CINAHL, Google Scholar, and Medline. The key terms used in the search were*: endotracheal tube cuff, endotracheal cuff pressure and techniques, and complications*. The initial search generated 119 articles between the years 2001-2018. Multiple studies were reviewed, and 14 met the inclusion criteria for the project. The inclusion criteria included peer-reviewed and clinical relevance. The articles obtained were organized and recorded in a literature matrix (Appendix B) based on year published and level of evidence. The researcher synthesized the data and developed an evidence-based policy recommendation for measuring ETT cuff pressure.

An expert panel was created to participate in the evaluation process of the recommendations. The panel included the following: (a) representative from healthcare administration, (b) representative from nursing anesthesia education, and (c) two practicing CRNAs in South Mississippi. The importance of the panelists chosen was to improve the probability of adoption and justify the evidence-based policy recommendation. A representative from healthcare administration was chosen due to the financial implications of equipment, patient complications, and patient satisfaction. A representative from nursing anesthesia education was chosen due to the current theoretical knowledge of ETT cuff pressure measurement. Practicing CRNAs from two different facilities in south Mississippi was chosen due to the multiple variations in measuring ETT cuff pressure in differing facilities.

The evidence-based policy recommendation (Appendix C) was emailed to the panel of experts for review electronically per secured USM server. The email included an informed consent, a copy of the evidence-based policy recommendations, and a link to the evaluation tool. The evaluation tool, the Appraisal of Guidelines for Research and Evaluation-Global Rating Scale (AGREE-GRS) was formatted utilizing Survey Monkey. The panel members were given three weeks to review and complete the evaluation.

The completed evaluations were stored in an encrypted file, and on a password protected computer. To protect the panel members' identity, only the researcher had access to emails and documents. All panel members completed an informed consent before reviewing and evaluating the policy recommendations. Upon completion of the project, the data will be destroyed per USM protocol.

Study of the Interventions

The Appraisal of Guidelines for Research and Evaluation (AGREE) tool was released in 2001 and now is one of the most widely used instrument to evaluate evidence-based practice guideline (Hoffman-Eber et al., 2017). According to Hoffman-Eber et al. (2017), the AGREE tool has been used by thousands of researchers for appraisals of guidelines (p.1). This tool has not only been used in the United States but other countries as well. The AGREE tool contains 23 questions to determine the reliability and validity of the guideline (Hoffman-Eber et al., 2017). This project utilized a simpler form of the AGREE tool, AGREE-GRS tool. The AGREE-GRS tool is only composed of seven questions, including an overall assessment of the guidelines (Brouwers et al., 2012). Researchers have shown a strong correlation between the endorsement of clinical guidelines and the AGREE-GRS (Brouwers et al., 2012).

The goal of this evaluation tool was to identify a willingness of anesthesia providers to adopt an evidence-based policy recommendation on measuring ETT cuff pressure in the intraoperative setting. The AGREE-GRS tool uses a seven-point scale to measure the quality of development methods, guideline presentation, completeness of reporting, and validity (Brouwers et al., 2012). The scale ranges from a score of one to seven. A score of one represents the lowest quality, and a score of seven represents the high quality. Although the AGREE-GRS tool is a substitute for researchers with small time frames, it remains capable of predicting the approval of evidence-based guidelines (Brouwers et al., 2012).

Measures

The panel of experts utilized the AGREE-GRS tool to evaluate the evidence-based policy recommendations via Survey Monkey. The AGREE-GRS tool can be found in Appendix D. The questionnaire assessed the development, presentation, completeness, and clinical validity of the evidence-based policy recommendations (Brouwers et al., 2012). The first question assessed the expert's opinion of the quality of the methods used by the researcher to develop the recommendations. The second question assessed the expert's opinion of the quality of the presentation of the recommendations. The fourth question assessed the expert's opinion of the completeness of reporting the recommendations. The fifth question assessed the expert's opinion of the overall quality of the recommendations. The sixth question assessed the expert's decision of endorsing the recommendations. The seventh question assessed the expert's decision to utilize the recommendations in practice.

Analysis

Descriptive statistics were used to summarize the data collected from the evaluation tool. A composite score from each category was calculated. A score of 1 demonstrated that the criteria were not met. A score between 2 and 6 demonstrated that the criteria do not meet the full considerations. A score of 7 demonstrated that the criteria were fully met. The average assessment score was calculated. The overall assessment score demonstrated if the expert strongly disagrees or strongly agrees with the recommendations.

Policy revisions were made as necessary based on the data collected from the AGREE-GRS tool. The best-practice policy and supporting evidence were compiled into

an executive summary. The executive summary (Appendix E) was distributed to the chief Certified Registered Nurse Anesthetist (CRNA) at a level 1 trauma center in south Mississippi with the intentions of adoption.

Ethical Considerations

An ethical consideration for this project is the potential for a certified registered nurse anesthetist (CRNA) to provide two levels of care. The choice for measuring ETT cuff pressures is based on the CRNA's preference. Therefore, there is a probability that a CRNA's decision to utilize the best-practice recommendations in practice would be based on CRNA choice of ETT insufflation and the availability of a manometer.

Summary

A panel of experts was assembled to guide the development of the evidence-based policy. The panel utilized a questionnaire to evaluate the evidence-based policy recommendations. The questionnaire was convenient and easily adaptable for this project. Also, the AGREE-GRS tool worked well in the small sample of participants.

CHAPTER III - RESULTS

The purpose of this best practice project was to examine and synthesize the current evidence-based literature on measuring ETT cuff pressure and to develop a policy recommendation for measuring ETT cuff pressure in the intraoperative setting by anesthesia providers. The developed evidence-based policy recommendation and supporting evidence were emailed to the panel of experts including, two practicing CRNAs, a representative from nursing anesthesia education, and a representative from healthcare administration. The panel members were asked to use the AGREE-GRS tool to assess the quality of the policy recommendations and supporting evidence.

Descriptive statistics were utilized to summarize the demographics and characteristics of the panel of experts. All four-panel members (100%) completed the evaluation tool via Survey Monkey. The panel members were all female (100%). Three of the panel members had more than 10 years of experience (75%), with only one member having 0-5 years of experience (25%).

Descriptive statistics were utilized to calculate what percentage of the panel members rated each category on the AGREE-GRS tool. The tool assessed the development, presentation, completeness, and clinical validity of the evidence-based policy recommendations. While 50% of the panel members responded highest quality on the development methods for the policy, 50% responded high quality. Not only did 50% of the panel members responded highest quality on the policy presentation, but also 50% responded high quality. Thirdly, 75% of the panel members responded highest quality on the completeness of reporting the recommendations, in contrast, 25% responded high quality. Regarding the overall quality of the policy recommendations, 75% of the panel

members responded highest quality, while 25% responded high quality. In terms of the overall quality of the policy, 75% of the panel members responded highest quality while 25% responded high quality. Additionally, 75% of the panel members strongly-agreed to recommending the policy for use in practice while 25% moderately agreed. Lastly, 75% of the panel members strongly agreed on utilizing the policy recommendations in practice, then again 25% moderately agreed. The results of the AGREE-GRS tool are summarized in Table 1.

Table 1

Results of AGREE-GRS Tool

Categories	Panel Member #1	Panel Member #2	Panel Member #3	Panel Member #4
Development Methods	Highest Quality	Highest Quality	High Quality	Highest Quality
Policy Presentation	Highest Quality	Highest Quality	High Quality	Highest Quality
Completeness	Highest Quality	Highest Quality	High Quality	Highest Quality
Validity	Highest Quality	Highest Quality	High Quality	Highest Quality
Overall Quality	Highest Quality	Highest Quality	High Quality	Highest Quality
Use in Practice	Strongly Agree	Strongly Agree	Moderately Agree	Strongly Agree

The evaluation of the policy components from the comments section is displayed in Table 2. A total of three comments were noted on the evaluation tool. The comments revealed that one-panel member had a concern with the cost of a manometer. The results of the AGREE-GRS tool conclude that most panel members agreed on the components

included in the policy recommendations and supporting evidence, and furthermore, all agreed the policy should be implemented in the practice setting.

Table 2

Evaluation of Policy Components

Components	Panel Member #1	Panel Member #2	Panel Member #3	Panel Member #4
Rationale	No Feedback	No Feedback	No Feedback	No Feedback
Policy	No Feedback	"important to current practice"	No Feedback	No Feedback
Procedure	No Feedback	"would adopt"	No Feedback	No Feedback
Report of Findings	"Cost"	No Feedback	No Feedback	No Feedback

Summary

In summary, the purpose of this project was to develop evidence-based policy recommendations based on a review of the current best practice for measuring ETT cuff pressure. From the responses, all participants agreed with each category of the policy. The findings of this project indicated that the panel of experts support the adoption of the policy in the practice setting.

CHAPTER IV – DISCUSSION

Summary

The anesthesia practice of measuring ETT cuff pressures in the intraoperative setting is subjective and is based on the provider's preference. The literature review discovered that the current techniques utilized by anesthesia providers are often not performed according to best-recommended practice as well as, potentially leading to negative consequences for patients. (Grant, 2013; Jordan et al., 2012; Purchon, 2017). In addition, ETT cuff pressures should be set and measured with a manometer in the intraoperative setting (Gilliland et al., 2015; Liu et al., 2010; Sengupta et al., 2004; Siamdoust et al., 2015; Stewart et al., 2003; Totonchi et al., 2015). A gap in practice was identified amongst anesthesia providers as it relates to the measurement of ETT cuff pressure. The specific aim of this project was to develop an evidence-based policy for measuring ETT cuff pressure based on the current evidence. By developing an evidence-based policy, there is the potential to minimize the variation in measuring ETT cuff pressure, while improving patient outcomes and reducing the risk of complications.

One of the strengths of this best practice project is the development of evidence-based policy. Currently, no guidelines or policies exist for anesthesia providers regarding the measurements of ETT cuff pressures. Another strength is the policy evaluation process that allowed for an expert panel to assess and provide feedback on the policy recommendations. Having input from the expert panel assisted in validating the policy recommendations and increased the probability of adoption.

Interpretation

The primary purpose of this best practice project was to evaluate the literature and use the results of the literature review to develop an evidence-based policy recommendation for measuring ETT cuff pressure in the intraoperative setting. This project resulted in the development of evidence-based policy that supports the use of a manometer to measure ETT cuff pressures intraoperatively. The results from the evaluation tool indicated that 100% of the panel members recommend the adoption of the policy in the practice setting. Likewise, the results reinforced what was found in the literature; a change in the practice of measuring ETT cuff pressures is needed (Purchon, 2017). The Doctor of Nursing Practice (DNP) eight essentials are the fundamental competencies that Advance Practice Nurses are required to achieve a DNP degree by the American Association of Colleges of Nursing (American Association of Colleges of Nursing [AACN], 2006). This project met seven essentials. The details on the fulfillment of each essential can be found in Appendix F.

Limitations

Limitations of this project include the small number of panel members. Given that only four members were selected to evaluate the policy recommendations. A larger panel may have been more beneficial to the evaluation process despite the AGREE-GRS tool minimum requirement of two members (Brouwers et al., 2012). Another limitation of this project was the absence of anonymity. The panel members may have given different responses.

Conclusion

This best practice project resulted in the development of an evidence-based policy for the measurement of ETT cuff pressures in the intraoperative setting. The policy was based on a summary of the current evidence in the literature and provides organizations with a standard method for measuring ETT cuff pressures. The findings revealed the agreement in the utilization of the manometer for measuring ETT cuff pressure from the expert panel, guided by the policy. Future research anticipated includes a cost-analysis for manometers and strategies for successful incorporation in the practice setting. Despite the absence of guidelines for ETT cuff pressure measurement in the intraoperative setting, this project has the potential to minimize the variation in measuring ETT cuff pressure, while improving patient outcomes and reducing the risk of complications.

APPENDIX A – IRB Approval Letter

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 18071905
PROJECT TITLE: Analysis of Current Best Practices for Measuring Endotracheal Tube Cuff
PROJECT TYPE: New Project
RESEARCHER(S): Myisha Dixon
COLLEGE/DIVISION: College of Nursing and Health Professions
DEPARTMENT: School of Leadership and Advanced Nursing Practice
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 08/06/2018 to 08/05/2019
Edward L. Goshorn, Ph.D.
Institutional Review Board

APPENDIX B Literature Matrix

Author/ Year	Level/ Grade	Design	Sample Size	Findings	Recommendations
Ansari, Bohluli, Mahasen, Valaei, Sadr-Eshkevar, & Rashad (2013)	Level 4 Grade B	Randomized Double-blind controlled trial	N=43	At 1 hr and 6 hr postoperative the palpation and minimal leak test had higher mean VAS scores compared to the study group.	N/A
Gilliland, Perrie, & Scribante (2015)	Level 3 Grade B	Prospective-Cohort study	N=96	64.58% of the patients undergoing general anesthesia had cuff pressures above 30cm H_20.	ETT cuff pressure should be measured using a manometer.
Harvie et al. (2016)	Level 4 Grade B	Observation cross-sectional study	N=45	Using the minimal leak test, only 44% of the patients had cuff pressures between 20 and 30cm H_20.	The minimal leak test leads to the over-inflation and under-inflation of ETT cuffs and alternative techniques, such as a manometer, should be used.

Hoffman, Parwani, & Hahn (2006)	Level 4 Grade B	Prospective, observational, cross-sectional study	N=41	Using the palpation technique, only 22% of the emergency medicine physicians were able to detect an overinflated ETT cuff pressure. The average cuff pressure produced by inflation was greater than 93cm H_20.	Clinicians should consider using devices to inflate and accurately measure ETT cuff pressure.
Jaensson, Gupta, & Nilsson (2012)	Level 4 Grade B	Prospective, cross-sectional study	N=97	Cuff pressure below 20cm H_20 (59%) increased the risk of post-operative hoarseness compared to pressures above 20cm H_20 (36%).	N/A
Liu et al., (2010)	Level 2	Randomized prospective,	N=509	The incidence of post-procedural sore throat, hoarseness, and blood-	The use of a manometer helps reduce ETT-related postprocedural respiratory complications such as a sore throat,

	Grade A	observational study		streaked expectoration was significantly higher in the control group.	cough, hoarseness, and blood-streaked expectoration even in procedures of short duration (1-3 hours).
Purchon (2017)	Level 4 Grade B	Quantitative study	N= 85	79% of the patients undergoing cardiac surgery had ETT cuffs that were inflated incorrectly.	The current practice of cuff inflation using a syringe and palpation of the pilot balloon should be abandoned. Manometers should be routinely used for inflation of ETT cuffs.
Sengupta et al. (2004)	Level 4 Grade A	Quantitative study	N= 93	Only 27% of patients undergoing general anesthesia had cuff pressures within the range of 20-30cm H_20.	ETT cuff pressure should be set and monitored with a manometer.
Siamdous-t, Mohseni, & Memaria-n (2015)	Level 4 Grade B	Quantitative study	N=52	55.8% of anesthesia personnel inflated ETT cuffs more than 30cm H_20.	Best practice for measuring ETT cuff pressure is with a manometer. The palpation technique should only be used in emergencies.
Stewart, Seacrest, Norwood, & Zachary (2003)	Level 4 Grade B	Quantitative study	N= 40	65% of the anesthesia providers achieved pressures greater than 40 cm H_20.	Estimation techniques are inadequate, and that direct measurement should be used.

Sultan, Carvalho, Rose, & Cregg (2011)	Level 1 Grade A	Systematic review	N/A	Cuff pressures above a critical value can cause congestion and edema of the tracheal mucosa.	Evidence suggests that cuff pressure may be an important factor in the development of complications related to ETT, however, is multifactorial. Also, there is an inability of clinicians to adequately inflate ETT cuffs within recommended levels. Anesthesia providers must recognize the morbidity and potential complications associated with over-inflating ETT cuffs.
Tobias, Schwartz, Rice, Jatana, & Kang, (2012)	Level 3 Grade B	Prospective-Cohort study	N=200	23.5% of the patients had a cuff pressure above 30cm H_20.	N/A
Totonchi, Jalili, Hashemia-n, & Jabardarj-ani (2015)	Level 4 Grade B	Cross-sectional study	N= 101	The MOV technique had 21.7% of patients within the permissible range compared to the palpation technique (8.9%).	The best way to measure ETT cuff pressure is with a manometer. The MOV technique is the preferred alternative technique to avoid complications.

Tsaousi, Pourzitaki, Chlorou, Papapostolou, & Vasilakos (2016)	Level 2 Grade B	Double-blind Randomized trial	N=139	The palpation and minimum leak techniques had the highest and lowest ETT cuff pressure volume. The palpation technique had the highest laryngotracheal complaints.	When a cuff manometer is not available, the air return method should be used.

APPENDIX C Policy Recommendations

Policy Area: Anesthesia Department	**Subject:** Monitoring
Title of Policy: Measurement of Endotracheal Tube Cuff Pressures	**Number:**
Effective Date:	**Supersedes:**
Approved Date: **Revision Date:**	**Approved by:**

1. **Rationale or background to policy**: This policy is to ensure that the cuff pressures of endotracheal tubes are inflated within the recommended range of 20-30 cm H_20. Several studies have demonstrated the frequent over-inflation of endotracheal tube cuffs by anesthesia providers, and that estimation techniques such as palpation technique and minimum occlusive volume technique are inaccurate. Sufficient evidence supports the use of a manometer for measuring endotracheal tube cuff pressure in the intraoperative setting.
2. **Policy**: All anesthesia providers will utilize a manometer to measure endotracheal tube cuff pressure after intubation.
3. **Procedure**:
    1. After intubation, the anesthesia provider will inflate the endotracheal tube cuff with enough air to provide an adequate seal.
    2. Attach manometer to pilot balloon and verify cuff pressure is between 20-30 cm H_20.

3. If cuff pressure is not within the range of 20-30 cm H_2O, the anesthesia provider will adjust cuff volume and recheck pressure.
4. Document cuff pressure in anesthesia record.

Report of Findings

Estimation Techniques

Although widely used, several researchers have demonstrated the shortcomings of endotracheal tube (ETT) cuff pressure estimation by the minimal occlusive volume technique, minimal leak technique, and the palpation technique (Grant, 2013; Sultan et al., 2011; Tobias et al., 2012). These techniques have been indicated to produce cuff pressures, not within the recommended range of 20-30 cm H_2O (Harvie et al., 2016; Totonchi et al., 2015; Tsaousi et al., 2016). Also, a correlation has been established between the potential risk for post-operative complications and ETT cuff pressures, not within the recommended range of 20-30 cm H_20 (Ansari et al., 2103; Grant, 2013; Liu et al., 2010; Tsaousi et al., 2016).

Anesthesia Providers

Numerous studies have proven the frequent over-inflation of endotracheal tube cuffs by anesthesia providers (Sengupta et al., 2004; Siamdoust et al., 2015; Stewart et al., 2003; Tobias et al.,2012). A prospective, cohort study performed showed that 64.58% of the patients undergoing general anesthesia had cuff pressures above 30cm H_20 (Gilliland, Perrie, & Scribante, 2015).

Manometer

Sufficient evidence supports the use of a manometer for measuring endotracheal tube cuff pressure in the intraoperative setting (Gilliland, Perrie, & Scribante, 2015; Liu et al., 2010; Sengupta et al., 2004; Siamdoust et al., 2015; Stewart et al., 2003; Totonchi et al., 2015). In particular, Purchon (2017) recommended restricting the palpation and minimum occlusive technique from current practice and incorporating the manometer for measuring cuff pressures.

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Totonchi, Z., Jalili, F., Hashemian, S. M., & Jabardarjani, H. R. (2015). Tracheal stenosis and cuff pressure: Comparison of minimal occlusive volume and palpation techniques. *Journal of Respiratory Disease, Thoracic Surgery, Intensive Care, and Tuberculosis, 14*, 252-256.

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AGREE II-Global Rating Scale (AGREE II-GRS) Instrument

Instructions: For each item, please choose the response on the 7 point scale which best characterizes the clinical practice guideline.

Item	Description	Lowest Quality (1)	(2)	(3)	(4)	(5)	(6)	Highest Quality (7)
1. Rate the overall quality of the guideline development methods	Consider: *Were the appropriate stakeholders involved in the development of the guideline?* *Was the evidentiary base developed systematically?* *Were recommendations consistent with the literature?*	☐	☐	☐	☐	☐	☐	☐
2. Rate the overall quality of the guideline presentation	Consider: *Was the guideline well organized?* *Were the recommendations easy to find?*	☐	☐	☐	☐	☐	☐	☐
3. Rate the completeness of reporting.	Consider: *Was the guideline development process transparent and reproducible?* *How complete was the information to inform decision making?*	☐	☐	☐	☐	☐	☐	☐
4. Rate the overall quality of the guideline recommendations	Consider: *Are the recommendations clinically sound?* *Are the recommendations appropriate for the intended patients?*	☐	☐	☐	☐	☐	☐	☐
5. Rate the overall quality of the guideline.		☐	☐	☐	☐	☐	☐	☐

General Questions: Overall Guideline Assessment

Instructions: For each item, please choose the response on the 7 point scale which best characterizes the clinical practice guideline.

Item	Strongly Disagree (1)	Disagree (2)	Disagree Slightly (3)	Neither Agree or Disagree (4)	Agree Slightly (5)	Agree (6)	Strongly Agree (7)
1. I would recommend this guideline for use in practice.	☐	☐	☐	☐	☐	☐	☐
2. I would make use of a guideline of this quality in my professional decisions.	☐	☐	☐	☐	☐	☐	☐

APPENDIX E – Executive Summary

Executive Summary of Analysis of Current Practices for Measuring Endotracheal Cuff Pressures

Myisha Dixon

The University of Southern Mississippi

The Student Registered Nurse Anesthetist convened a panel of experts to evaluate the collective evidence and develop an evidence-based clinical policy recommendation on the best practice for measuring endotracheal tube cuff pressure in the intraoperative setting. This is the executive summary of the full report, "Analysis of Current Practices for Measuring Endotracheal Cuff Pressures," which will be printed and presented at the University of Southern Mississippi College of Nursing in September 2018.

This policy recommendation regarding the utilization of a manometer to measure endotracheal tube cuff pressure after intubation is provided to ensure that the cuff pressures of endotracheal tubes are inflated within the recommended range of 20-30 cm H_20 and to minimize variation. The purpose of this best practice project was to examine and synthesize the current evidence-based literature on measuring ETT cuff pressure and develop a policy recommendation for measuring ETT cuff pressure in the intraoperative setting by anesthesia providers. The current policy recommendation is evidence-based and should be integrated with the anesthesia provider's professional judgment and the individual patient's needs and preferences.

Available Knowledge

Although widely used, several researchers have demonstrated the shortcomings of endotracheal tube (ETT) cuff pressure estimation by the minimal occlusive volume technique, minimal leak technique, and the palpation technique. These techniques have been indicated to produce cuff pressures, not within the recommended range of 20-30 cm H_2O. Also, a correlation has been established between the potential risk for post-operative complications and ETT cuff pressures not within the recommended range of 20-30 cm H_20.

Numerous studies have proven the frequent over-inflation of endotracheal tube cuffs by anesthesia providers. A prospective, cohort study performed showed that 64.58% of the patients undergoing general anesthesia had cuff pressures above 30cm H_20. Sufficient evidence supports the use of a manometer for measuring endotracheal tube cuff pressure in the intraoperative setting. In particular, one researcher recommended restricting the palpation and minimum occlusive technique from current practice and incorporating the manometer for measuring cuff pressures.

Process

An extensive literature review was performed to evaluate and synthesize the current evidence-based research that can be used to develop the policy on measuring endotracheal tube cuff pressure. The panel of experts utilized the AGREE-GRS tool to evaluate the evidence-based policy recommendations via Survey Monkey. The panel of experts included two practicing CRNAs, a representative from nursing anesthesia education, and a representative from healthcare administration. All members assessed the

development, presentation, completeness, and clinical validity of the evidence-based policy recommendations. The findings revealed a highest to high quality (100%) of agreement in all categories. A greater number of panel members agreed on the components included in the policy recommendations and supporting evidence, and furthermore, all agreed the policy should be implemented in the practice setting.

Policy Recommendation

The literature recommends that anesthesia providers utilize a manometer for measuring endotracheal tube cuff pressure in the intraoperative setting. Notably, the measurement should be performed after intubation and with any adjustments made to the cuff volume.

Policy Area: Anesthesia Department	**Subject:** Monitoring
Title of Policy: Measurement of Endotracheal Tube Cuff Pressures	**Number:**
Effective Date:	**Supersedes:**
Approved Date: **Revision Date:**	**Approved by:**

1. **Rationale or background to policy**: This policy is to ensure that the cuff pressures of endotracheal tubes are inflated within the recommended range of 20-30 cm H_20. Several studies have demonstrated the frequent over-inflation of endotracheal tube cuffs by anesthesia providers, and that estimation techniques such as palpation technique and minimum occlusive volume technique are

inaccurate. Sufficient evidence supports the use of a manometer for measuring endotracheal tube cuff pressure in the intraoperative setting.

2. **Policy**: All anesthesia providers will utilize a manometer to measure endotracheal tube cuff pressure after intubation.
3. **Procedure**:
    1. After intubation, the anesthesia provider will inflate the endotracheal tube cuff with enough air to provide an adequate seal.
    2. Attach manometer to pilot balloon and verify cuff pressure is between 20-30 cm H_20.
    3. If cuff pressure is not within the range of 20-30 cm H_2O, the anesthesia provider will adjust cuff volume and recheck pressure.
    4. Document cuff pressure in anesthesia record.

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APPENDIX F DNP Essentials

Doctor or Nursing Essentials	How the Essential is Achieved
I. Scientific Underpinning for Practice	This best practice project is based on the most current evidence-based literature for measuring ETT cuff pressures. The primary outcome of this project was creating a policy supported by peer-reviewed research.
II. Organizational and Systems Leadership for Quality Improvement and Systems Thinking	The development of an evidence-based policy for measuring ETT cuff pressures in the intraoperative setting has the potential for the enhancement of more desirable patient outcomes, decreasing the risk of complications, and maintaining patient satisfaction.
III. Clinical Scholarship and Analytical Methods for Evidence-Based Practice	This essential was met by performing an extensive literature review. Systematic methods were used to gather data on the different techniques for measuring ETT cuff pressure.
V. Health Care Policy for Advocacy in Health Care	This project leads to the development of a policy regarding measuring ETT cuff pressure in the intraoperative setting.
VI. Interprofessional Collaboration for Improving Patient and Population Health Outcomes	This project required effective communication between myself and the panel of experts that participate in the project. The dissemination of the executive summary allowed for an exchange of knowledge that could be used for practice improvements.
VII. Clinical Prevention and Population Health for Improving the Nation's Health	This essential was met by increasing awareness of the potential postoperative complications caused by the current techniques used to measure ETT cuff pressure.
VIII. Advanced Nursing Practice	This best practice project was ultimately aimed at utilizing the most current evidence-based literature to develop a policy. The purpose of the policy is to guide clinical decisions for measuring ETT cuff pressure while reducing the risk of complications.

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