Assessing Anesthesia Providers' Perceptions of Adequacy of Endotracheal Tube Cuff Pressure Assessment Techniques: A Doctor of Nursing Practice Project

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Notes from the Author

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Abstract

Endotracheal tube cuff pressure management is an important patient care intervention within the intraoperative setting. Current management practices include several subjective measurement methods as well as an objective manometer device. Due to a lack of consensus, there is no standardized method of assessing endotracheal tube cuff pressures used within the clinical setting today. The purpose of this quality improvement project was to assess anesthesia providers' perceptions of perioperative usefulness of subjective and objective assessment for obtaining adequate endotracheal tube cuff pressures. Current literature favors the manometer device and suggests there are negative implications with the use of subjective endotracheal tube cuff pressure measurement techniques. A video summarizing this currently available evidence was shared with the participating providers of this quality improvement project. Manometer devices were directly provided to the participating CRNAs for use, allowing them to make informed opinions on the perioperative usefulness of an objective manometer device as well as the subjective measurement methods they generally used. The purpose of this quality improvement initiative was to better understand anesthesia providers' perceptions of the available endotracheal tube cuff pressure management practices. Upon conclusion of the project implementation period, perceptions regarding subjective assessment of ETT cuff pressures shifted towards feelings of inadequacy as well as neutrality. In opposite fashion, opinions regarding the manometer device shifted towards a consensus of greater perceived adequacy. Furthermore, a planned change of behaviors was noted as the intent to use a manometer in the future increased among the majority of the participating CRNAs.

Keywords: endotracheal tube, cuff pressure, manometer, anesthesia, CRNA

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Section I. Introduction

Background

Appropriate cuff inflation of the endotracheal tube (ETT) is a necessary intervention in preventing the multitude of adverse effects associated with under- and over-inflated ETT cuffs in intubated patients. Currently, a cuff pressure reading between 20–30 centimeters of water (cm H_2O) is commonly regarded as safe for the intubated patient; cuff pressures above or below this range render the intubated patient at risk for complications not limited to tracheal stenosis, mucosal ischemia, micro aspiration, and inadequate ventilation (Hockey et al., 2016). Due to a lack of consensus, however, no standardized method of assessing cuff pressures currently exists in the perioperative setting (Hockey et al., 2016). Furthermore, there are no local or national benchmarks available to guide clinician practice.

Within the intraoperative setting, anesthesia providers, including Certified Registered Nurse Anesthetists (CRNAs) are responsible for patient intubation and subsequent inflation of the ETT cuff. With proper inflation the ETT is stabilized in the trachea, allowing for protection of the airway from gastric contents. Proper monitoring of the ETT cuff pressure is of utmost importance and resides within the intricate challenge of maintaining patient safety during anesthesia care.

Organizational Needs Statement

According to Tsaousi et al. (2016), the assessment and monitoring of ETT cuff pressures is often undervalued in the clinical setting; with this issue especially pronounced in the surgical setting. At a small rural hospital in eastern North Carolina, as in most other surgical settings (Hockey et al., 2016), a specific policy directed toward anesthesia provider management of the ETT cuff has not been delineated. This has led to the personal preference of CRNAs being the determining factor for the chosen cuff pressure measurement method. Available methods for assessing ETT cuff pressures include several subjective approaches that rely on estimation via palpation and auscultation as well as an objective method which utilizes a pressure measurement device known as a manometer. At the partnering institution, subjective measurement techniques are most commonly used to assess the appropriateness of the inflated ETT cuff. Manometer devices, though readily available at this facility, are not routinely utilized by the anesthesia providers after intubation and subsequent inflation of the ETT cuff (M.M., personal communication, August 17, 2020).

In the literature, researchers have noted inconsistencies in ETT cuff pressures obtained by the commonly used subjective methods (Bulamba et al., 2017; Tsaousi et al., 2016). Alternatively, in a systematic review and meta-analysis of seven randomized control trials and two pseudo-randomized control trials, an objective manometer device is suggested as being more accurate and reliable in assessing ETT cuff inflation (Hockey et al., 2016). Whichever method is chosen by the anesthesia provider, maintaining an appropriate ETT cuff pressure holds great significance in the intubated patient. This ETT cuff pressure, suggested to reside between 20–30 cm H_2O, is necessary in delicately balancing the functional seal of the airway alongside adequate tracheal perfusion (Hockey et al., 2016; Tsaousi et al., 2016). Methods that allow for ensuring and maintaining safe ETT cuff pressures are aligned with both the goals of Healthy People 2030 and the triple aim framework – each of which contribute to the overlying goal of providing safe, evidence-based patient care (Institute for Healthcare Improvement [IHI], 2020; Office of Disease Prevention and Health Promotion [ODPHP], 2020). In the realm of anesthesia, methods that allow for procurement of safe ETT cuff pressures are also aligned with the priorities of the

Anesthesia Patient Safety Foundation (APSF, 2021) as well as the core values of the American Association of Nurse Anesthetists (AANA, 2021).

Listed as a Healthy People 2030 objective, “health care” headlines the organization’s goal of ensuring high-quality health care to all American citizens (ODPHP, 2020). High-quality health care is a substantial component of ensuring that patients have the opportunity to improve their well-being. According to the ODPHP (2020), strategies that support health care providers in remaining cognizant of treatment recommendations are key in bettering patient health. As ETTs are routinely used, increased awareness of the importance of safe ETT cuff pressures and the various options available for monitoring these pressures is likewise necessary in preventing healthcare-related complications and enhancing patient health.

The triple aim is a triangular framework outlining three measures designed to ensure feasible and effective delivery of patient care. The three measures include positive patient experience, maximized population health, and medical cost containment (IHI, 2020). Health care systems that drive practices towards achieving these measures are able to optimize their performance and best meet the challenging medical demands of today (IHI, 2020). The benefits of ETT cuff pressure monitoring are in alignment with the triple aim framework. This alignment is evidenced by the documented capability of adequate ETT cuff pressures to reduce possible adverse effects of over- and under-inflated ETT cuffs (positive patient experience); to facilitate post-operative patient health and functional status (public health improvement); and to limit the incidence of complications from improper cuff inflation needing further medical treatment (cost containment).

Listed as one of APSF’s top ten perioperative patient safety priorities, “preventing, detecting, determining pathogenesis, and mitigating clinical deterioration in the perioperative period" (APSF, 2021, Perioperative Patient Safety Priorities section) stands as the third safety priority of the organization. Within this priority, APSF mentions the need for early warning systems in all perioperative patients. Active ETT cuff pressure monitoring provides an early indication of unsafe ETT cuff pressures and allows anesthesia personnel to perform timely cuff pressure adjustments, lessening the risk of patient harm.

Lastly, listed as one of the AANA's core values, "professionalism" highlights the AANA's desire for nurse anesthetists to demonstrate professionalism through continuing their education, maintaining their accountability, and heightening their standards of patient care (AANA, 2021). ETT cuff pressure monitoring resides within this core value of professionalism as it encourages anesthesia personnel to remain accountable in obtaining and maintaining safe ETT cuff pressures in their patients and it improves the quality of anesthetic care provided to the surgical patient.

Problem Statement

Safe ETT cuff pressure management can be obtained via subjective and objective measurement methods. Within the surgical setting at the partnering hospital, selection of one method for ETT cuff pressure management is determined by individual anesthesia provider preference. At this time, there is a current lack of understanding regarding anesthesia provider preference for one method over the other to monitor ETT cuff pressures.

Purpose Statement

The purpose of this quality improvement (QI) project was to assess anesthesia providers' perceptions of perioperative usefulness of subjective assessment (tactile) and objective assessment (manometer) for obtaining adequate ETT cuff pressures.

Section II. Evidence

Literature Review

A literature review was conducted to investigate best practices for ETT cuff pressure management as well as QI initiatives focused on intraoperative ETT cuff pressure monitoring. A comprehensive search strategy utilizing PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), ProQuest Search, and Google Scholar was performed. Each source was limited to the previous five years (2015-2020) other than Google Scholar – which was limited to the previous six years (2014-2020). Related articles and references from selected papers were also reviewed.

Utilizing guidelines by Melynk and Fineout-Overholt (2011), evidence ranging from level I (systematic review of randomized controlled trials) through level VI (single descriptive or qualitative study) was accepted. Institutional QI initiatives were also considered as long as the focus was placed on ETT cuff pressure management within the operating room or the comparison between subjective and objective methods in obtaining safe pressures. Individual keywords and search terms utilized in the searches can be found in Appendix A. The specifics of each search strategy are displayed in Appendix B. Lastly, a literature matrix listing the included studies and QI initiatives can be found in Appendix C.

Current State of Knowledge

Within the trachea, the ETT cuff serves as an important barrier to gastric contents and creates a seal for anesthetic gas flow. Unfortunately, adverse sequelae exist for both under-inflation and over-inflation of the ETT cuff. These sequelae range in severity and might include hoarseness, aspiration, mucosal ischemia, tracheal stenosis, or inadequate ventilation (Hockey et al., 2016). Several methods commonly utilized today allow for the subjective assessment of ETT cuff pressure in the intubated patient.

The most commonly utilized subjective method, based upon its simplicity and ease, includes manual pilot balloon palpation with tactile feedback as a qualitative estimate of cuff pressure within the trachea (Tsaousi et al., 2016). In addition to the palpation method, other subjective methods include the minimal occlusive volume (MinVol) technique and the minimum leak (MinLeak) technique. The MinVol is obtained with the elimination of an audible end-inspiratory leak while the MinLeak technique is characterized by a slight leak that can be auscultated via stethoscope upon termination of patient inspiration. The fourth subjective technique is known as the air-return/loss of resistance (LOR) method. This technique involves clinicians assessing for passive air return back into a syringe after the ETT cuff has been purposely over-inflated. The idea with the air return/LOR method, though less commonly utilized today, is that excess air within the ETT cuff is released back into the syringe as a result of pressure from the tracheal wall (Tsaousi et al., 2016).

In a randomized controlled study (Level II) comparing the efficacy of the four subjective cuff pressure measurement methods, Tsaousi et al. (2016) observed post-operative sore throat as a frequent complaint, associated with each of the subjective cuff inflation techniques. Furthermore, these authors discovered a high risk for cuff over-inflation using the palpation technique and high risk for cuff under-inflation using the MinLeak technique. Laryngotracheal complications including sore throat, hoarseness, and dysphagia were observed most frequently with the palpation technique but were minimized with the MinVol technique and MinLeak technique. Notably, the air return/LOR method resulted in ETT cuff pressures most frequently within the safe margins of ETT cuff pressures (Tsaousi et al., 2016).

In a prospective controlled study (Level IV), Ünsal et al. (2018) similarly acknowledged the risk for ETT cuff over-inflation and increased frequency of laryngotracheal complaints from patients within their control group who received cuff inflation via the palpation method. Likewise, in a randomized controlled study (Level II), Bulamba et al. (2017) discovered poor performance of the palpation method with the number of optimal ETT cuff pressures obtained via palpation being significantly lower in number as compared to the air return/LOR method. Interestingly, in a randomized prospective study (Level II), Saraçoglu et al. (2014) discovered that anesthesia provider experience exhibited no correlation with the achievement of safe ETT cuff pressures after providers were instructed to inflate the cuff to a level that they perceived as appropriate.

With the findings of inaccuracy associated with a majority of the subjective ETT cuff pressure inflation techniques, several suggestions have been made within the literature to change current practices. One suggestion includes utilizing objective measurements obtained by a manometer. In a prospective, double-blind, randomized controlled study (Level II) Ganason et al. (2019) compared the percentage of post-operative airway complications utilizing pilot balloon palpation versus objective measurement. These investigators concluded that objective adjustment of ETT cuff pressures to 25 cm H_2O reduces post-operative complications such as sore throat and cough as compared to pilot balloon palpation. Upon conclusion of their study, Ünsal et al. (2018) made the similar suggestion to utilize a manometer device to decrease upper airway complications secondary to inappropriately inflated ETT cuffs.

Providing further support for objective management of the ETT cuff, in their systematic review and meta-analysis (Level I), Hockey et al. (2016) examined whether or not objective cuff pressure measurement as compared to subjective cuff pressure measurement was advantageous in limiting adverse effects from mechanical airway use within the operating room. The authors noted strong evidence that adjustments of cuff pressure guided by a manometer were effective in ensuring accurate cuff pressures as well as preventing the adverse effects associated with unsafe cuff pressures. Despite this common trend in literature findings, subjective cuff pressure methods remain commonplace in practice and guidelines regarding ETT cuff pressure monitoring are lacking (Feng et al., 2015). Without specific guidelines, personal preference remains the determining factor behind the chosen cuff pressure measurement method for the anesthesia provider; and these personal preferences remain poorly understood.

Current Approaches to Solving Population Problem

Several QI initiatives were also identified and reviewed in the previously described literature search – each addressing appropriate intraoperative cuff pressure measurement and management (Ashman et al., 2017; Fritz et al., 2020; Seyed Siamdoust et al., 2015; Stevens, et al., 2018; Turner et al., 2020). With current literary evidence leaning towards manometer use, the approaches utilized by the authors of these QI initiatives commonly included educational intervention regarding ETT cuff pressure management, provision of manometers to anesthesia providers, and placement of reminder labels on anesthesia machines. As these QI initiatives were incorporated, cuff pressure monitoring practices improved.

Fritz et al. (2020) utilized an educational module that included step-by-step instructions on manometer use. A pre- and post-intervention questionnaire was utilized to determine the impact of the educational intervention on anesthesia provider knowledge. Cuff pressures and patient surveys regarding post-operative complications were also obtained before and after the QI intervention.

Turner et al. (2020) likewise implemented an evidence-based educational intervention for anesthesia providers at a single medical center with the intent to improve ETT cuff pressure knowledge, increase the charting of cuff pressures, and increase manometer utilization. Electronic charting reminders were implemented, manometers were made available in each operating room, and labels with the recommended cuff pressure range were placed onto each available anesthesia machine. A pre-intervention data collection tool was used to assess pre-intervention practices as well as baseline knowledge. A post-intervention data collection tool was utilized to assess the efficacy of the QI project while a medical chart review was conducted to assess cuff pressure documentation adherence.

Stevens et al. (2018) also utilized an educational initiative focused on increasing manometer use intraoperatively. Operating rooms were stocked with manometers, sticker reminders were placed on machines, and manometer education was provided. The effectiveness of the QI initiative was assessed via pre- and post-intervention cuff pressure measurements.

Ashman el al. (2017) aimed to increase the frequency of manometer use as well as decrease the occurrence of high cuff pressures by 25% in the OR at a single facility by providing an educational intervention that highlighted the inaccuracy of pilot balloon palpation. Pre- and post-intervention ETT cuff pressures measurements were obtained in assessing the effectiveness of the QI project. Furthermore, these clinicians utilized self-reporting by the involved providers as to whether they quantitatively monitored and adjusted cuff pressures intraoperatively both before and after the intervention.

On an alternate note, Seyed Siamdoust et al. (2015) implemented an educational initiative focusing on improving the safety of the palpation estimation technique, acknowledging that manometers may not be available at all times. In their initiative, involved anesthesia providers were requested to inflate an ETT cuff via their typical inflation method. The pressure of the ETT cuff was then measured with a manometer and the obtained pressure was shared with the provider. The anesthesia providers were then given the opportunity to train their fingers via palpation of the pilot balloon alongside a validated manometer measurement.

Each of these five QI initiatives relied on an educational intervention that led to successful outcomes based on their varying intents. In partnership with this author's participating organization, the implemented QI intervention focused on utilizing a multi-media educational intervention that highlighted the available subjective and objective methods of ETT cuff pressure management alongside the evidence-based recommendations for use. The educational intervention highlighted the importance of ensuring ETT cuff inflation pressures within the recommended range. This QI project's purpose was modified from the aforementioned QI initiatives to seek a direct understanding of anesthesia provider perceptions behind ETT cuff pressure management as well as their opinions of adequacy for their chosen method of cuff inflation.

Evidence to Support the Intervention

Evidence presented by the authors of the previously mentioned QI projects supported the implementation of a modified initiative at the partnering organization. In their educational QI initiative, Fritz et al. (2020) discovered a lower occurrence of post-operative complications associated with ETTs after the provision of an educational seminar regarding ETT cuff pressure management. Turner et al. (2020) observed a statistically significant increase in the rate of appropriate ETT cuff pressures as well as an improvement in the frequency of pressure checks and anesthesia provider knowledge after the provision of their evidence-based educational QI project. Stevens et al. (2018) likewise observed a statistically significant improvement in appropriate cuff pressures after the implementation of their educational QI initiative. Ashman et al. (2017) witnessed a decrease in mean ETT cuff pressure after the provision of their educational QI intervention as well as an increase in provider monitoring. Lastly, Seyed Siamdoust et al. (2015) observed a significant improvement in ETT cuff pressures via the palpation method after the implementation of their educational intervention. Alongside their acknowledgement that formal education on the importance of safe ETT cuff pressures is neglected amongst anesthesia learners, these authors suggested that an educational program which introduces subjective techniques for ETT cuff inflation will improve the safety of such techniques when utilized.

Though the purpose of this QI initiative differed from the aforementioned ones, increased discussion regarding ETT cuff pressure management as well as improved ETT cuff pressure awareness was anticipated to occur amongst the CRNA participants as a result of the initiative. Assessment was focused on identifying changes in anesthesia provider perceptions regarding ETT cuff pressure management before and after the educational intervention.

Evidence-Based Practice Framework

The ACE star model of knowledge transformation (ACE star model) is a conceptual framework highly applicable to the current knowledge and practice issue of ETT cuff pressure monitoring. This model, developed by Stevens (2012), contends that “the complexity of knowledge, including volume, and the form of available knowledge” (para. 1) can serve as barriers to providing evidence-based care. The ACE star model addresses these barriers through a framework consisting of five stages of building knowledge: “1) discovery research, 2) evidence summary, 3) translation to guidelines, 4) practice integration and 5) process, outcome evaluation" (Stevens, 2012, The Star Model section, para. 2). The goal of this framework is to operationalize scientific literature for direct incorporation into clinical practice (Stevens, 2012).

Current literature regarding the clinical issue of ETT cuff pressure monitoring has achieved stage two within the ACE star model, which consists of an evidence summary (Stevens, 2012). The summary of evidence serves to synthesize the vast volume of primary evidence into a meaningful statement and must come from a systematic review of randomized controlled studies. Under the topic of ETT cuff pressure monitoring, the systematic review and meta-analysis by Hockey et al. (2016) serves as a high level of evidence on which to base a change from current subjective cuff pressure management practices to the consistent use of objective methods.

Though stage two has been achieved on a grander scale, the provision of this evidence summary to anesthesia providers within the partnering institution served as an efficacious method of directly increasing provider awareness and promoting initial discussion of ETT cuff pressure management practices. The intent of this QI initiative was not to change current practices or to form new guidelines, but to better understand anesthesia providers' perceptions of available ETT cuff pressure management practices. Ultimately, discussion of current clinical practices and analysis of personnel perceptions may prevent institutions from being overly comfortable with the status quo and encourage an atmosphere that supports evolving patient care rooted in safety.

Ethical Consideration & Protection of Human subjects

In preparation for the formal approval process by the Institutional Review Board (IRB), the author participated in training via the Collaborative Institutional Training Initiative (CITI) program. This online program provides comprehensive training addressing the safety of human subjects as well as the ethics of research (CITI, 2018). Additionally, this project was deemed as exempt from full review through a process created in conjunction with the East Carolina University (ECU) IRB and the partnering organization (see Appendix D).

As this QI project involved current accepted anesthesia provider practices, ethical considerations were minimal. ETT cuff pressures were already assessed in a variety of ways by the participating anesthesia providers qualified to do so within their scope of practice. Within the educational intervention, alongside the discussion of the manometer, the recommended ETT cuff pressure range (20-30 cm H_2O) presented was based on evidence, not experimental in nature. No patient information or personal identifiers for patients or anesthesia participants were recorded or maintained as part of this project, eliminating the potential for future misuse.

Section III. Project Design

Project Site and Population

Description of the Setting

The setting for this DNP project was within the operating rooms of a small, rural hospital located in eastern North Carolina. Manometers were available within this facility but not frequently used. To facilitate the implementation of this DNP project, manometers were directly provided to the participating CRNAs. Project implementation was facilitated by the project chair who served as a liaison between the project team and the practicing CRNAs; which was especially helpful during the COVID-19 pandemic and its associated restrictions on social interactions and gatherings among staff members and students.

Description of the Population

The population of interest in this DNP project was anesthesia providers – with a sample consisting of five CRNAs who provided anesthesia services at the participating facility. These CRNAs were responsible for administering anesthesia care for patients undergoing various types of surgery. The participating CRNAs had various backgrounds and levels of work experience (T.C., personal communication, January 7, 2020). Demographic factors were not considered pertinent to the focus of this DNP project and thus were not collected as data. Voluntary participation, CRNA interest in ETT cuff pressure management, and CRNA concern for ETT safety in the intubated patient were all identified as facilitators of the successful implementation of this DNP project. Participant resistance to change, participant perceptions of cost, and the fast-paced nature of the operating room were identified as potential barriers.

Project Team

The project team consisted of a student registered nurse anesthetist (SRNA) who served as the lead of this DNP project as well as a CRNA clinical faculty member who served as the project chair, content specialist, and liaison to the clinical setting. There was also a non-faculty site representative, the department chair, and a non-CRNA faculty member who supported the technical aspects of the project. Initial project development was completed collegially with three other students, but implementation, data collection, and data analysis were performed independently by the student lead. The CRNA clinical faculty member provided assistance with recruitment of participants and implementation of the DNP project amongst the aforementioned CRNA population. The site representative provided clearance for the implementation of this project by the project team.

Project Goals and Outcome Measures

Description of the Methods and Measurement

This DNP initiative employed pre-survey/intervention/post-survey methodology and was guided by the four stages of the Plan-Do-Study-Act (PDSA) cycle. The four stages of this cycle include planning the initiative, carrying out the initiative, analyzing the results, and reacting to what has been learned (Institute for Healthcare Improvement, 2021). The fourth stage of the PDSA cycle will not be discussed here as it was beyond the scope of this scholarly project.

Within stage one of the PDSA cycle, upon approval through the established review processes, a scripted multi-media video presentation was prepared and produced by four SRNAs within the university's nurse anesthesia program. Through textual display as well as voiceover audio, this educational video addressed the importance of ETT cuff pressure monitoring and discussed the various methods for ETT cuff pressure management. A brief discussion about ETT cuff pressure management via the manometer was also included. The discussion contained in the video presentation first highlighted the evidence-based range for ETT cuff pressures and acknowledged the risks associated with under- and over-inflated ETT cuffs. The video presentation went on to highlight the available subjective methods for ETT cuff pressure management followed by the introduction of the manometer device and its proposed role in adding safety to ETT cuff inflation. A recorded closeup visual of the manometer device available within the partnering institution was presented, followed by video demonstration of proper manometer use in inflating and measuring the ETT cuff pressure using a simulation mannikin. The succinct educational video (3.5 minutes) concluded by thanking the participating viewer and summarizing the project implementation timeline.

Within stage two of the PDSA cycle, an invitation email was sent to the nonrandomized convenience sample of CRNA volunteers. The invitation email contained a link to the educational video as well as a link to the anonymous Qualtrics survey. Consent was obtained by the CRNA clicking on the survey link, completing the pre-intervention survey, and carrying out the intervention. Instructions were provided to the recipients, advising them to first answer the survey questions and then watch the linked video. An estimated allotment of time needed to complete the survey and view the video was provided within the initial instructions in an effort to encourage participation. Furthermore, each participant was personally informed that they would receive a follow-up survey upon completion of the two-week implementation period. Both surveys utilized multi-formatted questions in order to obtain yes/no, Likert scale, and open-ended responses regarding perceptions of ETT cuff pressure practices. The ultimate goal of this project was to gain further insight into anesthesia provider's perceptions of adequacy regarding the various assessment methods of ETT cuff pressures.

Discussion of the Data Collection Process

The initial (see Appendix E) and follow-up (see Appendix F) surveys shared via email with the participating CRNAs from the partnering organization served as the basis for the data collection in this DNP project. The CRNAs received an anonymous link to the initial survey to be completed before viewing the educational intervention. They then received an email containing the follow-up survey link after the two-week implementation period. Within stage three of the PDSA cycle, a summary report of each survey was preliminarily assessed via the descriptive statistics offered through the Qualtrics survey program. Collected data were then transferred to Excel software for data analysis.

Implementation Plan

Upon completion of the literature review and finalization of the project idea and assessment methods, the implementation plan for this DNP project began with drafting and finalizing the pre–intervention and post-intervention surveys. Upon completion of the surveys, the educational video was created, filmed, and edited by four SRNA colleagues. The next step in the implementation process was recruiting CRNA volunteers from the partnering organization. These volunteers needed to be willing to participate in a QI initiative focused on understanding anesthesia provider preferences regarding ETT cuff pressure management. Recruitment of participants was accomplished by the project chair as, due to COVID-19 restrictions, social interactions were limited and gatherings such as staff meetings were either being canceled or performed virtually. Prospective volunteers were informed about the educational video presentation as well as the two short surveys, one to be completed before and one after viewing of the educational video associated with the DNP project.

After obtaining the email addresses of the five CRNA volunteers for online contact, each participant was sent the invitational email along with links to the pre-intervention Qualtrics survey and educational video on the first day of project implementation. Each was encouraged to complete the initial survey and video within 24 hours of receipt so as to allow an appropriate timeframe for clinical practice implementation prior to the post-intervention survey. Manometers, though already available within the partnering institution, were directly provided to the participating CRNAs on the first day of on-site project implementation. Two weeks after sending out the initial survey, an anonymous post-intervention survey was sent to each participant via email.

Timeline

The timeline for this project began in August 2020 and concluded in November 2021. Though project implementation periods for each participant involved only two weeks, implementation was somewhat staggered for individual CRNA convenience. The project implementation period followed by data collection spanned approximately six-weeks during the months of May and June 2021. A more detailed project timeline is available as Appendix G.

Section IV. Results and Findings

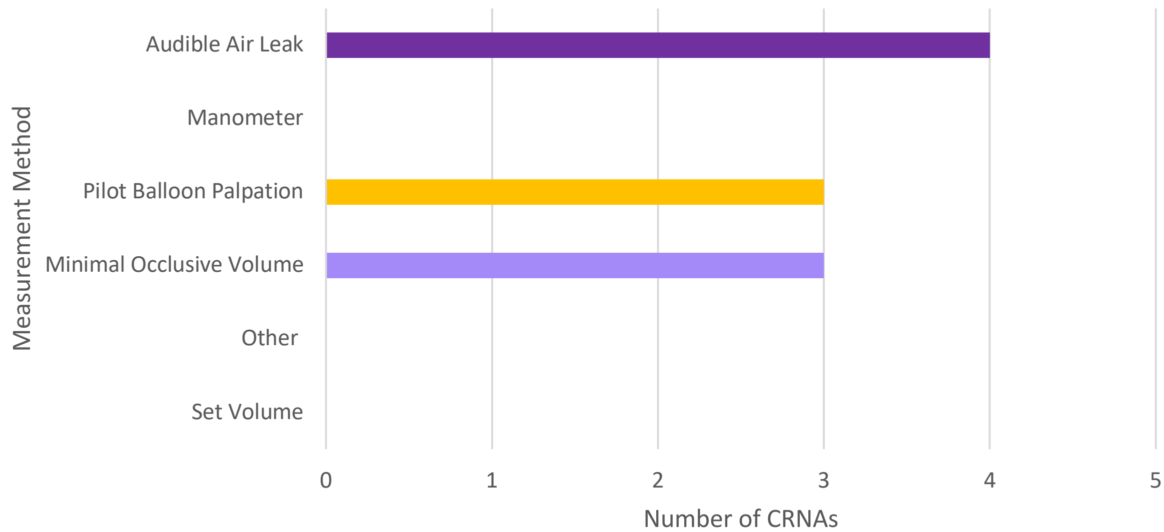
Results

The data collection for this DNP project spanned approximately six weeks due to the flexible timeline provided to each of the participating CRNAs. Initial data collection was performed via a Qualtrics pre-intervention survey sent via email using an anonymous link. The email was sent on May 24, 2021 with 5 responses received during the time frame of May 24, 2021 to June 14, 2021. The pre-intervention survey focused on assessing current ETT cuff pressure measurement methods utilized by the participating CRNAs, along with their opinions on subjective and objective measurement practices. The frequency of subjective versus objective measurement practices utilized by the participating CRNAs was also assessed. Follow-up data collection was performed via a second anonymous Qualtrics survey sent two weeks (June 07, 2021) after the initial email. Responses for the post-survey were collected during the time frame of June 07, 2021 to June 30, 2021.

In the pre-intervention survey, the most common method for obtaining ETT cuff pressures reported by the participating CRNAs was the audible air leak method, with 4 out of the 5 CRNAs selecting this option (see Figure 1). Following the audible air leak method, the minimal occlusive volume technique and the pilot balloon palpation method were also favored. No participating CRNAs selected the manometer as a favored method of choice for obtaining adequate ETT cuff pressures. Of note, 1 CRNA mentioned in the free response, ‘other’ answer choice, that they ‘have not found manometers freely available’ at the participating facility.

Figure 1

Pre-Intervention: Preferred ETT Cuff Pressure Measurement Methods (n =5)



Note. Each CRNA had the option to select all measurement methods applicable to their practice.

In assessing the CRNAs' opinions of adequacy regarding the use of subjective assessment techniques for ETT cuff pressures, 4 CRNAs selected that subjective assessment was somewhat adequate for obtaining appropriate ETT cuff pressures whereas 1 selected that subjective assessment was neither adequate nor inadequate. In assessing the sole use of subjective assessment of ETT cuff pressures, 4 CRNAs selected that they utilize subjective assessment methods most of the time, whereas 1 selected that they always utilize subjective assessment methods to assess ETT cuff pressures. In assessing the anesthesia providers' reliance on objective ETT cuff pressure measurement, 4 CRNAs selected that they do not use a manometer whereas 1 selected that they use a manometer less than 25% of the time in order to obtain an appropriate ETT cuff pressure. Lastly, in assessing opinions on objective ETT cuff pressure measurement, 4 CRNAs selected that this method is somewhat adequate whereas 1 selected that the manometer is somewhat inadequate for obtaining an appropriate ETT cuff pressure.

In the post-intervention survey, the maximum number of times a CRNA utilized the manometer during their two week implementation period was 12 times, whereas the minimum was 3 times. The median number of times the manometer was used by participating CRNAs was 5. In assessing the CRNAs' opinions of adequacy regarding subjective assessment of ETT cuff pressures post-intervention, 1 selected subjective assessment as somewhat adequate; 2 selected neither adequate nor inadequate; 1 selected somewhat inadequate, and 1 selected extremely inadequate. In assessing the CRNAs' opinions of adequacy regarding objective measurement for obtaining appropriate ETT cuff pressures, 4 selected this method as being extremely adequate whereas 1 selected somewhat adequate.

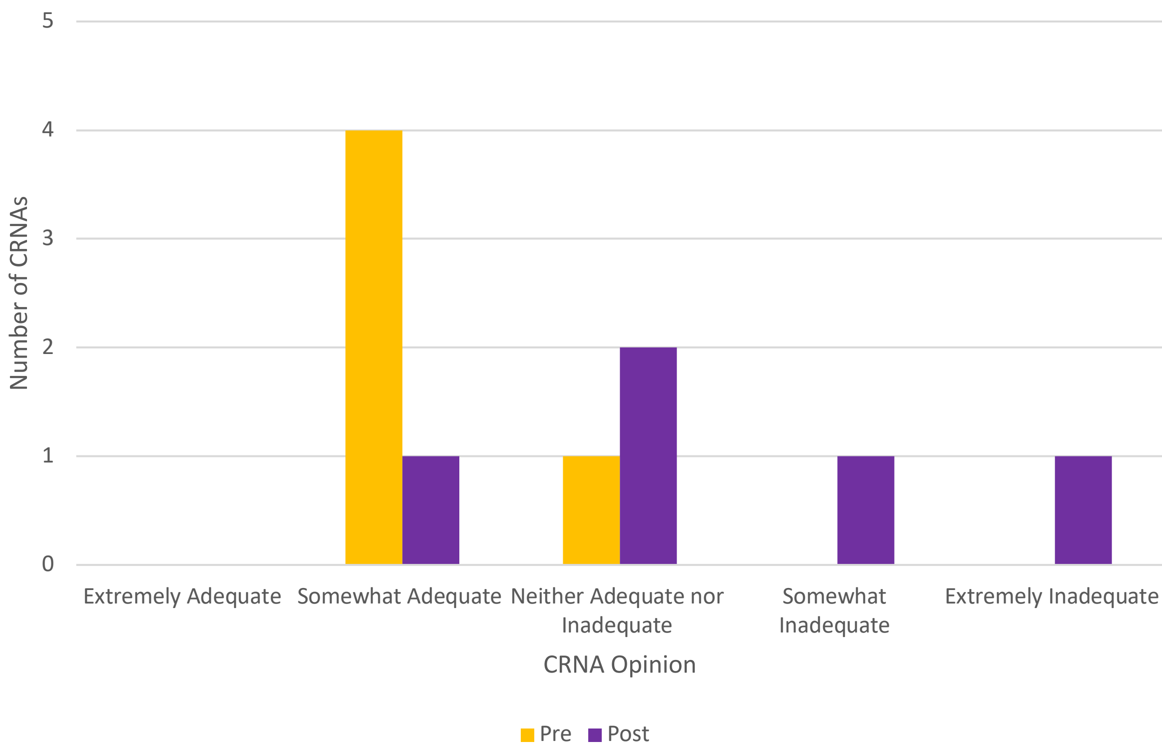
In assessing the CRNAs' predicted sole use of subjective ETT cuff pressure assessment methods, 2 CRNAs selected that they intended to solely utilize subjective assessment methods about half the time whereas 3 selected that they intended to solely utilize subjective assessment methods most of the time. Alongside this data, in assessing future use of the manometer by the CRNAs, 2 selected that they planned to utilize the manometer less than 25% of the time; 2 planned to utilize the manometer 25-50% of the time, and 1 planned to utilize the manometer 50-75% of the time. Lastly, in assessing the CRNAs' opinions on the types of cases to most-benefit from the use of manometer, the mode of the free responses was pediatric cases, followed by cases with long operating times.

Analysis

Several of the survey questions were scripted purposefully to allow for direct comparison of CRNA perceptions prior to, and after, the educational intervention and provision of manometers. Upon conclusion of the project implementation period, the opinions of adequacy regarding subjective ETT cuff pressure measurement methods showed a shift away from the initial consensus of subjective assessment as being somewhat adequate. Figure 2 portrays the difference in opinions following the project implementation period.

Figure 2

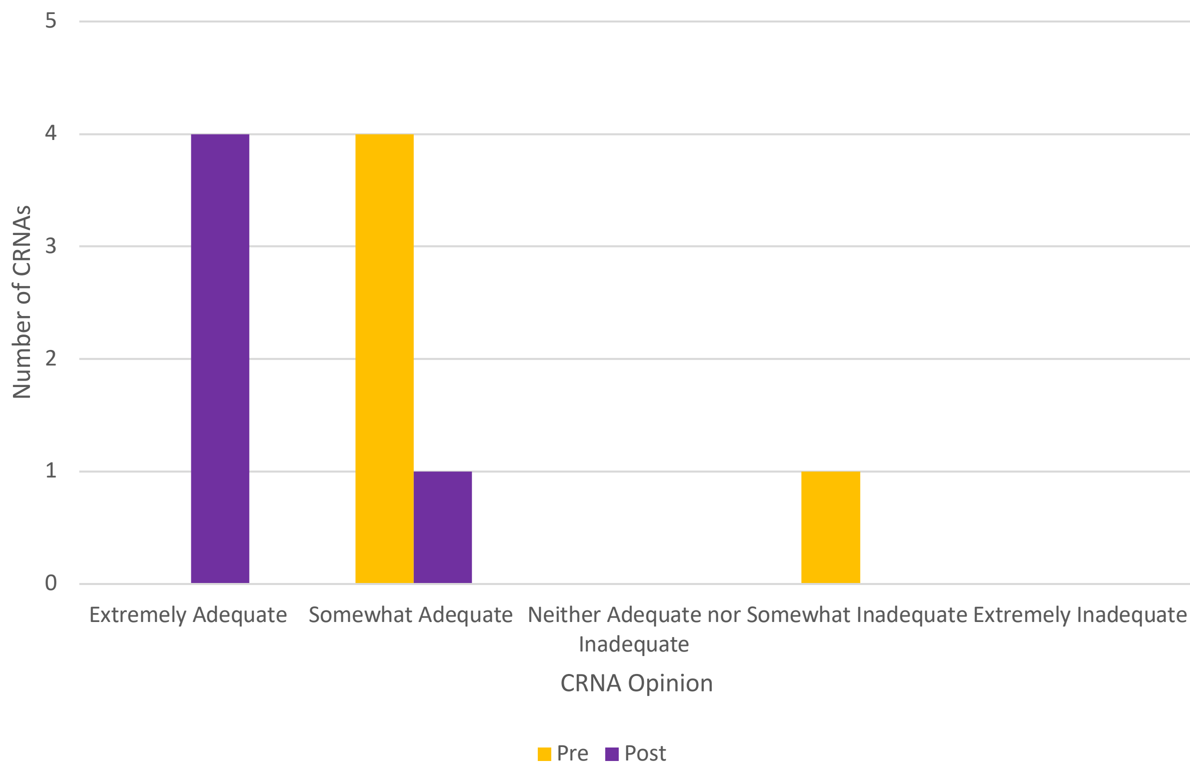
Opinion on Subjective Assessment of ETT Cuff Pressure: Pre- and Post-intervention (n=5)



Upon conclusion of the project implementation period, there was also a shift in feelings of adequacy regarding the manometer after hands-on experience with the device was encouraged (see Figure 3). Whereas the responses prior to the intervention revealed most participants felt objective assessment of ETT cuff pressure was somewhat adequate, after the intervention most participants reported that objective assessment was extremely adequate. Furthermore, 1 CRNA's initial opinion of the manometer being somewhat inadequate, was shifted towards an opinion of increased adequacy. Whether this shift was to somewhat or extremely adequate is unclear due to the anonymous nature of the data collection.

Figure 3

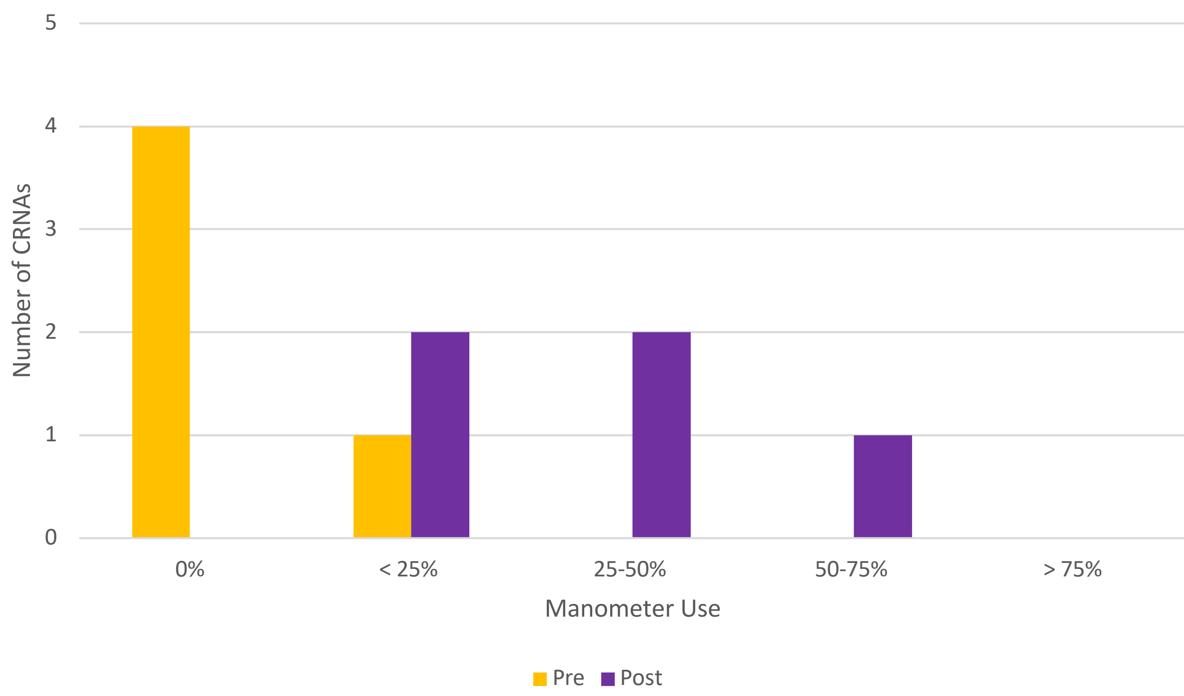
Opinion on Objective Assessment of ETT Cuff Pressure: Pre- and Post-intervention (n=5)



Each survey contained a question regarding manometer use, one current (pre-intervention) and one predicted (post-intervention). With a majority of the CRNAs reporting not utilizing the manometer device in practice prior to the project implementation period, a positive shift in future manometer use was observed, with 2 CRNAs planning to use the manometer less than 25% of the time, 2 CRNAs 25-50% of the time, and 1 CRNA 50-75% of the time (see Figure 4).

Figure 4

Manometer Use: Pre- and Post-Intervention (n = 5)



The purpose of this QI project was to increase understanding of anesthesia provider perceptions behind ETT cuff pressure management techniques. Through the educational video as well as direct provision of manometers to the participating CRNAs, a change was observed in anesthesia provider perceptions regarding ETT cuff pressure management. Prior to the project, manometer use was infrequent among the anesthesia providers. As a result, perceptions of this technique were similar to those of subjective assessment methods, with somewhat adequate being the mode response for each. Upon conclusion of the project implementation period, perceptions regarding subjective assessment of ETT cuff pressures shifted towards feelings of inadequacy as well as neutrality. In opposite fashion, opinions regarding the manometer device shifted towards a consensus of greater perceived adequacy. Furthermore, a planned change of behaviors was noted as the intent to use a manometer in the future increased among the majority of the participating CRNAs.

Increased familiarity with and knowledge of the manometer device after the project intervention appear to have contributed to observed changes in perceptions regarding subjective and objective ETT cuff pressure measurement methods. Though manometers are (and have been) readily available to the practicing CRNAs, their use is limited as subjective ETT cuff pressure measurement methods remain commonplace. Furthermore, within the facility, it appears the location of the manometer devices may not be widely known by all CRNAs. With limited awareness of and familiarity with the manometer, the device is an under-utilized tool at the participating facility. This conclusion is supported by the results of this QI project; through provider education and direct provision of manometers, perceptions of the manometer device became more favorable and estimates of future use increased.

Section V. Interpretation and Implications

Cost Benefit Analysis

ETT cuff pressure measurement practices may have important cost-benefit implications in clinical practice. Upon intubation of the intraoperative patient, the anesthesia provider's goal is to secure an ETT cuff pressure that not only allows for adequate tidal volumes to be delivered to the patient but also serves as an important barrier between gastric and airway contents. Most importantly, this goal must be obtained without damaging or compromising blood flow to the surrounding structures.

One of the possible adverse effects of an improperly inflated ETT cuff is laryngotracheal stenosis. Laryngotracheal stenosis is a costly and resource-intensive complication; in a retrospective cohort study by Yin et al. (2018), the mean laryngotracheal stenosis costs were found to be $4,080.09 annually for the associated treatments and medical visits (p. 3). Furthermore, in comparison to those patients with idiopathic laryngotracheal stenosis, patients with intubation-related laryngotracheal stenosis were burdened with significantly higher annual costs ($5,286.56 compared to $2,873.62; p. 3). Another adverse effect of an improperly inflated ETT cuff is ventilator-associated pneumonia (VAP) as a result of micro-aspiration and subsequent colonization of bacteria in the oropharynx and upper airways (Sethi, 2020). The estimated economic burden of VAP is far from insignificant and ranges from $10,000 to $40,000 per patient (Luckraz et al., 2017, p. 95).

In envisioning that this DNP project was an organizational endeavor rather than a student endeavor, a similar project initiated by the organization would be monetarily feasible, at little to no cost to the organization. The life of the manometer device stocked within the facility is limited to 100 patient uses at a cost of $39.95 per device (QuadMed, 2020). Thus each patient runs at a minimum cost of about $0.40 (one use) up to an estimated maximum of $2.00 (five uses). These minimum and maximum costs are insignificant compared to the thousands of morbidity and mortality costs associated with improperly inflated ETT cuffs. Notably, the total cost savings in one patient as a result of using the manometer device could be, at a minimum, $5,284.56 up to $39,999.60 as a result of preventing complications such as laryngotracheal stenosis and/or VAP. With the manometer device already stocked at the participating facility, education regarding this device could similarly be provided by emailing the educational video created within this DNP project to all of the organization's anesthesia providers. Educational resources found at the manometer manufacturer's website along with a reminder of the device's location within the facility could be included within the email for further education. This intervention may achieve results similar to those identified within this DNP project, costing the organization minimally, time-, money-, and employee-wise.

Benefits of the aforementioned project idea would include improved anesthesia provider awareness of the importance of ETT cuff pressure monitoring, increased competency amongst anesthesia providers on how to use a manometer, and increased awareness of manometer availability including stocking locations. Most importantly, the provision of such a project within this organization may serve to empower the employed anesthesia providers by allowing them to make more informed decisions regarding their ETT cuff pressure management practices. ETT cuff pressure management would likely improve, reducing potential ETT-related complications.

One negative implication associated with the implementation of the aforementioned organizational project might include improper use of the device, even with education. Improper use of the manometer could result in improperly inflated ETT cuff pressures and thus, the multitude of adverse effects associated with under- and over-inflated ETT cuffs as well as their associated costs. Furthermore, with increased awareness of objective ETT cuff pressure measurement, a higher demand than the facility's stock supply could certainly result in an initial shortage of the devices at the participating facility. With an increase in demand, an increase in manometer stock supply would be required, producing an increase in costs for the organization. Acknowledging the possible negatives, the implementation of the suggested project would still favor a good return on the facility's investment in improved education regarding ETT cuff pressure management.

Resource Management

Contributing to the success of this DNP project was the already established availability of manometer devices at the participating facility. The provision of these devices to participating CRNAs was seamless during the project implementation period. A potential limitation at the participating facility was lack of current information regarding ETT cuff pressure management as well as instructions on how to utilize the stocked manometers. The project's informational video closed the existing knowledge gap amongst the participating CRNAs and allowed for their informed use of the manometer devices during their two-week project implementation period. An additional existing limitation to manometer use at the participating facility was lack of knowledge among CRNAs on where the manometers were located and that the manometers were available for them to use. Direct provision of these devices during the intervention allowed the participating CRNAs to access and trial the manometers. Relocation of the stocked manometer devices to a more common area and within each anesthesia workstation may promote increased awareness of the device and subsequent use. Furthermore, education about the device via the emailed video would likewise increase awareness and promote use of the tool. Providing educational resources and relocating the stocked manometers would certainly be feasible and add to successful outcomes.

Implications of the Findings

This DNP project increased the awareness of ETT cuff pressure monitoring amongst the participating CRNAs and allowed them to assess their perceptions of adequacy regarding the subjective and objective methods of ETT cuff pressure monitoring. In the realm of anesthesia, methods that support measurement and management of safe ETT cuff pressures are aligned with the priorities of the Anesthesia Patient Safety Foundation (APSF, 2021) and the core values of the American Association of Nurse Anesthetists (AANA, 2021). Active ETT cuff pressure monitoring is an important factor in maintaining the safety of the intraoperative patient. Whether the chosen method is subjective or objective, ETT cuff pressure monitoring serves as a method of identifying potentially unsafe ETT cuff pressures. Accurate assessments allow anesthesia providers to perform timely cuff pressure adjustments, lessening the risk of patient harm. This safety measure is in alignment with the APSF's safety priority of "preventing, detecting, determining pathogenesis, and mitigating clinical deterioration in the perioperative period" (APSF, 2021, Perioperative Patient Safety Priorities section). Furthermore, active and systematic ETT cuff pressure monitoring resides within the AANA's core value of "professionalism," which highlights the AANA's goal for CRNAs to remain accountable for their patient actions and to heighten their standards of patient care.

Revisiting the ACE star model, the clinical issue of ETT cuff pressure monitoring has achieved stage two, which consists of an evidence summary (Stevens, 2012). This evidence summary regarding ETT cuff pressure monitoring exists as the systematic review and meta-analysis by Hockey et al. (2016) which presents the recommendation of switching current ETT cuff pressure measurement practices to the objective manometer device. The provision of this evidence summary to the anesthesia providers within the partnering institution successfully increased their awareness of ETT cuff pressure measurement methods and allowed the participating CRNAs to make more informed decisions regarding use of the available measurement methods.

In alignment with the support for use of objective ETT cuff pressure measurement (Hockey et al., 2016), the participating anesthesia providers developed more favorable opinions towards objective ETT cuff pressure measurement by the end of the project implementation period. Furthermore, this QI project negatively impacted participant opinions of adequacy regarding the subjective ETT cuff pressure measurement methods. Based on the comparison of pre-intervention and post-intervention survey answers, rather than remaining overly comfortable with the status quo of subjective ETT cuff pressure measurement methods, the participating anesthesia providers developed an increased appreciation for the less-utilized objective measurement method. This increased appreciation may positively impact future implementation efforts by the organization to evolve a standard of care for ETT cuff pressure management. Furthermore, future anesthesia department discussions regarding the patient safety issue of ETT cuff pressure monitoring should anticipate success if centered around education about the topic and if access to objective measurement devices is ensured.

Implications for Patients

Within the intraoperative setting, appropriate cuff inflation of the ETT is a necessary intervention in preventing the multitude of adverse effects associated with under- and over-inflated ETT cuffs in intubated patients. ETT cuff pressures outside of the accepted safety range render the intubated patient at risk for significant complications including tracheal stenosis, mucosal ischemia, micro aspiration, and inadequate ventilation (Hockey et al., 2016). Patients in every realm of the health system deserve to receive the highest standard of care. Within the operating room, it is the expectation of the patient that the anesthesia provider is aware of the risks of inadequate ETT cuff inflation pressures and understands the resources available for managing ETT cuff pressures to ensure a positive outcome for every patient.

Implications for Nursing Practice

Within the intraoperative setting, CRNAs and other anesthesia providers are responsible for patient intubation and subsequent inflation of the ETT cuff. With proper cuff inflation, the ETT is stabilized in the trachea and provides protection to the airway. In the same way that patients are hemodynamically monitored within the intraoperative period, proper intraoperative monitoring of the ETT cuff pressure is of great importance and should remain a priority within the intricate challenge of ensuring patient safety during anesthesia care. Improved CRNA awareness of the risks of inappropriate ETT cuff pressures and the alternatives for ETT cuff pressure monitoring supports patient care that is both safe and evidence-based.

Impact for Healthcare System

The entire healthcare system, along with its many specialties, is responsible for remaining abreast of all technological advancements and continuing to work towards improved patient standards. As the patient population continues to age and medical problems become more complex, medical advancements and practices that prevent adverse sequela associated with the provision of healthcare will become that much more important. Appropriate management of ETT cuff pressures is an important aspect of care not confined to the intraoperative setting; the information presented within this DNP project may also be translated to alternate care settings such as intensive care units and long-term acute care facilities.

Sustainability

The DNP project discussed within this text is a sustainable intervention for the partnering organization. The educational video created within this intervention has the feasibility of being made available to the organization at no additional cost to them. The manometers utilized within this DNP project cost just cents per use and already exist as a budgeted stock item for the organization. Furthermore, with 100 uses per manometer, the demand for these devices should remain reasonable enough for the organization to avoid a supply and demand issue. See Appendix H for a simplified budget of the organization's implementation of this sustainable QI project.

Dissemination Plan

The dissemination plan for this DNP project included the creation of a poster, coupled with an oral presentation that was delivered to an audience of faculty and students in the nurse anesthesia program as well as facility CRNAs involved in the project via an in-person presentation shared simultaneously via Zoom. The anesthesia provider participants of this QI project were informed of and invited to the presentation though not required to participate. Additionally, this scholarly paper has been posted within the university's digital archive, The Scholarship, which contains scholarly output from its community of faculty, staff, and students.

Section VI. Conclusion

Limitations

This DNP project had several limitations. First, the sample size was small – with only five CRNAs participating in the project. With such a small sample size, an in-depth statistical analysis was not appropriate. Second, self-reported data was utilized in the pre- and post-intervention results. This self-reported data could not be independently verified and may have contained bias. Each CRNA's participation in the intervention was limited to two weeks; a longer time period might have allowed more interaction with the manometer device, thus the collected opinions would be further supported by increased device familiarity. Fourth, the number of times the manometer was used by each CRNA varied from as little as 3 to a maximum of 12 times. With such differences in manometer use between participants, it seems appropriate to question whether the opinion of the CRNA who used the manometer only 3 times during this QI project had the same grounds for an opinion as the CRNA who used the manometer device 4 times more.

Recommendations for Others

With the limitations of this DNP projected identified, several recommendations for future implementation of a similar intervention by other students and/or organizations have been identified. First, it is recommended that in the planning phase of a future QI intervention, a larger sample size of CRNAs is obtained. Second, it is recommended that any future DNP projects utilize questions similar to the ones presented in this project. The pre- and post-intervention questions within this QI intervention were carefully scripted to allow for direct comparison of opinions before and after the project implementation period. Third, it is recommended that the implementation period of any future QI interventions be extended to at least one month; this will allow for the participating CRNAs to have a longer trial period with the manometer device and thus will improve the reliability of the collected opinions. Fourth, it is recommended that during the evaluation period of any similar DNP projects, descriptive statistics (measures of central tendency, range, and standard deviation) be utilized to analyze the data set. Due to the small size of this project, in-depth descriptive analysis of the data was not possible.

Recommendations for Further Study

It is recommended that future QI projects addressing the topic of ETT cuff pressure management focus not only anesthesia providers' perceptions of adequacy of ETT cuff pressure assessment techniques, but also investigate the performance of the manometer device as well as the various subjective assessment techniques in achieving safe ETT cuff pressures. Further investigation into the performance of subjective versus objective ETT cuff pressure management practices has the potential to improve anesthesia provider awareness of the effectiveness of the methods they routinely use and subsequently, promote the adoption of evidence-based techniques into clinical practice.

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Appendix A

Keywords, PubMed MeSH, and CINAHL Subject Headings Used for Literature Searches

	Concept		
	Endotracheal	Cuff pressure	Monitoring/Manometry
Keywords	Endotracheal	"Cuff pressure"	Monitoring
	"Endotracheal tube"	Pressure	Monitor
	"Endotracheal tubes"		Manometer
PubMed MeSH	___	Pressure [Mesh Terms]	Manometry [Mesh Terms]
CINAHL Subject Headings	(MH "Endotracheal Tubes")	(MH "Pressure") ___	(MH "Manometry) ___

Note. The identified keywords, PubMed MeSH terms, and CINAHL Subject Headings were utilized with Boolean operators to conduct a comprehensive literature search amongst the presented databases and one search engine (Google Scholar).

Appendix B

Search Strategy

Search date	Database or search engine	Search strategy	Limits applied	Citations Found/Kept
11/25/20	PubMed	(Endotracheal) AND (Pressure [Mesh] OR pressure) AND (Monitoring OR Manometer)	5 years (2015-2020)	196 found/20 kept
11/25/20	CINAHL	(MH “Endotracheal Tubes” OR “Endotracheal Tube”) AND (“Cuff Pressure”)	5 years (2015-2020)	198 found/11 kept
11/25/20	ProQuest Search	(Endotracheal) AND (Cuff) and (Pressure) AND (Monitor) AND (Manometer)	5 years (2015-2020)	161 found/9 kept
11/25/20	Google Scholar	(Endotracheal) AND (Cuff) and (Pressure) AND (Monitor) AND (Manometer)	6 years (2014-2020)	First 20 pages reviewed/10 kept

Note. Articles retrieved within the search were assessed for applicability via title and abstract review. Elimination targeted duplicate copies, those articles not available in English, and those articles not focused on the topic at hand.

Appendix C

Literature Matrix

Author/Year	Design/Level	Sample	Findings	Recommendation/Conclusion
Ashman, R.E, Appel, S.J, & Barbra, A. J. (2017)	QI	N = 204	Provider monitoring of ETT cuff pressures was increased post-educational intervention; the mean ETT cuff pressure was significantly lower post-educational intervention.	An educational intervention and reference cards were effective in increasing anesthesia provider monitoring of ETT cuffs intraoperatively.
Bulamba, F., Kintu, A., Ayupo, N., Kojjo, C., Ssemogerere, L., Wabule, A., & Kwizera, A. (2017)	Randomized controlled study, Level II	N = 178	The LOR method was superior to the palpation method in obtaining ETT cuff pressures within recommended range.	The LOR is preferable to the palpation method in estimating ETT cuff pressures but remains less superior than the manometer. A comparison between the LOR method and the MinLeak technique should be considered.
Fritz, A. V., Mickus, G. J., Vega, M. A., Renew, J. R., & Brull, S. J. (2020)	QI	N = 609	Manometry reduced the incidence of post-operative complications. Pre- versus post-intervention patient results: sore throat 35:31, hoarseness 30:13, & dysphagia 13:5.	An educational program that involves anesthesia provider training is feasible for implementation into clinical practice and can reduce postoperative airway complications.
Ganason, N., Sivanaser, V., Liu, C. Y., Maaya, M., & Ooi, J. S. (2019)	Prospective, double blind, randomized controlled study: Level II	N = 292	Manometry reduced the incidence of post-operative complications. Manometer versus palpation method results: sore throat 39%: 75.5%, hoarseness 6.2%: 15.1%, cough 7.5%:21.9%	Adjusting the ETT cuff pressure objectively to 25 cm H_2O reduces post-operative complications (sore throat, hoarseness, and cough) as compared to the pilot balloon palpation method.
Hockey, C. A., van Zundert, ,A.A.J., & Paratz, J. D. (2016)	Systematic review & meta-analysis of 7 randomized controlled trials and 2 pseudo-randomized controlled trials: Level I	N = 9	Cuff pressure adjustment guided by an objective device prevents adverse effects (hoarseness, sore throat, tracheal lesions, silent aspiration) as compared to subjective measurement. Subjective methods used alone to guide the cuff pressure can lead to inaccuracies.	An objective form of measurement for ETT cuff pressure monitoring should be used.
Saraçoglu, A., Dal, D., Pehlivan, G., & Gögüs, F.Y. (2014)	Randomized prospective study: Level II	N = 220	Professional anesthesia experience has no significant impact on provider ability to achieve safe ETT cuff pressure without objective monitoring.	Introduction of the manometer, regardless of anesthesia experience, will prove useful in achieving normal cuff pressures and

				preventing tracheal adverse effects.
Seyed Siamdoust, S. A., Mohseni, M., & Memarian, A. (2015)	QI	N = 52	The ability of anesthesia providers to estimate ETT cuff pressure significantly improved after an educational intervention.	Education may play an important role in the safe inflation of ETT cuffs via palpation method. Best practice is objective measurement via manometer.
Stevens, G. J., Warfel, J. W., Aden, J. K., & Blackwell, S. D. (2018)	QI	N = 200	Statistically significant improvement in the obtainment of appropriate cuff pressures with the implementation of manometers as well as the provision of department-wide education regarding the device.	Manometers should be made available to intubating providers. Department-wide education can help to improve the frequency of safe ETT cuff pressures intraoperatively.
Tsaousi, G. G., Pourzitaki, C., Chlorou, D., Pappostolou, K., & Vasilakos, D. G. (2016)	Double-blind, randomized control trial: Level II	N = 139	The palpation method carries a high risk for ETT cuff overinflation whereas the minimum leak and minimal occlusive volume run the risk of cuff underinflation in certain circumstances.	A manometer device should first be used if available. When not available, the better subjective technique is the air return method.
Turner, M. A., Feeney, M., & Deeds, J.L. (2020).	QI	N = 70	Statistically significant increase in the rate of appropriate cuff pressures. Improvement in the frequency of ETT cuff pressure checks and anesthesia provider knowledge of ETT cuff pressures.	An education program with improved OR manometer access and visible labels on all anesthesia machines is effective in improving the frequency of safe ETT cuff pressures as well as provider monitoring of ETT cuff pressures.
Ünsal, Ö., Seyhun, N., Türk, B., Ekici, M., Dobrucalı, H., & Turgut, S. (2018)	Prospective Controlled Study, Level IV	N = 67	Postoperative laryngotracheal complications were higher in the group that did not receive ETT cuff inflation via an objective method.	ETT cuff adjustment via manometer is an important method in decreasing complications from intubation.

Note. QI studies and evidence from Levels I-VI were accepted during the literature search. Sources acceptable for inclusion placed focus on ETT cuff pressure management within the operating room and/or the comparison between subjective and objective methods in obtaining safe pressures.

Appendix D

Project Approval

NHSR vs. HSR Determination:

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

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

Approval Signatures:

Department (Site) Manager: ______ **Date:** 2-25-2021

CRG Reviewer: ______ Digitally signed by Date: 2021.03.08 06:55:04 -05'00' **Date:** ______

UMCIRB Office Staff Reviewer: ______ **Date:** 3-10-21

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Note. Signatures redacted to preserve the identity of the participating facility.

Appendix E

Pre-Intervention Survey Questions

In your current practice, which method(s) do you prefer for obtaining adequate ETT cuff pressure? (select all that apply)

- Minimal occlusive volume
- Pilot balloon palpation
- Manometer
- Audible air leak
- Set volume
- Other ____________

In your opinion, is subjective assessment (tactile) adequate for obtaining appropriate ETT cuff pressure?

- Extremely adequate
- Somewhat adequate
- Neither adequate nor inadequate
- Somewhat inadequate
- Extremely inadequate

How often in your practice do you solely utilize subjective assessment (tactile) to obtain appropriate ETT cuff pressure?

- Never
- Sometimes
- About half the time
- Most of the time
- Always

In your opinion, is objective measurement (manometer) adequate for obtaining appropriate ETT cuff pressure?

- Extremely adequate
- Somewhat adequate
- Neither adequate nor inadequate
- Somewhat inadequate
- Extremely inadequate

How often in your practice do you utilize an objective measurement (manometer) for obtaining appropriate ETT cuff pressure?

- 0% of the time
- < 25% of the time
- 25-50% of the time
- 50-75% of the time
- > 75% of the time

Appendix F

Post-Intervention Survey Questions

While participating in this quality improvement project, approximately how many times did you use the manometer over the last two weeks?

In your opinion, is subjective assessment (tactile) adequate for obtaining appropriate ETT cuff pressure?
- Extremely adequate
- Somewhat adequate
- Neither adequate nor inadequate
- Somewhat inadequate
- Extremely inadequate

How often in your practice do you solely utilize subjective assessment (tactile) to obtain appropriate ETT cuff pressure?
- Never
- Sometimes
- About half the time
- Most of the time
- Always

In your future practice, how often do you think you will choose to solely utilize subjective assessment (tactile) for obtaining appropriate ETT cuff pressure?
- Never
- Sometimes
- About half the time
- Most of the time
- Always

In your opinion, is objective measurement (manometer) adequate for obtaining appropriate ETT cuff pressure?
- Extremely adequate
- Somewhat adequate
- Neither adequate nor inadequate
- Somewhat inadequate
- Extremely inadequate

In your future practice, how often do you think you will utilize an objective measurement (manometer) for obtaining appropriate ETT cuff pressure?
- 0% of the time
- < 25% of the time
- 25-50% of the time
- 50-75% of the time

- >75% of the time

Are there certain types of cases in which you think utilization of an objective manometer would be beneficial?

- No
- If yes, which types of cases?

Appendix G

Project Timeline

Date	Project Completion Measures
August 2020 – November 2020	-Exploration of project background and definition of project goals -Literature review -Initial draft of pre- and post-intervention surveys
January 2021	-Initial draft of educational video
February 2021	-Recording and finalization of educational video -Chair approval of surveys, educational video, & email script -Application for project approval by site manager
March 2021	-Project approval granted by site manager -Pre- and post-intervention surveys finalized -Qualtrics test-run of surveys
April 2021	-Recruitment of CRNA participants
May 2021 – June 2021	-Initiation of intervention to the targeted sample -Provision of manometers on-site -Collection of data via Qualtrics
July 2021	-Data analysis & synthesis
November 2021	-Oral presentation delivered to an audience of university faculty, university nurse anesthesia students, and facility CRNAs involved in the project via an in-person presentation shared simultaneously via Zoom.

Note. This timeline was created in conjunction with the guidance of university faculty members.

Appendix H

Project Budget (Organization)

Item	Quantity	Unit Cost	Total
Manometer	Per hospital	$39.95	$0.00
Educational Video	1	$0.00	$0.00
TOTAL			$0.00

Note. Manometers are currently stocked by the organization; no additional cost is incurred to the organization within the total amount above. An increase in the overall cost may occur if increased demand exceeds the current supply of manometers.