UNDERSTANDING ANESTHESIA PROVIDERS' KNOWLEDGE AND UTILIZATION OF ALVEOLAR RECRUITMENT MANEUVERS AS A LUNG PROTECTIVE VENTILATION STRATEGY

by

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ABSTRACT

BRANDON PALUBA. Understanding Anesthesia Providers' Knowledge and Utilization of Alveolar Recruitment Maneuvers as a Lung Protective Ventilation Strategy
(Under the direction of DR. STEPHANIE WOODS)

Problem Statement: Obese adults having laparoscopic surgery are at increased risk for postoperative pulmonary complications (PPCs) due to the alteration in pulmonary physiology caused by their body habitus, the use of Trendelenburg position, and abdominal insufflation required for this surgical approach.

Background: Current literature recommends utilizing lung protective ventilation (LPV) strategies to reduce the incidence of PPCs, but anesthesia provider implementation of LPV strategies is inconsistent. The purpose of this quality improvement project is to explore anesthesia providers' knowledge and utilization of lung protective alveolar recruitment maneuvers (ARMs) in obese patients undergoing laparoscopic surgery.

Clinical question: In a large urban trauma center, what are anesthesia providers' knowledge and utilization of lung-protective alveolar recruitment maneuvers (ARMs) in obese (BMI>30kg/m^2) patients aged 18 and older undergoing laparoscopic surgeries?

Methods: The descriptive design of this project aimed to investigate anesthesia providers' knowledge and use of LPV alveolar recruitment maneuvers in obese patients (BMI>30kg/m^2) undergoing laparoscopic surgery via an anonymous, quantitative electronic survey consisting of 24 Likert scale questions. A convenience sampling of certified registered nurse anesthetists (CRNAs) and physician anesthesiologists (MDAs) was used. The survey was disseminated via email and available by QR code. Data was evaluated and stratified by role/education, age, and years of experience to evaluate for trends.

Results: Fifty-two providers completed the survey. There were significant differences in likelihood to utilize lung protective ARMs.

Conclusions: Anesthesia provider utilization of LPV strategies remains inconsistent. Education regarding implementation of evidence-based lung protective ARMs in obese patients undergoing laparoscopic surgery is warranted.

Keywords: postoperative pulmonary complications, lung-protective ventilation, positive end-expiratory pressure, alveolar recruitment maneuver

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DEDICATION

This project is dedicated to all of those who have impacted, encouraged, and supported me throughout my academic career. To my wife, Lindsay, thank you for your unwavering support and unconditional love. You and our dogs – Bailey, Ellie, Henry and Kit – have made the hardest days seem easy. I could not have done this without you all by my side. Lastly, this project and everything I do is dedicated to my mother, Diane. Although you are not with us physically, your presence is forever felt. What you've instilled in me throughout your battle will forever motivate me to make you proud. This one's for you.

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LIST OF ABBREVIATIONS

ACT	anesthesia care team
ANOVA	analysis of variance
ARDS	acute respiratory distress syndrome
ARM	alveolar recruitment maneuver
BMI	body mass index
CRNA	certified registered nurse anesthetist
CRS	respiratory system compliance
DNP	doctor of nursing practice
FRC	functional residual capacity
IAP	intra-abdominal pressure
IRB	institutional review board
LPV	lung protective ventilation
MDA	physician anesthesiologist
MSN	master of science in nursing
PACU	post-operative care unit
PaO2	partial arterial oxygen tension

PDSA	plan-do-study-act
PEEP	positive end-expiratory pressure
PFT	pulmonary function test
PPC	postoperative pulmonary complication
QI	quality improvement
RCT	randomized control trial
SD	standard deviation
V-Q	ventilation-perfusion
ΔP	driving pressure

SECTION I: INTRODUCTION

1.1 Background

The delivery of general anesthesia alters normal respiratory physiology. This is compounded by the respiratory alterations induced by both laparoscopic surgery and obesity, defined as a body mass index (BMI) greater than or equal to 30 kg/m^2. Anesthesia providers deliver mechanical ventilation to patients during surgery in hopes of maintaining respiratory homeostasis despite all of these alterations. The way in which this ventilation is delivered affects patient outcomes.

The term “postoperative pulmonary complications” (PPCs) refers to a number of complications negatively affecting the respiratory system following surgery, such as atelectasis, pneumothorax, aspiration pneumonitis, pneumonia, pulmonary edema, exacerbation of pre-existing lung disease and many others (Miskovic & Lumb, 2017). PPCs can be caused by ventilator-induced lung injury, the mechanisms of which include barotrauma, volutrauma, and atelectrauma. Barotrauma results from excessive pressure, volutrauma results from excessive volume, and atelectrauma results from shear stress induced by cyclic recruitment and derecruitment of alveoli (Tsumara et al., 2017).

The reported incidence of PPCs varies greatly, likely due to varied definitions. According to Miskovic and Lumb (2017), “incidence of PPCs in major surgery ranges from <1 to 23%” (p. 319). In their article referencing multiple studies, Tsumara et al. (2021) reported an incidence of PPCs of between 2-70%. PPCs increase morbidity, mortality and healthcare costs. Lung-protective ventilation (LPV) strategies are a proven method to reduce PPC incidence. More specifically, LPV “minimizes damage to pulmonary epithelial and vascular endothelial cells and their associated connective tissue” (Nieman et al., 2017, p. 1517). Evidence continues to grow in support of LPV strategies, which include low tidal volumes, application of PEEP, and use of alveolar recruitment maneuvers (ARMs) among other strategies (Tsumura et al., 2021).

Routine use of ARMs is well-defined and highly recommended in current literature. Obese patients undergoing laparoscopic surgery in the Trendelenburg position are at high risk for PPCs due to the larger-than-normal abdominal contents pushing cephalad, which reduces pulmonary compliance and increases airway pressures. ARMs help combat these changes by reducing atelectasis, restoring FRC, optimizing respiratory system compliance (C_{RS}), and improving lung homogeneity (Tsumura et al., 2021). The PICO question "At a large urban trauma center, what are anesthesia providers' knowledge and utilization of lung-protective ARMs in obese (BMI > 30 kg/m^2) patients aged 18 and older undergoing laparoscopic surgeries?" attempts to better understand current practice and reservations to the routine use of ARMs among anesthesia providers.

1.2 Purpose

The purpose of this project, which is part of a larger quality improvement project, is to understand anesthesia providers' knowledge and utilization of LPV strategies, specifically alveolar recruitment maneuver, in obese patients undergoing laparoscopic surgery.

1.3 Problem Statement

Anesthesia providers care for a variety of patient populations in many practice areas. The risk for PPCs varies among patient population and type of surgery. Having a body mass index (BMI) of 30 kg/m^2 or above poses increased risk for PPCs. Obesity reduces pulmonary compliance and increases airway resistance, leading to reduced lung capacities (Dixon & Peters, 2018). Due to the obesity pandemic, there is an increased number of laparoscopic bariatric surgeries being performed. Obesity is associated with many respiratory comorbidities including obstructive sleep apnea, restrictive lung disease, and obesity hypoventilation syndrome (Atkinson et al., 2017). In fact, induction of general anesthesia in the obese patient reduces functional residual capacity (FRC) up to 50% compared with approximately 20% in the non-obese patient (Tsumura et al., 2021). This reduced FRC equates to a smaller oxygen reserve. Additionally, obesity increases the required work of breathing which subsequently increases myocardial oxygen consumption (Nagelhout & Elisha, 2018, p. 1001).

Intraoperative positioning is also an important risk factor for developing PPCs. Specifically, laparoscopic surgeries that require the use of the Trendelenburg position, which shifts abdominal contents cephalad, reduces pulmonary compliance and increases peak airway pressures. The abdominal insufflation used for a laparoscopic approach further displaces the diaphragm cephalad and leads to even higher airway pressures, increased ventilation-perfusion (V-Q) mismatches, and further reduces pulmonary compliance (Atkinson et al., 2017). This laparoscopic approach has become increasingly common for abdominal and gynecologic procedures, making the risk for PPCs higher and the need for LPV greater. Because the obese patient undergoing laparoscopic surgery is highly vulnerable to PPCs, they have much to gain from diligent use of LPV.

LPV, initially shown to improve outcomes in acute respiratory distress syndrome (ARDS), "minimizes damage to pulmonary epithelial and vascular endothelial cells and their associated connective tissue" (Nieman et al., 2017, p. 1517). LPV strategies include low tidal volumes, optimal PEEP, optimal inspiratory time, ARMs, and lowest possible FiO_2. Despite growing evidence, anesthesia providers do not consistently utilize LPV strategies. In one study, only 50% of surveyed providers used the recommended tidal volumes of 6-8 mL/kg, and only 22.3% used optimal PEEP (Tretheway et al., 2021). LPV strategies, including alveolar recruitment maneuvers are important for reducing the occurrence of atelectasis, ventilator-induced lung injury and subsequent PPCs. The aim of this scholarly project is to understand anesthesia providers' knowledge and current use of LPV strategies, specifically alveolar recruitment maneuvers in obese patients (BMI $\geq$ 30 kg/m^2) undergoing laparoscopic procedures.

1.4 Clinical Question

In a large urban trauma center, what are anesthesia providers' knowledge and utilization of lung-protective alveolar recruitment maneuvers (ARMs) in obese (BMI > 30 kg/m^2) patients aged 18 and older undergoing laparoscopic surgeries?

SECTION II: LITERATURE REVIEW

2.1 Alveolar Recruitment Maneuvers

The goal of mechanical ventilation during anesthesia is to maintain sufficient oxygenation and ventilation despite the pulmonary changes induced by anesthetic agents and surgical factors. In order to achieve this, strategies must be employed to limit atelectasis, as the shunting of pulmonary blood flow can lead to hypoxia and other dangerous sequelae. Use of ARMs in mechanically ventilated patients under anesthesia has been shown to be beneficial through its reduction of atelectasis and the resulting shunting of pulmonary blood flow.

Atelectasis is the de-recruitment of alveoli, meaning they are functionally unavailable to participate in gas exchange. This leads to reduced pulmonary compliance, meaning higher pressures are required to recruit these alveoli. The pressure that must be generated with each respiration to overcome the decreased respiratory elasticity and produce the desired tidal volume is referred to as the driving pressure. The cyclic recruitment and derecruitment of alveoli during mechanical ventilation that occurs when driving pressures are elevated is an important risk factor for acute lung injury and increased PPCs (Young et al., 2019). Driving pressure (ΔP) is the ventilator plateau pressure (the pressure at end-inspiration) minus the PEEP. Several retrospective studies suggest that driving pressure impacts the occurrence of pulmonary complications more than any other ventilatory parameter (Park et al., 2019). ARMs are a key facet of a lung protective ventilation strategy aimed at decreasing driving pressures.

ARMs, also known as “sigh breaths,” are techniques used by anesthesia providers to improve lung function and oxygenation during general anesthesia. The sigh is a normal homeostatic reflex that maintains lung compliance and decreases atelectasis (Hartland et al., 2015). ARMs, by definition, reopen the small alveolar sacs where the patients’ blood and lungs exchange oxygen and carbon dioxide to ensure homeostasis. There are many techniques to perform ARMs, some of which include the following: long, slow increases in inspiratory pressure (pressure that is applied to lungs during inspiration) to approximately 40 cmH_2O (RAMP technique), intermittent sigh breaths targeting a certain plateau pressure (pressure that is added at end-inspiration and applied to the alveoli and small airways during mechanical ventilation), or maintaining the airway pressure around 30 cmH_2O for 30 continuous seconds every 30 minutes (Pelosi et al., 2010). ARMs have been recognized as a LPV strategy to decrease both atelectasis and PPCs while improving lung function for obese patients undergoing laparoscopic surgery.

2.2 Use of ARMs for Obese Patients during Laparoscopic Procedures

Through the administration of general anesthesia, obese patients are prone to many PPCs which can be exacerbated when they are undergoing laparoscopic procedures. PPCs such as atelectasis, volutrauma, barotrauma, atelectrauma, pneumonia, acute respiratory distress or failure, and pulmonary embolism can be influenced by manipulation of driving pressures. High ventilator driving pressure has been recognized as a significant determinant of lung injury (Young et al., 2019). Application of ARMs after induction of anesthesia and throughout the perioperative period have been recommended to decrease driving pressures, improve oxygenation, re-open collapsed alveoli, improve lung mechanics, decrease PPCs, and combat anesthesia-induced FRC changes (Young et al., 2019).

In a randomized control trial (RCT) by Wei et al. (2017), 36 obese patients (BMI > 40 kg/m^2) who underwent laparoscopic sleeve gastrectomy surgery were randomly allocated into three groups that utilized ARMs with and without PEEP. The trial tracked arterial oxygenation, respiratory mechanics, hemodynamics, and postoperative outcomes. Wei et al. (2017) found that when ARMs were intermittently repeated throughout surgery, both with or without PEEP, they improved early postoperative oxygenation and shortened time to extubation. The trial also noted that ARMs without PEEP resulted in lower airway pressure and less hemodynamic impairments in the patients who underwent laparoscopic bariatric surgery.

The importance of ARMs in laparoscopic surgery cannot be overstated. When the diaphragm is displaced cephalad during laparoscopic surgery due to the increased intra-abdominal pressure (IAP) from gastric insufflation, there is a physiologic increase in airway pressures and reduction in FRC that can lead to hypercarbia, hypoxemia, and a reduction in pulmonary compliance (Atkinson et al., 2017). A study by Severac et al. (2021) demonstrated the significance of ARMs in obese patients undergoing laparoscopic surgery when completing their single-center, randomized, double blind, superiority trial. The study involved 230 obese patients split between groups of those who received protective ventilation with ARMs, and those who received standard protective ventilation. The patients in the alveolar recruitment group had significantly lower rates of pulmonary dysfunction in the recovery room (73% versus 84%) ($p=0.043$) and (77% versus 88%) ($p=0.043$) in the postoperative day one period. The trial also revealed that oxygen needs were lower in the ARM group. Severac et al. (2021) concluded that ARMs associated with a LPV strategy were safe and effective, may reduce early pulmonary dysfunction in obese patients undergoing laparoscopic bariatric surgery, and may also prevent lung atelectasis and control driving pressures that are associated with pulmonary dysfunction and complication.

A meta-analysis by Pei et al. (2022), which included 17 RCTs, compared ARMs to conventional ventilation strategies in patients undergoing various types of laparoscopic abdominal surgeries in patients who were at high risk for PPCs. The results showed that both single and repeated ARMs both reduced incidences of PPCs. In addition, the results also indicated that ARMs improved respiratory mechanics by increasing static lung compliance and decreasing driving pressures. The meta-analysis concluded that utilization of ARMs for patients undergoing laparoscopic abdominal surgery reduced the driving pressure, decreased the incidences of PPCs, increased static lung compliance, and improved oxygenation compared to the control groups.

In summary, the use of ARMs are essential in preventing PPCs for obese patients undergoing laparoscopic procedures. ARMs help prevent the collapse of the alveoli in the lungs, which occurs due to the high intra-abdominal pressures from both body habitus and laparoscopic insufflation, leading to a decrease in functional residual capacity. By improving oxygenation and preventing atelectasis, ARMs counteract the negative sequelae that arise when obese patients undergo laparoscopic procedures in the Trendelenburg position.

2.3 ARMs and other LPV Strategies

Since LPV strategies often employ various techniques to achieve related outcomes, it is important to note their benefits when combined. Nguyen et al. (2021) aimed to illustrate the combined effectiveness of LPV strategies at offsetting the atelectasis and decreased residual capacity caused by laparoscopic surgeries, thus improving intraoperative oxygenation. Their RCT examined 62 patients randomly assigned to receive either LPV (tidal volume 7 mL/kg IBW, 10 cmH_2O PEEP, and ARMs) or conventional ventilation (tidal volume 10 mL/kg IBW, 0 cmH_2O PEEP, and no ARMS), who underwent abdominal laparoscopic surgeries. Compared to the conventional ventilation group, the LPV group was found to have improved intraoperative oxygenation, increased pulmonary compliance, and reduced driving pressures. Nguyen et al. (2021) noted that periodic ARMs and continuous PEEP demonstrated effectiveness in re-expanding alveoli and preventing recurrent atelectasis.

A study by Whalen et al. (2006) supplemented previous notions concluding that utilizing ARMs followed by the continuous use of 12 cm H_2O of PEEP significantly improved intraoperative oxygenation by preventing atelectasis. Their prospective randomized study looked at patients who underwent laparoscopic bariatric surgeries specifically testing the LPV strategy on arterial oxygenation. The recruitment group received 4 sustained lung recruitments followed by the application of 12 cmH_2O of PEEP versus the control group who only received 4 cm H_2O of PEEP without ARMs. Whalen et al. (2006) concluded that recruiting the collapsed alveoli led to significantly higher arterial oxygenation and increased respiratory system dynamic compliance, suggesting that ARMs followed by continuous PEEP improves intraoperative oxygenation in morbidly obese patients undergoing laparoscopic abdominal surgeries.

Similarly, Talab et al. (2009) found that patients who received ARMs immediately after induction of general anesthesia and intubation followed by PEEP had better oxygenation throughout the perioperative period and into the post anesthesia care unit (PACU). Their RCT studied 66 obese adults with BMIs between 30-50 kg/m^2 undergoing laparoscopic surgeries. In their conclusion they disclosed that the group who received ARMs after induction of general anesthesia followed by 10 cmH_2O of PEEP had lower atelectasis scores (postoperative chest CT scans compared to preoperative chest CT scans), lower PPCs, and improved intraoperative oxygenation compared to the other groups which consisted of no ARMs and reduced PEEP.

A systematic review of literature by Hartland et al. (2015) paralleled the aforementioned importance of ARMs combined with PEEP in the prevention of PPCs. Their review of six RCTs cited "a significant advantage when alveolar recruitment maneuvers were followed by PEEP application" (Hartland et al., 2015, p. 618). The researchers found that the subjects in the ARM groups experienced a higher intraoperative PaO2 with improved lung compliance. In their conclusion they recommended that ARMs should be followed by the immediate and continuous application of PEEP. Additionally, they suggest that ARMs be implemented after induction of general anesthesia and throughout the procedure to reduce PPCs and improve patient outcomes.

In conclusion, the use of ARMs in combination with other LPV strategies is crucial in reducing PPCs in obese patients that undergo laparoscopic procedures in the Trendelenburg position. Since the obese patient is at higher risk of developing PPCs due to physiologic respiratory system changes, the incorporation of ARMs with other LPV strategies in these mechanically ventilated obese patients undergoing laparoscopic procedures is paramount in enhancing patient safety and significantly improving postoperative outcomes.

2.4 Conclusion of Literature Review

The literature demonstrates a clear benefit in mechanically ventilated patients undergoing general anesthesia who receive a combination LPV strategies including the use of alveolar recruitment maneuvers. Patients who receive this combination of LPV strategies have a reliably lower incidence of PPCs than those who do not. Obese patients undergoing laparoscopic surgery encounter multiple risk factors that predispose them to PPCs. These patients demonstrate better outcomes when they receive LPV strategies, particularly PEEP and ARMs.

Although the evidence supporting the use of LPV strategies is abundant, their utilization varies among anesthesia providers (Trethewey et al., 2021). Studies have shown that anesthesia providers' utilization of lung protective strategies is insufficient, especially in the obese population (Trethewey et al., 2021). It is recommended that anesthesia providers consistently implement LPV strategies to mitigate PPCs, facilitate optimal respiratory mechanics, and reduce morbidity and mortality, especially in the obese population undergoing laparoscopic surgery.

2.5 Conceptual Framework

This quality improvement project's framework followed the Plan-Do-Study-Act (PDSA) method. For this project, the "plan" was to complete an in-depth review of the literature surrounding the identified clinical problem and the LPV strategy (ARMs). A validated survey was created to assess current knowledge and practice habits regarding LPV strategies among anesthesia providers. The survey was distributed to the identified anesthesia providers, which represents the "do" component of this method.

The "study" component included analyzing survey responses and identifying trends surrounding the knowledge and use of LPV strategies amongst those who completed the survey. Areas for improvement were identified by comparing survey responses with current evidence-based practice from the literature. The "act" component was completed via presentation of the survey findings and discussing identified areas in which responses deviate from practice recommendations in the evidence.

SECTION III: METHODOLOGY

3.1 Project Design

This quality improvement project's methodology utilized a descriptive design. The project aimed to investigate anesthesia providers' knowledge and use of lung protective ventilation (LPV) strategies, specifically alveolar recruitment maneuvers, in obese patients (BMI > 30kg/m^2) via a survey. Relationships between variables were not addressed, and participants were not assigned to groups. This project was part of a larger quality improvement project aimed at the use of LPV in obese patients.

3.2 Sample

The sample for this quality improvement project consisted of certified registered nurse anesthetists (CRNAs) and physician anesthesiologists (MDAs). CRNAs completed their undergraduate studies with a Bachelor of Science in Nursing, followed by at least one year of critical care/intensive care unit experience prior to entering their nurse anesthesia programs. The CRNAs at the large urban trauma center acquired either their doctoral (DNP) or master degree (MSN) in nurse anesthesia practice. The MDAs completed four years of medical school, four years of residency, and some completed another one to two years of specialized fellowship training.

Inclusion criteria for the sample consisted of providers who administered anesthesia at the large urban trauma center during data collection period. Those providers were either CRNAs (MSN or DNP) or physician anesthesiologists (MDAs). The project's sample excluded any other healthcare employees, including student registered nurse anesthetists (SRNAs).

The anesthesia administered in the operating rooms at the large urban trauma center utilized an Anesthesia Care Team (ACT) model. In the ACT Model, MDAs were responsible for up to four simultaneously functioning operating rooms with care managed by CRNAs who were present throughout the entire anesthetic. The MDAs, who were present on the induction and emergence of anesthesia, also performed specialized skills including insertion of central venous catheters and performance of regional anesthesia for multimodal analgesia. The MDAs visited the patient prior to the surgery to perform and document a thorough preoperative assessment. The CRNAs were responsible for one patient per case, allowing them to provide vigilant care and safe passage for patients undergoing anesthesia. The CRNAs also performed a preoperative assessment and tailored a patient-specific anesthetic plan in collaboration with the MDA and surgeon. This quality improvement project used a convenience sample with the project survey sent to the 259 CRNAs and 62 MDAs that practiced at the data collection site.

3.3 Setting

This quality improvement project took place at a large 874-bed urban trauma center and teaching hospital. This institution served the needs of a large southern city and its surrounding regions, and was the only Level 1 trauma center and transplant center for heart, kidney, liver, and pancreas transplants. As a teaching hospital, this large urban trauma center provided residency training to more than 200 physicians in 15 specialties. This facility was equipped to serve many medically complex patients. There were 45 operating rooms at this facility, not including obstetric operating rooms and procedural areas. Approximately 150 to 200 surgical cases were performed each day. Around 60 to 70 CRNAs were staffed each day, along with about 15 to 20 physician anesthesiologists.

3.4 Data Collection

Data was collected via a quantitative electronic survey sent to anesthesia providers (CRNAs and MDAs) who practiced at the previously described facility. The survey was conducted via the SurveyMonkey platform and was delivered to anesthesia providers via their employer email addresses, as well as made available via QR code. QR codes were placed in anesthesia department break rooms and operating rooms, particularly those where laparoscopic cases routinely occurred, in order to increase participation. Participants were able to complete the survey on their mobile devices.

This survey consisted of 24 Likert scale questions that aimed to elicit anesthesia providers' knowledge and utilization of evidence-based recommendations for LPV strategies. Eight of the twenty-four questions were specific to alveolar recruitment maneuvers as a LPV strategy. The survey responses used a Likert scale which allowed providers to answer each question based on their likelihood to utilize each LPV strategy. The Likert scale options were arranged as such: extremely unlikely (0), very unlikely (1), unlikely (2), likely (3), very likely (4) and extremely likely (5). Survey questions were reviewed by CRNA faculty and clinical experts prior to dissemination to establish validity of survey items. Responses were anonymous with only basic demographic data collected, including age, professional title, location of practice, educational background, and years of experience in anesthesia. Survey participants indicated the range that their age and years of experience fell into to avoid jeopardizing confidentiality. The survey design of study and content was informed by evidenced-based literature recommendations, and the project addressed possible setbacks and challenges in implementation at the outset to ensure consistency throughout the study's course (Bellg et al., 2004, pg 446). The project lead's intent was to understand anesthesia providers' knowledge and utilization of alveolar recruitment maneuvers as a LPV strategy in obese patients undergoing laparoscopic surgery at a large urban trauma center.

3.5 Data Analysis and Evaluation

Basic data analysis was performed via the SurveyMonkey platform. The results were also exported to Microsoft Excel for more advanced analysis. The SurveyMonkey responses and Microsoft Excel data were password-protected and only accessible to the project committee. The results were analyzed to assess trends in anesthesia providers' knowledge and use of ARMs as a lung protective ventilation strategy, and how these practices compared to evidence-based LPV recommendations. Bar charts were utilized to display the distribution of the demographic information of job title, age, years of experience, educational background of the survey participants. The data was then stratified for each subgroup, allowing for evaluation of patterns in clinical practice and schools of thought for each demographic variable. The groups' responses were compared using ANOVA.

3.6 Timeline

The project proposal was defended on April 18, 2023. Institutional Review Board (IRB) was obtained from Atrium Health Wake Forest School of Medicine and University of North Carolina at Charlotte in June of 2023. The survey was disseminated and data collection began on August 1, 2023. A reminder email to the previously described subjects occurred at week 2 and week 4 to maximize potential participants. The survey closed on August 28, 2023, and thus was open for 4 weeks. At conclusion, the survey had a total of 52 participants, with a 16.2% response rate. Data analysis began in late September and early October. The discussion of final results, limitations, and recommendations on how anesthesia providers can improve outcomes in this patient population was completed in November of 2023. The quality improvement project group defended on December 1, 2023.

3.7 Needed Support/ Challenges

Because the project's data collection occurred in the form of a survey, its success relied on the participation of CRNAs and MDAs at the clinical sites. The project team worked to gain buy-in from anesthesia department leaders and staff by maintaining an open line of communication with them regarding the purpose, needs, and importance of the project. The project lead relied heavily on support from the anesthesia department leaders. Their permission was needed to advertise the survey in anesthesia break rooms to promote participation, as well as to encourage their staff to complete the survey. Though the survey was accessible via cell phone, computers in anesthesia break rooms were another valuable resource in enhancing survey participation.

There were many challenges that threatened survey participation. One was the pace of the operating room and the brevity of breaks taken by anesthesia providers. There was often little down time between cases, and providers were under pressure to get back to work quickly to maintain productivity. It was also impossible to know where providers took their breaks. To address these challenges, the project team promoted the survey in the most common break areas and kept the survey as brief as possible. Despite this, some providers choose not to complete the survey. Another potential challenge that could have risen was the possibility of technical issues with the electronic survey. The project team regularly accessed and reviewed the survey to ensure it was functioning properly and resolved any problems noted. If unable to solve a problem with the survey, the team had planned to seek technical assistance from the survey platform.

By using Likert scale style questions, data could be distorted by multiple types of respondent bias. Central tendency bias, which describes the idea that people have a tendency to rate items toward the middle of the scale, may affect survey results. Acquiescence bias, which describes the idea that people tend to agree with provided statements whether or not they truly reflect their own actions or views, could also affect survey results. A third type of bias that may affect survey results is social desirability bias, describing the idea that people wish to portray themselves or their affiliations in a positive light (*Analyzing Likert Scale/Type Data,* 2013). To monitor this, the investigator looked at item response rates for trends of bias.

As with all projects, unforeseen challenges such as provider participation and online survey application cost, arose along the way. The project team collectively discussed and executed the most effective solutions to these problems, seeking guidance from mentors throughout the process.

SECTION IV: SURVEY RESULTS

4.1 Sample Characteristics

In total, 52 anesthesia providers participated in the online survey, yielding an overall participation rate of 16.7%. The majority of participants were CRNAs (n=45), of which 73% held a master's degree in Nurse Anesthesia Practice (MSN) (n=33), and 27% held a Doctor of Nursing Practice degree (DNP) (n=12). The remaining 7 participants (13.5%) were physician anesthesiologists (MDA/DO) (see Figure 1).

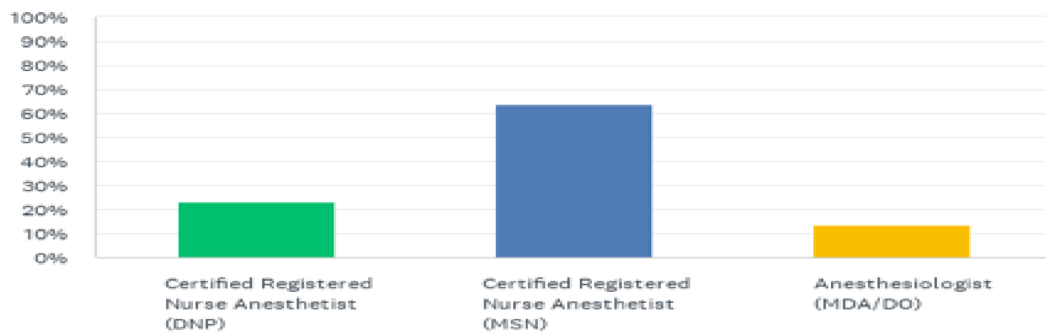

Figure 1: Anesthesia provider job title and level of education

In terms of age, 15.4% of participants were 20 to 30 years old, 42.3% were 31 to 40 years old, 25.0% were 41 to 50 years old, and 17.3% were 50 years or older (see Figure 2). In terms of years of experience, 51.9% had less than 5 years of experience, 7.7% had 6 to 10 years of experience, 15.4% had 11 to 15 years of experience, and 25.0% had more than 15 years of experience (see Figure 3).

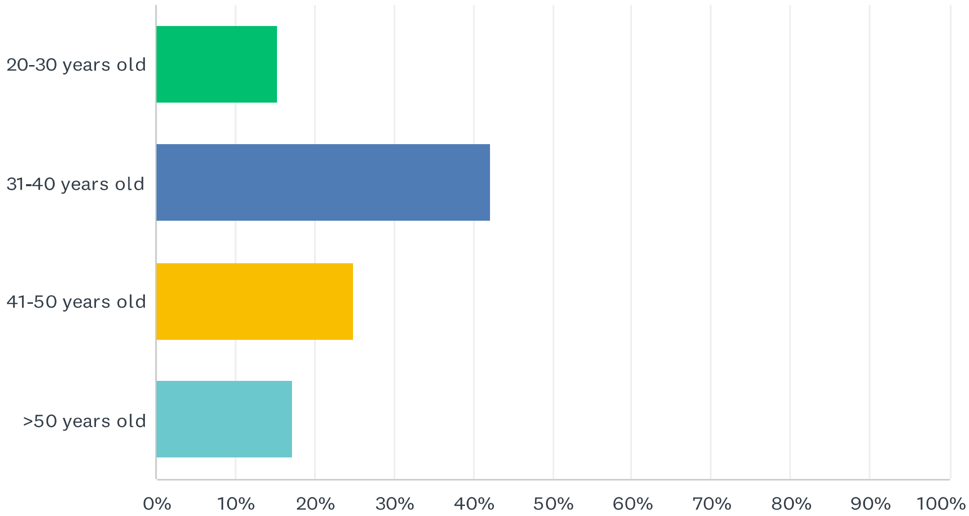

Figure 2: Age ranges of anesthesia providers

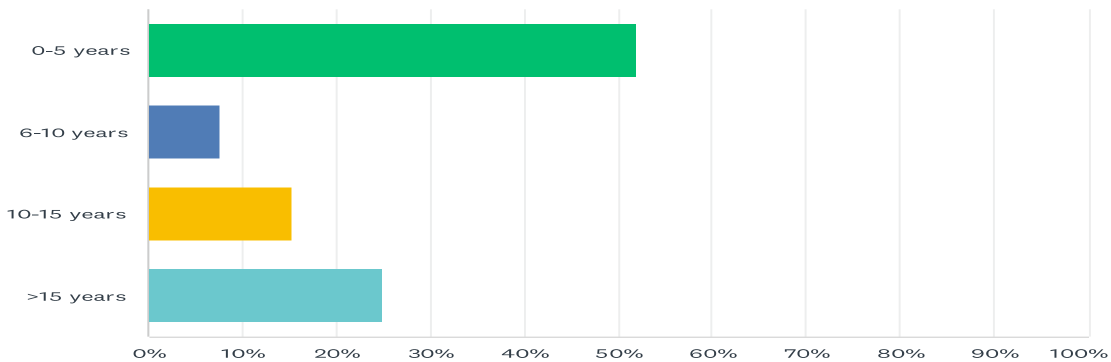

Figure 3: Anesthesia provider years of work experience (excluding training)

4.2 Survey Results

A 6-choice Likert scale was utilized to allow providers to precisely identify their likelihood to perform each action throughout survey item scenarios (see Table 1). Table 2 demonstrates the mean responses from anesthesia providers for the Provider Utilization of Lung Protective Ventilation – Alveolar Recruitment Maneuver survey. Survey items are listed in the order they were answered throughout the LPV survey. The "LPV Compliant - Answer" column was included to indicate the Likert scale answer that was equivalent to the recommended LPV strategy for each item. The "Average Likert Scale Score" was the average Likert scale response from anesthesia providers with the Mean and Standard Deviation (SD). The "Mean Response Meaning" column described what the mean response indicated when compared to the Likert scale.

Table 1: Likert scale answer key

Extremely Unlikely = 0	Very Unlikely = 1	Unlikely = 2
Likely = 3	Very Likely = 4	Extremely Likely = 5

Table 2: Provider utilization of lung protective ventilation – alveolar recruitment maneuver survey

Survey Item	**LPV Compliant Answer**	**Average Likert Scale Score Mean (SD*)**	**Mean Response Meaning**
How likely are you to incorporate lung protective ventilation strategies as part of your anesthetic plan in obese patients?	5	4.21 (0.91)	Very Likely to Extremely Likely
1 – Your obese patient presents for a laparoscopic total hysterectomy for uterine fibroids. Her BMI is 37 kg/m^2. How likely are you to administer a *post-induction* alveolar recruitment maneuver while still in the supine position?	5	3.75 (1.12)	Likely to Very Likely

*Standard deviation in parenthesis

Table 2: Provider utilization of lung protective ventilation – alveolar recruitment maneuver survey (continued)

Survey Item	**LPV Compliant Answer**	**Average Likert Scale Score Mean (SD*)**	**Mean Response Meaning**
2 – Your patient (BMI 40 kg/m^2**)** is about to undergo laparoscopic pelvic surgery. After being positioned into steep Trendelenburg their oxygen saturation is 99% with stable hemodynamics. How likely are you to administer a *post-induction* alveolar recruitment maneuver?	5	3.31 (1.16)	Likely to Very Likely
3 – Your patient (BMI is 37 kg/m^2) is undergoing a laparoscopic total hysterectomy for uterine fibroids. During the *maintenance phase* of anesthesia in this hemodynamically stable patient, how likely are you to administer an alveolar recruitment maneuver while in steep Trendelenburg?	5	3.15 (1.39)	Likely to Very Likely
4 – How likely are you to administer an alveolar recruitment maneuver every 30 minutes throughout the surgical procedure?	5	2.06 (1.23)	Likely to Very Likely

*Standard deviation in parenthesis

Table 2: Provider utilization of lung protective ventilation – alveolar recruitment maneuver survey (continued)

Survey Item	LPV Compliant Answer	Average Likert Scale Score Mean (SD*)	Mean Response Meaning
5 – How likely are you to incorporate alveolar recruitment maneuvers as a routine part of your anesthetic plan?	5	3.98 (0.97)	Very Likely
6 – How likely are you to administer an alveolar recruitment maneuver to your patient to improve oxygen saturation prior to adjusting the fraction of inspired oxygen (FiO2)?	5	3.65 (1.06)	Likely to Very Likely
7 – How likely are you to administer an alveolar recruitment maneuver to decrease the driving pressure on your obese, hemodynamically stable patient in a steep Trendelenburg position undergoing laparoscopic surgery?	5	3.14 (1.20)	Likely

*Standard deviation in parenthesis

The overarching question in the Provider Utilization of Lung Protective Ventilation Strategies – Alveolar Recruitment Maneuver (ARM) survey (Table 2) assessed the likelihood of participants to incorporate these LPV strategies into their anesthesia practice. The mean total response across all roles was 4.21, indicating that providers were "very likely to extremely likely" to incorporate lung protective ventilation strategies into their anesthesia practice. There was a significant difference on likelihood to incorporate these lung protective ventilation ARMs across roles, F=4.67, p = .014. The CRNA DNP participants (n=12) were more likely to incorporate these lung protective ventilation strategies than CRNA MSN (n=33), p = .019 (see Appendix A).

Item 1 of the Provider Utilization of LPV – ARMs – survey asked how likely providers were to administer a post-induction ARM while in the supine position for an obese patient undergoing laparoscopic surgery. The mean participant response was 3.75 on the Likert scale, indicating “likely to very likely” to administer, with an LPV- Compliant Answer of 5. Although, this indicated that providers were more likely than not to incorporate a post induction ARM, all should be incorporating them at this point of the anesthetic to reduce negative postoperative outcomes (Taleb et al., 2009).

Item 2 of the Provider Utilization of LPV – ARMs – survey asked how likely providers were to administer a post-induction ARM while in the steep Trendelenburg position to their obese patient undergoing laparoscopic surgery. The mean participant response was 3.31 on the Likert scale, indicating that they were “likely to very likely” to administer an ARM at this portion of the anesthetic, with an LPV-Compliant Answer of 5. This also indicated that although providers were more likely than not to incorporate a post induction ARM in the steep Trendelenburg position, all providers should be administering them in this position post induction to improve perioperative oxygenation (Taleb et al., 2009).

Item 3 of the Provider Utilization of LPV – ARMs – survey asked how likely providers were to administer an ARM during the maintenance phase of anesthesia for their obese patient undergoing laparoscopic surgery in the steep Trendelenburg position. The mean Likert score participant response was 3.15, indicating providers were “likely to very likely” to administer an ARM during the maintenance phase of anesthesia in the steep Trendelenburg position, with an LPV-Compliant Answer of 5. This finding indicated that although providers are more likely than not to administer an ARM during this time period of the anesthetic, Pei et al. (2022) recommends all providers initiate ARMs intermittently throughout the procedure to decrease PPCs and shorten time to extubation.

Item 4 of the Provider Utilization of LPV – ARMs – survey asked how likely providers were to initiate an ARM every 30 minutes throughout the surgical procedure. The mean Likert scale participant response was 2.06, indicating anesthesia providers were “likely” to implement an ARM every 30 minutes, with an LPV-Compliant Answer of 5. This indicated a level of provider non-adherence, as the literature recommends ARMs to be administered periodically throughout the procedure to decrease both atelectasis and PPCs while improving perioperative lung function (Pelosi et al., 2010; Wei et al., 2017).

Item 5 of the Provider Utilization of LPV – ARMs – survey asked how likely providers were to incorporate ARMs into their anesthetic plan. The mean Likert scale response was 3.98, with a LPV-Compliant Answer of 5, indicating that providers were “very likely” to incorporate ARMs into their anesthetic plans. The literature recommendations that all providers utilize ARMs throughout their anesthetics to control the driving pressures that are associated with pulmonary dysfunction, to lower oxygen needs, and to prevent atelectasis (Severac et al., 2021).

Item 6 of the Provider Utilization of LPV – ARMs – survey asked how likely providers were to administer an ARM prior to improve their patient’s oxygen saturation prior to adjusting their FiO2 setting. The mean Likert scale response was 3.65, with an LPV-Compliant Answer of 5, indicating that providers were approximately “likely to very likely” to administer an ARM prior to adjusting FiO2 to improve their patient’s oxygen saturation. It is recommended in the literature to utilize an LPV strategy that incorporates ARMs while maintaining the lowest possible FiO2 setting (Nieman et al., 2017).

Item 7 of the Provider Utilization of LPV – ARMs – survey asked how likely providers were to administer an ARM to decrease the driving pressure on their obese, hemodynamically stable patient in the steep Trendelenburg position undergoing laparoscopic surgery. The mean Likert scale response was 3.14, with an LPV-Compliant Answer of 5. This response indicated that providers were approximately “likely” to administer an ARM to attempt to decrease the driving pressure in this patient population. The literature recommends the utilization of ARMs to reduce driving pressure on obese patients undergoing laparoscopic surgery (Nguyen et al., 2021; Pei et al., 2022).

Other than the item asking about likelihood to incorporate ARM strategies into anesthesia practice, there were no group difference on any other questions across role, years of experience, or age. Appendices A, B, and C summarize group descriptive and p-values for comparing the means.

SECTION V: DISCUSSION

5.1 Implications for Practice

The findings from the Provider Utilization of Lung Protective Ventilation Strategies – Alveolar Recruitment Maneuver (ARM) survey revealed pertinent implications for anesthesia provider practice. The literature recommends the consistent utilization of LPV strategies on obese patients undergoing laparoscopic surgery to help mitigate PPCs and to reduce morbidity/mortality. Use of such LPV strategies, particularly ARMs, remains mostly inconsistent as shown with the survey results (see Table 2). Anesthesia provider participants surveyed "very likely" with a mean Likert scale score of 4.21, to incorporate LPV strategies into their anesthesia practice (see Table 2), yet all the individual responses to the ARM strategies were inconsistent with the literature recommended lung protective ARM survey scenarios (items 1-7), with mean responses not achieving 5 as an LPV-Compliant answer.

The use of ARMs are suggested after induction of general anesthesia to reduce atelectasis and the incidence of PPCs. (Hartland et. al, 2015). All surveyed participants responded "likely to very likely" to utilize a post induction ARM in the supine position (Table 2, item 1). All surveyed participants also responded "likely to very likely" to utilize a post induction ARM in the steep Trendelenburg position (Table 2, item 2). Interestingly, the CRNA DNP group surveyed "very likely to extremely likely" to administer a post induction ARM while in the supine position (see Appendix A, item 1). The CRNA DNP group also surveyed "very likely" to administer a post induction ARM in the steep Trendelenburg position (see Appendix A, item 2).

In contrast, the CRNA MSN group surveyed "likely to very likely" for the same post induction ARM in the supine position, and only "likely" to administer an ARM in the steep Trendelenburg position (see Appendix A, item 1 & 2), indicating a difference across education levels. The CRNA DNP (n=12) responses of "very likely to extremely likely" more closely align with the current literature recommendations in that patients who receive ARMs right after induction of general anesthesia in the supine and steep Trendelenburg positions have better perioperative oxygenation and postoperative outcomes (Talab et al., 2009). In contrast, the CRNA MSN (n=33) providers' mean survey response of "likely" signifies a lesser likelihood of ARM implementation compared to their DNP prepared colleagues.

When ARMs are used to maintain airway pressure around 30cmH_2O for 30 continuous seconds every 30 minutes, they decrease both atelectasis and PPCs (Pelosi et al., 2010). Surveyed anesthesia providers were "unlikely" to implement an ARM every 30 minutes throughout the surgical procedure, with a mean of 2.06 on the Likert scale. This finding suggests a gap in knowledge surrounding current literature for appropriate implementation and timing of ARMs in the obese population undergoing laparoscopic surgery. Furthermore, Wei et al. (2017) recommends ARMS to be intermittently repeated throughout surgery to improve early post operative oxygenation and to shorten time to extubation.

The various scenario-based questions offered insight as to whether or not anesthesia providers have knowledge on current LPV ARM strategies, as well as if they are putting this knowledge into their current practice.

In summary, anesthesia providers surveyed that they were likely to incorporate lung protective ARMs in their practice. However, their responses to the various evidence-based clinical scenarios suggested varying and inconsistent adherence to such lung protective implementations. Anesthesia provider education on adherence of lung protective ARMs in the obese population undergoing laparoscopic surgery should be continuously emphasized.

5.2 Recommendations

After receiving and analyzing the results from the project survey, there are both short- and long-term recommendations to improve provider utilization of LPV strategies, specifically

ARMs. First, a cognitive aid placed in operating rooms where laparoscopic surgeries are frequently performed would be a helpful reminder to anesthesia providers to implement these evidence-based LPV strategies and would include: ARMs, optimal PEEP, Vt 6-8ml/kg IBW, and lowest possible FiO2.

Second, a notification in the electronic health record (EHR) could trigger a reminder to anesthesia providers to utilize an ARM whenever specific variables (increased BMI, laparoscopic procedures, bed position change to Trendelenburg) are met in the patients' electronic chart. This would not force an anesthesia provider to complete the task, but act as a subtle reminder when the charting mandatory assessments every 15 minutes, which could increase provider utilization of ARMs as a LPV strategy.

Third, continuing education in the anesthesia realm is paramount. Continuing education lectures/modules would benefit all currently practicing anesthesia providers in keeping them up to date on evidence-based best practice.

Last, as CRNA programs make the mandatory shift from Master's (MSN) prepared to Doctorate in Nursing Practice (DNP) degrees by 2025, continued evidenced-based education promoting LPV strategies and their effectiveness compared to traditional ventilation strategies may shift future provider utilization trends in the coming years. Increasing numbers of DNP cohorts may allow more opportunity for future quality improvement projects to analyze and better understand provider utilization of LPV strategies.

5.3 Limitations

This QI project's limitations included sample size, participant response rates, and utilization of a survey platform. The sample size of 52 anesthesia providers yielded a participation rate of only 16.2%, limiting extensive anesthesia provider insight. Of the 52 survey respondents, only 6 MDAs participated, signifying a lack of anesthesiologist participation. The large urban trauma center facility where this QI project was conducted had many staffing issues and rapid provider turnover throughout the data collection period. This, in conjunction with the increased demand and limited downtime of the currently employed anesthesia providers, could have limited the sample size and participation response rates.

Another limitation to this project was that the data was collected via survey, opening opportunity for anesthesia provider response bias and inaccurate reporting of responses. Participants may have reported the “correct” answer rather than depicting their true anesthetic practices limiting the accuracy of results. Since a Likert scale was utilized, another limitation was that there was no comment box available to understand why certain anesthesia providers choose not employ LPV strategies.

5.4 Summary

Overall, this QI project sheds light upon the continued inconsistent utilization of lung protective ventilation strategies, specifically ARMs, in the obese patient population undergoing laparoscopic surgery, a population that is at significant risk for PPCs, longer hospital stays, and increased morbidity/mortality. With the continued rise of minimally invasive laparoscopic surgeries in conjunction with the obesity epidemic, anesthesia providers, regardless of education level, have the responsibility to provide consistent evidence-based lung protective ventilation strategies to these at-risk populations.

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APPENDIX A: TABLE 2. SURVEY ITEM SCORES ACROSS PROFESSIONAL TITLE/DEGREE

Role	Total	Anesthesiologist (*n* =7)	CRNA DNP (*n* = 12)	CRNA MSN (*n* = 33)	*p*-value
Likely to incorporate	4.21 (0.91)	4.57 (0.79)	4.75 (0.62)	3.94 (0.93)	.014
Q1. Post ind/supine	3.75 (1.12)	4.00 (1.00)	4.50 (0.90)	3.42 (1.09)	.011
Q2. Post ind/Tburg	3.31 (1.16)	3.57 (0.98)	4.08 (1.00)	2.97 (1.13)	.012
Q3. Maint/Tburg	3.15 (1.39)	3.71 (0.95)	3.25 (1.86)	3.00 (1.27)	.459
Q4. 30 minutes	2.06*(1.23)	2.43 (1.40)	2.00 (1.13)	2.00 (1.25)	.699
Q5. Routine	3.98 (0.97)	4.14 (0.90)	4.42 (0.79)	3.78 (1.01)	.137
Q6.ARM/O2	3.65 (1.06)	4.29 (0.76)	3.92 (1.24)	3.42 (1.00)	.092
Q7. Driving pressure	3.14 (1.20)	3.50 (0.84)	3.17 (1.53)	3.06 (1.14)	.716

Note. *p*-values were based on ANOVA testing differences across the experience groups. In the cells were mean (standard deviation).

APPENDIX B: TABLE 3. SURVEY ITEM SCORES ACROSS YEARS OF EXPERIENCE

Years of experience	0-5 (n = 8)	6-10 (n = 22)	10-15 (n = 13)	> 15 (n = 9)	p-value
Likely to incorporate	4.30 (0.91)	4.50 (0.58)	4.12 (0.99)	4.00 (1.00)	.718
Q1. Post ind/supine	3.93 (1.07)	2.50 (1.29)	3.88 (1.36)	3.69 (0.85)	.119
Q2. Post ind/Tburg	3.37 (1.21)	2.50 (1.73)	3.50 (0.93)	3.31 (1.03)	.540
Q3. Maint/Tburg	3.11 (1.45)	2.50 (2.08)	3.12 (1.46)	3.46 (1.05)	.684
Q4. 30 minutes	1.93 (1.30)	1.50 (1.91)	2.00 (0.76)	2.54 (1.05)	.378
Q5. Routine	4.00 (1.02)	4.00 (1.41)	3.75 (0.71)	4.08 (0.95)	.904
Q6. ARM/O2	3.67 (1.14)	4.25 (0.50)	3.50 (1.07)	3.54 (1.05)	.676
Q7. Driving pressure	3.07 (1.27)	2.75 (1.26)	3.12 (1.46)	3.42 (0.90)	.778

Note. *p*-values were based on ANOVA testing differences across the experience groups. In the cells were mean (standard deviation).

APPENDIX C: TABLE 4. SURVEY ITEM SCORES ACROSS AGE GROUPS

Age	20-30 (*n* = 8)	31-40 (*n* = 22)	41-50 (*n* = 13)	> 50 (*n* = 9)	*p*-value
Likely to incorporate	4.12 (0.99)	4.36 (0.90)	4.00 (0.91)	4.22 (0.97)	.723
Q1. Post ind/supine	4.00 (0.76)	3.86 (1.32)	3.38 (1.04)	3.78 (0.97)	.723
Q2. Post int/Tburg	3.62 (1.19)	3.23 (1.34)	3.23 (0.83)	3.33 (1.22)	.581
Q3. Maint/Tburg	3.38 (1.30)	3.09 (1.48)	3.00 (1.58)	3.33 (1.12)	.866
Q4. 30 minutes	2.12 (1.25)	1.91 (1.41)	1.77 (0.83)	2.78 (1.09)	.912
Q5. Routine	4.12 (0.83)	3.95 (1.16)	3.92 (0.76)	4.00 (1.00)	.248
Q6. ARM/O2	3.75 (1.28)	3.77 (1.11)	3.54 (0.88)	3.44 (1.13)	.972
Q7. Driving pressure	2.75 (1.04)	3.27 (1.2)	2.85 (1.34)	3.62 (1.06)	.848

Note. *p*-values were based on ANOVA testing differences across the age groups. In the cells were mean (standard deviation).

APPENDIX D: IRB APPROVAL LETTER WAKE FOREST

WAKE FOREST
UNIVERSITY
HEALTH SCIENCES

Association for the Accreditation of Human Research Protection Programs, Inc.
Full Accreditation

MEMORANDUM

To: Karen Lucisano
Clinical and Translational Science Institute {CTSI}

From: Jeannie Sekits, Senior Protocol Analyst
Institutional Review Board

Date: 7/19/2023

Subject: Exempt Protocol: IRB00098451
Understanding Anesthesia Providers' Utilization of Lung Protective Ventilation Strategies in Obese Patients Undergoing Laparoscopic Surgery

No protected health information will be used or disclosed in this research proposal; therefore the requirement for individual Authorization does not apply.

null (Category null).

Note that only the Wake Forest University School of Medicine IRB can make the determination for its investigators that a research study is exempt. Investigators do not have the authority to make an independent determination that research involving human subjects is exempt. Each project requires a separate review and approval or exemption. The Board must be informed of any changes to this project, so that the Board can determine whether it continues to meet the requirements for exemption.

The Wake Forest School of Medicine IRB is duly constituted, has written procedures for initial and continuing review of clinical trials; prepares written minutes of convened meetings, and retains records pertaining to the review and approval process; all in compliance with requirements of FDA regulations 21 CFR Parts 50 and 56, HHS regulations 45 CFR 46, and International Conference on Harmonisation (ICH) E6, Good Clinical Practice (GCP), as applicable. WFSM IRB is registered with OHRP/FDA; our IRB registration numbers are IRB00000212, IRB00002432, IRB00002433, IRB00002434, IRB00008492, IRB00008493, IRB00008494, and IRB00008495.
WFSM IRB has been continually fully accredited by the Association for the Accreditation of Human Research Protection Programs (AAHRPP) since 2011.

APPENDIX E: IRB APPROVAL LETTER UNCC

CHARLOTTE
DIVISION OF RESEARCH

To:	Brandon Paluba University of North Carolina at Charlotte
From:	Office of Research Protections and Integrity
Approval Date:	25-Jul-2023
RE:	Notice of Determination of Exemption
Exemption Category:	2
Study #:	IRB-24-0045
Study Title:	Understanding Anesthesia Providers' Utilization of Lung Protective Ventilation Strategies in Obese Patients Undergoing Laparoscopic Surgery

This submission has been reviewed by the Office of Research Protections and Integrity (ORPI) and was determined to meet the Exempt category cited above under 45 CFR 46.104(d). This determination has no expiration or end date and is not subject to an annual continuing review. However, you are required to obtain approval for all changes to any aspect of this study before they can be implemented and to comply with the Investigator Responsibilities detailed below.

Your approved consent forms (if applicable) and other documents are available online at Submission Page.

Investigator's Responsibilities:

1. Amendments **must** be submitted for review and the amendment approved before implementing the amendment. This includes changes to study procedures, study materials, personnel, etc.
2. Researchers must adhere to all site-specific requirements mandated by the study site (e.g., face mask, access requirements and/or restrictions, etc.).
3. Data security procedures must follow procedures as described in the protocol and in accordance with OneIT Guidelines for Data Handling.
4.Promptly notify the IRB office (uncc-irb@charlotte.edu) of any adverse events or unanticipated risks to participants or others.
5.Five years (5) following this approval/determination, you must complete the Admin-Check In form via Niner Research to provide a study status update.
6.Be aware that this study is included in the Office of Research Protections and Integrity (ORPI) Post-Approval Monitoring program and may be selected for post-review monitoring at some point in the future.
7. Reply to the ORPI post-review monitoring and administrative check-ins that will be conducted

periodically to update ORPI as to the status of the study.
8. Complete the Closure eform via Niner Research once the study is complete.

Please be aware that approval may still be required from other relevant authorities or "gatekeepers" (e.g., school principals, facility directors, custodians of records).

APPENDIX F: LUNG PROTECTIVE VENTILATION SURVEY

1. How likely are you to set PEEP between **5-9 cmH2O** for most obese adult patients undergoing laparoscopic surgery?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. Your patient presents for a roux-en-y procedure. He is male, **5 foot 9 inches (175 cm)** tall, and weighs **200 kg**. How likely would you be to use an initial tidal volume of **450 mL**?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. Your obese patient presents for a laparoscopic total hysterectomy for uterine fibroids. Her **BMI is 37 kg/m^2**. How likely are you to administer a post-induction alveolar recruitment maneuver while still in the supine position?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. During any part of the procedure, how likely are you to increase PEEP to **10 cmH2O or above** in an obese patient undergoing laparoscopic surgery?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. How likely are you to use an initial tidal volume of greater than 8 mL/kg of ideal body weight/predicted body weight for an obese patient?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. Your patient (**BMI 40 kg/m^2**) is about to undergo laparoscopic pelvic surgery. After being positioned into steep Trendelenberg their oxygen saturation is 99% with stable hemodynamics. How likely are you to administer a post-induction alveolar recruitment maneuver?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. How likely are you to keep PEEP the same throughout a case so long as the patient is oxygenating and ventilating adequately?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. Your patient presents for a roux-en-y procedure. He is male, **5 foot 9 inches (175 cm)** tall, and weighs **70 kg**. How likely would you be to use an initial tidal volume of **450 mL**:

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. Your patient (**BMI is 37 kg/m^2**) is undergoing a laparoscopic total hysterectomy for uterine fibroids. During the maintenance phase of anesthesia in this hemodynamically stable patient, how likely are you to administer an alveolar recruitment maneuver while in Trendelenberg?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. How likely are you to routinely increase PEEP upon abdominal insufflation in an obese patient?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. Your patient presents for a roux-en-y procedure. He is male, **5 foot 9 inches (175 cm)** tall, and weighs **70 kg**. How likely would you be to use an <u>initial</u> tidal volume of **700 mL**?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. <u>How likely are you to administer an alveolar recruitment maneuver every 30 minutes throughout the surgical procedure?</u>

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. How likely are you to routinely increase PEEP upon placing an obese patient in the Trendelenburg position?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. Your patient presents for a roux-en-y procedure. He is male, **5 foot 9 inches (175 cm)** tall, and weighs **200 kg**. How likely would you be to use an <u>initial</u> tidal volume of **700 mL**?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. <u>How likely are you to incorporate alveolar recruitment maneuvers as a routine part of your anesthetic plan?</u>

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. How likely are you to <u>increase</u> PEEP if you notice elevated plateau pressures in an obese patient undergoing laparoscopic surgery?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. I was taught in my anesthesia training to deliver tidal volumes of 6-8 mL/kg of ideal or predicted body weight.

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. <u>How likely are you to administer an alveolar recruitment maneuver to your patient to improve oxygen saturation prior to adjusting the fraction of inspired oxygen (FiO2)?</u>

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. How likely are you to titrate PEEP based on driving pressure (plateau pressure minus PEEP) throughout laparoscopic surgery on an obese adult?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. How likely are you to consider the BMI of the patient when setting tidal volume for general anesthesia?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. <u>How likely are you to administer an alveolar recruitment maneuver to decrease the driving pressure on your obese, hemodynamically stable patient in a steep Trendelenberg position undergoing laparoscopic surgery?</u>

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. After insufflation and Trendelenburg positioning have been achieved, how likely are you to titrate PEEP at regular time intervals throughout the maintenance phase of the case?

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. Setting tidal volumes based on ideal body weight in obese patients may contribute to the development of atelectasis.

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely

1. <u>How likely are you to incorporate lung protective ventilation strategies as part of your anesthetic plan in obese patients?</u>

Extremely unlikely, very unlikely, unlikely, likely, very likely, extremely likely