INCREASING UTILIZATION OF
LUNG PROTECTIVE VENTILATION GUIDELINES AMONG CERTIFIED REGISTERED NURSE ANESTHETISTS

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Abstract

Background: Although lung protective ventilation (LPV) guidelines have been established, applying appropriate Positive End-Expiratory Pressure (PEEP) and Alveolar Recruitment Maneuvers (ARMs) varies among anesthesia providers. Ventilating obese patients undergoing laparoscopic surgery poses even more difficulty with ventilation due to the combination of excess fat tissue and abdominal insufflation. Therefore, it is important to understand how to apply PEEP and know when to perform ARMs to optimize ventilation in this patient population.

Purpose: This purpose of this project was to examine Certified Registered Nurse Anesthetist's (CRNAs) knowledge and desire to increase their utilization of LPV strategies in obese adults having laparoscopic surgery.

Methods: A quantitative design, involving the development of a pre and post questionnaire, was distributed among the participants involved in this study. Participating CRNAs were given a questionnaire related to their use of lung protective ventilation. The questionnaire contained domains such as knowledge, confidence, and utilization. Following the initial questionnaire, an educational session was performed by the researchers regarding lung protective ventilation techniques. Participating CRNAs were then instructed to complete the same questionnaire following the education session. The pre and post surveys were paired and data was analyzed after conducting a paired T-test performed to obtain our results. Data was displayed via charts and graphs.

Results: The total number of participants involved in this study was 17, with all participants responding to the pre and post education survey. After our education, the results showed a 18%

increase in confidence when choosing individualized PEEP for laparoscopic obese patients and a 13% increase in confidence when ventilating patients with a BMI > 55. In addition, there was a 12% increase in confidence when applying alveolar recruitment maneuvers, and a 11% increase in participants utilizing LPV strategies in their practice. However, the results contained p-values > 0.05, indicating our intervention did not statistically influence the mean scores of utilization.

Conclusion: The results showed that participating CRNAs had improvement in willingness to utilize one aspect of LPV (recruitment maneuvers), but an unchanged willingness to use individualized PEEP. However, our data demonstrated our interventions did not significantly impact overall CRNA desire to implement LPV strategies in patients. Although the literature still varies on LPV strategies, we recommend utilizing our educational interventions to promote further increases in knowledge, confidence and utilization. In addition, we recommend further investigations to help establish a standard LPV evidence-based practice guideline for obese patients undergoing laparoscopic surgery.

Background and Significance

Obesity is becoming more prevalent in society. It is estimated that one-half of the world's population will be overweight or obese by 2030 (Fernandez-Bustamante et al., 2015; Serin et al., 2019). According to the World Health Organization (WHO), obesity is defined as a body mass index (BMI) ≥ 30 kg/m^2, and morbid obesity is defined as a BMI ≥ 35 kg/m^2 (Serin et al., 2019). As fat tissue increases, chest wall compliance and lung volumes decrease due to a restriction in chest wall movement (Maia et al., 2017). These anatomical changes are an issue when maintaining intraoperative oxygen saturations during laparoscopic surgery (Fernandez-Bustamante et al., 2015; Serin et al., 2019). Also, functional residual capacity (FRC) is decreased, leading to early airway closure and gas trapping in the lungs which can decrease oxygen saturation (Masa et al., 2019). Abdominal insufflation, known as CO_2 pneumoperitoneum, provides additional challenges such as making the lungs more susceptible to damage and ventilator induced lung injuries from inappropriate mechanical ventilation (Liu et. al., 2019).

Around 234 million patients undergo surgical procedures annually, with approximately 5% experiencing postoperative pulmonary complications such as acute lung injury/failure, atelectasis, pulmonary infection, bronchospasm, bronchial obstruction, aspiration, and reintubation within 48 hours (Trethewey et al., 2021). In addition, mortality rates with postoperative pulmonary complications can be as high as 20% (Trethewey et al., 2021). In 2010, obesity was estimated to cause 3.4 million deaths, 3.9% decrease in lifespan, and 3.8% of disability worldwide (Carron et al., 2020). During surgery, obese patients will desaturate to an oxygen saturation (Spo2) <90% within two minutes, and spontaneous breathing is more difficult to achieve compared to lean individuals (Coussa et al., 2004). Additionally, Grieco et al. (2019) reported that 22% of obese patients have early airway closure after intubation in comparison to lean subjects. These changes intraoperatively can delay wake-up and Post-Anesthesia Care Unit (PACU) discharge from the hospital. Carron et al. (2020) suggests that obese patients should be monitored at least one hour before discharge for oxygen desaturation (<90%), increased oxygen requirements, and periods of apnea to prevent re-intubation. To overcome these issues, it is important anesthesia providers understand the difference between conventional and LPV strategies.

Traditionally, conventional lung strategies involved using high tidal volumes (V_T) > 10 mL/kg based on predicted body weight (PBW) and low levels of positive end-expiratory pressure (PEEP ≤ 5 cm H_2O) (Serpa et al., 2015; Tsumura et al., 2021). Also, ARMs, which involve maintaining an increase in airway pressures to re-open collapsed alveoli, are not performed with these strategies (Serpa et al., 2015; Trethewey et al., 2021). LPV strategies are defined as (V_T) of 6-8 mL/kg PBW, individualized PEEP ≥ 5 cm H_2O and the usage of alveolar recruitment maneuvers (Tsumura et al., 2021; Young et al., 2019). A study conducted by Taleb et al (2009), demonstrated the impact of alveolar recruitment maneuvers followed by PEEPs of 10 cmH2O had improved intra- and post-operative oxygenation, shorter post anesthesia care unit stay, and fewer pulmonary complications than patients ventilated with traditional lung strategies. Sixty-six patients were included in a randomized controlled trial and divided into a zero-end expiratory pressure (ZEEP) group, PEEP < 5 group, and PEEP > 10 group (Taleb et al., 2009). The average length of stay for the PEEP > 10 group was 66.90 ± 18.60 compared to 77.50 ± 20.35 in the PEEP < 5 group and 87.95 ± 35.31

in ZEEP group (Taleb et al., 2009). Additionally, only one patient in the PEEP > 10 group needed 100% oxygen compared to 5 patients in the ZEEP and three patients in the PEEP < 5 group (Taleb et al., 2009). However, not all surgery patients receive LPV. O'Gara and Talmor (2018) suggested that as many as 50% of anesthetic patients do not receive LPV strategies which entail tidal volumes 8 mL/kg PBW or lower, with or without the use of alveolar recruitment maneuvers, and a PEEP ≥ 5 cm H_2O. Therefore, it is important that CRNAs apply current literature when mechanically ventilating these patients intraoperatively, to provide optimal oxygenation.

Relevance to Clinical Site

At the clinical site of interest, a total of 2,654 laparoscopic cases were performed between October 2020-September 2021. The data was obtained by the Chief CRNA at the clinical site. Of these laparoscopic surgeries, 701 were bariatric (gastric sleeves, gastrectomy, gastric bypass, duodenal switches, single/double anastomosis, Roux-En-Y and gastric revisions). The average length of stay (LOS) for all laparoscopic cases was 1.49 days and average LOS for bariatric surgery was 1.45 days. These bariatric surgeries are performed on patients with a BMI ≥ 30. The patient population at this clinical site is at increased risk for developing intraoperative and postoperative pulmonary complications (atelectasis, decreased oxygen saturations, bronchospasm). According to Mahmood et al.

(2018) bariatric surgery and increased BMI are significant factors in prolonging LOS. Patients undergoing sleeve gastrectomy with BMI ≥ 50 were 3.3 times more likely to stay longer than one day after surgery compared to BMI ≤ 50. Taleb et al. (2009) demonstrated that obese patients undergoing general anesthesia were more likely to develop atelectasis compared to non-obese patients due to the impairment of respiratory mechanics (decreased chest wall and lung compliance) associated with general anesthesia and body habitus. Currently, this clinical site does not implement a LPV protocol.

Purpose

The purpose of this project is to examine CRNAs' knowledge, confidence and willingness to utilize LPV strategies following implementation of our PEEP and ARM protocol. Although lung protective guidelines have been established, there is a need to translate these guidelines into adoption perioperatively. Our question we investigated was in anesthesia providers performing anesthesia for obese patients undergoing laparoscopic surgery, how does implementing lung protective ventilation education increase knowledge and willingness to use such strategies during surgery?

Review of Current Evidence

A literature review was performed to explore information on LPV guidelines, identify gaps in knowledge, and confidence issues anesthesia providers may have that prevent them from utilizing these guidelines. Information was collected via PubMed, CINAHL, and SCOPUS. The following terms were utilized during the literature search: “lung protective ventilation guidelines,” “laparoscopic surgery,” “obesity,” “perioperative lung protective ventilation,” and “adherence to intraoperative lung protective strategies in anesthesia.” This search initially resulted in a total of 1528 articles. The abstract and discussion sections were analyzed, allowing relevant articles to be included in this review. Inclusion criteria involved sources that were peer-reviewed, full text, and in English. Additionally, systematic reviews, meta-analysis, and randomized controlled trials were included in this literature review. Articles not pertaining to LPV, or laparoscopic surgery were excluded from this review. Articles older than five years were excluded, unless they provided seminal studies that would be beneficial for this research project.

Anatomical Changes

General anesthesia reduces functional residual capacity (FRC) in non-obese individuals by 20% and as high as 50% in obese patients (Parameswaran et al., 2006). In obesity, the diaphragm shifts towards the lungs when lying supine, producing a restrictive pattern that is responsible for reducing FRC and expiratory reserve volume (ERV) (Grassi et al., 2020). As body mass index (BMI) increases, FRC, ERV, and total lung capacity (TLC) decrease significantly, especially lying supine (Mafort et al., 2016; Maia et al., 2017). These changes in lung mechanics lead to decreased oxygen saturations and increased ventilation requirements (Tharp et al., 2020) Additionally, the supine position facilitates early airway closure through excess adipose tissue compressing the lung, resulting in impaired gas exchange and air trapping (Levitzky, 2017; Grassi et al., 2020). Lying supine causes abdominal contents to push upward into the lungs, limiting diaphragmatic movement and FRC (Brodsky, 2021). In obesity, limiting diaphragm movement and FRC create a ventilation/perfusion (V/Q) mismatch which impairs ventilation and decreases oxygen saturation (Brodsky, 2021). The ramped position or reverse Trendelenburg position allows the abdominal contents to shift downward, alleviating the lungs from the compressed forces of the abdomen (Brodsky, 2021; Stankiewicz-Rudnicki et al., 2016). However, reduced ERV can still happen even with proper positioning, increasing closing volumes which decrease oxygen saturation (Maia et al., 2017; Masa et al., 2019).

During laparoscopic surgery, steep Trendelenburg positioning and pneumoperitoneum (abdominal CO_2 insufflation) are often encountered by the anesthesia provider. Trendelenburg positioning increases peak inspiratory pressures (greater than 35 cm H_2O), reduces lung compliance, and increases driving pressures (greater than 25 cm H_2O) (Rouby et al., 2019). Bao and Vidal Melo (2020) reported a 300% increase in chest wall stiffness in obese patients when they were in the Trendelenburg positioning with the robot docked compared to non-obese individuals. Pneumoperitoneum uses CO_2 to inflate the abdomen to facilitate surgical exposure, thus increasing abdominal pressures by 50% and compressing the lungs (Rouby et al., 2019). In the iPROVE study conducted by Ferrando et al. (2018) patients receiving LPV strategies with individualized PEEP and ventilation had approximately 50% decreased risk of prolonged ICU stay compared to conventional (non-individualized) ventilation strategies and a fixed PEEP of 5cm H2O. To overcome the issues associated with obesity and laparoscopic surgery, important ventilator settings need to be established to improve perioperative respiratory mechanics without damaging the alveoli of the lungs. Sarin et al. (2019) stated that atelectasis was the fourth most common cause of postoperative complications (respiratory failure and death). Additionally, Baltieri et al. (2016) suggested that 37% of bariatric surgery patients developed atelectasis.

Intraoperative Ventilatory Settings

Appropriate tidal volumes (Vt) must be applied to avoid volutrauma (overdistension of alveoli from increased lung volumes) in any surgical patient. Studies have demonstrated the use of low tidal volumes of 6-8 ml/kg based on ideal body weight (IBW) are optimal for obese patients (Fernandez-Bustamante et al., 2015; Maia et al., 2017; Serin et al., 2019; Young et al., 2019). The simplest way of calculating ideal body weight is with the DeVine formula. In previous studies, large tidal volumes would be given with bodyweight causing overdistention of alveoli and damage to pulmonary tissue. Ideal body weight is utilized because lung volumes remain the same and do not increase due to excessive fat tissue (Fernandez-Bustamante et al., 2015; Young et al., 2019). However, the use of low tidal volumes must be used with adequate positive end-expiratory pressure (PEEP) to prevent atelectrauma (consistent opening and closing of alveoli) from occurring due to lung derecruitment (Cipulli et al., 2018).

Intraoperative PEEP

Several studies conducting randomized control trials suggested that groups receiving higher levels of PEEP (10 cmH_2O), compared to groups receiving lower levels of PEEP (5 cmH_2O) observed the prevention of intraoperative atelectasis (Baltieri et al., 2014; Coussa et al., 2004). Baltieri et al. (2014) established that high levels of PEEP (≥10 cmH_2O) can maintain lung expansion for up to 48 hours as evidenced by decreased atelectasis on chest radiographs taken on postoperative day two. Other evidence suggests that the use of high (≥ 10 cmH_2O) or low levels (≤ 5 cmH_2O) of PEEP in conjunction with low tidal volumes did not exclusively prevent the occurrence of postoperative pulmonary complications such as atelectasis, hypoxemia, pneumonia, respiratory failure, etc. (Young et al., 2019). However, acute respiratory distress patients with obesity and cardiac disease were able to sustain high levels of PEEP (>20 cmH_2O) in the critical care setting with no evidence of any hemodynamic instability. (Bao & Vidal Melo, 2020). Recent evidence suggests initial PEEP should be applied based on 30% of the patient's BMI (Trethewey et al., 2021). Individualizing PEEP demonstrates beneficial changes such as decreasing driving pressure, increasing oxygenation, and strengthening compliance in obese surgical patients (Young et al., 2019).

Intraoperative Recruitment Maneuvers

Alveolar recruitment maneuvers (ARMs) use sustained pressure to open collapsed alveoli, thus improving respiratory compliance and alveolar ventilation, while decreasing elasticity and airway resistance (Hu, 2016). Two types of recruitment maneuvers are manual and ventilator-driven ARMs. Manual ARMs involve using the reservoir bag and dialing the appropriate PEEP value with the adjustable pressure-limiting valve (Young et al., 2019). One disadvantage of this method is the ability to lose positive pressure when switching from the reservoir bag to the ventilator after performing a recruitment breath (Young et al., 2019). Ventilator-driven ARMSs provide multiple ways to conduct this recruitment breath and it does not lose positive pressure (Young et al., 2019). Vital-capacity ARMs work by delivering tidal volumes (VT) through the ventilator circuit while manipulating the time and pressure delivered (Taleb et al., 2009; Young et al., 2019). The time should be kept to less than 10 seconds to avoid hemodynamic issues and include a pressure of 40-50 cmH_2O (Hess, 2015; Taleb et al., 2009; Young et al., 2019). ARMs are only effective if they are followed by adequate levels of PEEP (Costa Souza et al., 2020; Hu, 2016). A recruitment maneuver followed by individualized PEEP increases the amount of normally ventilated lung tissue and decreases the amount of poorly oxygenated tissue at the top and middle portions of the lung (Reinius et al., 2009).

Multiple studies have suggested that obese patients receiving mechanical ventilation benefit from ARMs, such as improved oxygenation and compliance, especially in conjunction with higher levels of PEEP (Costa Souza et al., 2020; Hu, 2016; Taleb et al., 2009). However, some drawbacks of high levels of PEEP ($\geq$ 10 cmH_2O) with ARMs include: possible hemodynamic instability such as hypotension, decrease in venous return due to increased intrathoracic pressure, and an increased risk of deep vein thrombosis through venous stasis (Baltieri et al., 2014). Several studies have utilized an incremental approach to increasing PEEP and preloading with crystalloids at 20 ml/kg/hr. saw no significant reductions in mean arterial pressures (MAP) when PEEP and recruitment maneuvers were applied (Hess, 2015; Taleb et al., 2009). Before increasing PEEP to an individualized level via the incremental (stepwise) approach, a recruitment maneuver must be performed to establish individualized PEEP (iPEEP).

Individualized PEEP and Staircase Recruitment

The stepwise or staircase method performs a recruitment maneuver while setting iPEEP (Tusman et al., 2014; Hess, 2015). There are various ways to perform this maneuver, yet primarily involves ascending and descending portions which may vary with literature. Generally, the ascending portion involves setting the driving pressure to 20 cm H_2O , I:E ratio 1:1, and respiratory rate (RR) at 10-15 breaths per minute (Tusman et al., 2014; Hess, 2015; Hol et al., 2020; Ferrando et al., 2014). PEEP should be increased in increments of 2–5 cm H_2O with a fixed tidal volume of 7 mL/kg ideal body weight (IBW) using volume control ventilation every 15-180 seconds (Hess, 2015). Simultaneously, the driving pressure, which is the pressure that results from moving air into the lungs (plateau pressure - PEEP) must be set in accordance with BMI (Hol et al., 2020; Reinus et al., 2009). Establishing these settings allows the opening pressure to become 40-45 cm H_2O, recruiting approximately 75-80% of the lung's atelectasis regions (Gattinoni et al., 2017). Maximum lung compliance should be determined at this stage. Afterwards, driving pressure is decreased by 2 cm H_2O every 20-180 seconds until a fixed tidal volume of 7 mL/kg IBW is achieved resulting in the decremental stage (Tusman et al., 2014; Hol et al., 2020). Subsequently, PEEP is titrated by 2 cm H_2O until a 10% decrease in compliance or 1% decrease in SPO2 saturation is achieved. Once the decrease in compliance or SPO2 has occurred, the same process is repeated with the established PEEP level increased 2 cm H_2O greater than the level at which best compliance was determined (Becher et al., 2021; Hess, 2015). The frequency of recruitment maneuvers varied among the literature; however, 5 out of 6 studies using recruitment maneuvers at least once every hour (Hartland et al., 2014). In addition, Nguyen et al. (2021) suggests performing recruitment maneuvers after intubation, 30 min after insufflation, and before extubating to provide the best lung compliance.

Significance of iPEEP and Staircase Recruitment

Applying iPEEP and a staircase recruitment process optimizes the lung to avoid hyperinflation and prevent or reverse atelectasis in obese patients (Ruszkai et al., 2021). High driving pressures during surgery have been associated with acute respiratory distress syndrome (Periera et al., 2018). High driving pressure causes stress on the lungs, creating uneven ventilation due to not utilizing LPV strategies (Periera et al., 2018). In addition, Ferrando et al. (2017) found a 22% increase in compliance and a 28% decrease in driving pressures associated with this method of recruiting and establishing PEEP. Furthermore, Ferrando et al. (2017)

reported ICU patients receiving this recruitment method had approximately 50% lower risk of prolonged stay in ICU and decreased atelectasis when compared to conventional lung methods.

Intraoperative FiO2

Another critical ventilatory setting that affects atelectasis in the obese population is FiO2. During induction and extubation, high concentrations of FiO2 > 0.8 results in absorption atelectasis, particularly in obese individuals (Serin et al., 2019; Young et al., 2019). Absorption atelectasis occurs from losing PEEP on induction after intubation and leads to a mismatched ventilation to perfusion (V/Q) ratio (Duggan et al., 2005). The small airways compress, reabsorbing oxygen and carbon dioxide into the pulmonary circulation (Levitsky, 2017). Increasing FiO2 on the ventilator raises the partial pressure of oxygen (PaO2) in the body, causing the oxygen rate from alveoli to capillary blood to increase significantly (Duggan et al., 2005). This can result in the formation of atelectasis in the lower lobes of the lung. Studies suggest the lowest use of FiO2 (< 0.8 but ideally 0.3-0.4) possible during maintenance of anesthesia and emergence to reduce the incidence of atelectasis (Trethewey et al., 2021; Tsumura et al., 2021; Young et al., 2019).

Intraoperative Mode of Ventilation

Lastly, the mode of ventilation and inspiratory/expiratory ratios should be considered in the obese population, yet there have been mixed results on whether Pressure Controlled Ventilation (PCV) or Volume Controlled Ventilation (VCV) is superior. Some studies suggest that PCV was superior because it improved oxygenation, compliance, arterial blood gases (ABGs), and lowered peak inspiratory pressure (PIP) in obese patients undergoing bariatric surgery (Fernandez-Bustamante et al., 2015; Hu, 2016; Young et al., 2019). Other studies concluded that VCV was superior because it provided lower plateau pressures, greater VT, and less dead space while ventilating obese patients (Young et al., 2019). However, a new ventilatory mode, Pressure Control Volume-Volume Guarantee (PCV-VG), has been recently introduced into a standard of care for obese patients. PCV-VG is a time-cycled, pressure-regulated mode that varies inspiratory flow to achieve a targeted tidal volume within the pressure limit established on the ventilator (Fernandez-Bustamante et al., 2015; Hu, 2016). This ventilatory mode combines PCV and VCV, offering minimum tidal volumes with lower PIP (Hu, 2016). However, future studies are needed to determine if this is the best ventilatory mode for obese patients.

Inspiratory/Expiratory Times

When utilizing the ventilatory modes mentioned above, the inspiratory/expiratory (I:E) time must be adjusted to prevent atelectasis development in bariatric surgery patients. Typically, the normal I:E ratio in a non-obese patient is 1:2. However, in the obese population, evidence has suggested that a 1:1 ratio provides higher PaO2 values and results in better lung compliance of the lungs (Mousa, 2013). This 1:1 ratio means that 30 seconds are inspiratory, and 30 seconds are expiratory. Young et al. (2019) suggested that the 1:1 ratio resulted in a reduction of lung damage that can be seen with prolonged I:E ratios due to gas trapping. However, Young et al. (2019) claimed that optimal I:E ratios should be based individually and can be monitored through oxygenation, respiratory compliance, and changes in pressure.

Knowledge and Confidence of CRNAs

Although lung protective guidelines may vary, anesthesia providers are not implementing them into practice due to lack of knowledge and confidence (Tretheway et al., 2021). Kim et al.

(2018) discussed the fact that anesthesia providers who were aware of LPV strategies applied LPV strategies more often than those that were not cognizant of those strategies. Additionally, Kim et al. (2018) suggested that a knowledge gap existed regarding the usage of low tidal volumes (a LPV strategy). Wolthuis et al. (2007) states that the adoption of LPV strategies increases after feedback and education, including addressing commonly perceived barriers. Also, some anesthesia providers may not be comfortable applying high levels of PEEP due to its potential hemodynamic complications. Furthermore, a study conducted by Trethewey et al. (2021) demonstrated increases in knowledge of initial VT settings (95.7% vs 63.8%) and maintenance Fio2 (100% vs 55.3%) when educated through multiple lunch sessions, individual sessions, emails, and badge cards. Implementing a lung protective guideline tool, may help address knowledge and confidence concerns when ventilating laparoscopic obese patients.

Conceptual Framework

Lewin's Model of Change is a theory that describes the process of change in an organization as a dynamic equilibrium (Barrow et al., 2021). This equilibrium consists of forces that push individuals towards a desired change and factors that inhibit movement towards that desired change (Barrow et al., 2021). In Lewin's Model of Change, the tension between the forces towards change and the forces towards keeping the status quo keep the organization at an equilibrium. (Wojciechowski et al., 2016). Lewin's theory describes the process of change in an organization such as unfreezing, change, and refreezing. The unfreezing step is an essential component because it allows for disruption of the current situation (Wojciechowski et al., 2016). Once the resistance to change is overcome, change can be implemented, allowing individuals to move to a new norm (Barrow et al., 2021; Wojciechowski et al., 2016). The final step in this process is refreezing, where this change is solidified. (Barrow et al., 2021)

The scope of this DNP project focuses on the first two steps of this conceptual framework. Regarding Lewin's theory, unfreezing the normal routine of practice at the clinical site of interest through educational sessions will allow our project to be as effective as possible. The first step in Lewin's theory was performed by making staff at the clinical site aware of clinical practice guidelines related to LPV. Increasing provider knowledge of current recommendations is shown to increase adherence to practice changes (Kim et al., 2018) Refreezing will occur when the new practice has been established and the utilization of LPV strategies becomes the new normal. Assessing the refreezing step around the desired change is beyond the scope of this project, due to time limitations. The refreezing step was facilitated by creating a badge card to allow providers a reference for the current guidelines.

Resistance to change is a normal response to proposed changes within an organization for a multitude of reasons. Some reasons for resistance can include feelings of a threat, fear of change, and communication barriers. (Dubose & Mayo, 2020). These responses are to be expected when implementing a practice change at the clinical site of interest and addressing these concerns is instrumental in initiating step one of Lewin's change theory. As demonstrated by Kim et al. (2018) and Trethewey et al. (2021), increasing provider knowledge increases adherence to current recommendations in practice change.

Methods

Project Design. This project utilized a quality improvement approach to assess clinical knowledge and confidence in anesthesia providers using LPV guidelines. The design included a pre/post survey involving demographic and clinical practice data through the usage of multiple choice, short answer, and yes/no questions. The purpose of the project was to increase the knowledge and confidence in performing LPV strategies (individualized PEEP and ARMs) intraoperatively on obese patients undergoing laparoscopic surgery. Two SRNAs conducted this project and it involved anesthesia providers at the clinical site of interest. I conducted and reported data on confidence using LPV strategies. My co-partner, Andrew Jimenez, assessed the data collected on knowledge and utilization of LPV strategies. Additionally, anesthesia providers were provided education and given a reference tool (badge card) that they could review when providing anesthesia to laparoscopic obese patients. We focused on how education impacted confidence and knowledge of providers performing ARMs and applying individualized PEEP to see if there was any correlation between receiving education and adherence to lung protective recommendations. Also, we assessed if our interventions instilled confidence to perform these tasks.

We provided two education sessions and conducted surveys electronically through Qualtrics. Additionally, a badge card with the proposed protocol was created and distributed to all CRNAs participating in the study. The badge card served as a reference tool for administering PEEP and ARMs during surgery. The reference tool was tailored with specific details on what to set PEEP at initially, and how to titrate PEEP in a stepwise manner. Additionally, references on how much pressure for vital capacity holds was included based on the patient's BMI. Data was collected over a month to ensure an adequate amount of time for confidence and education to improve.

Translational Framework. The Stelter model was the translational framework that best aligns with this project. This framework enabled researchers to assess how relevant research is implemented into clinical practice (Spring Publishing Model, 2022). Additionally, the Stelter model analyzes how to use evidence collected to establish change within organizations (Stetler, 2001). The five phases involved are preparation, validation, comparative evaluation/decision making, application, and evaluation (Spring Publishing Model, 2022). The application of these five phases was applied to our project. During preparation, face-to-face interactions with CRNAs regarding PEEP and ARM determined the need for this project and extensive research was obtained to provide education regarding these topics. Research was conducted regarding intraoperative PEEP and ARMs for obese laparoscopic patients. Validation involved authenticating data through an exhaustive literature review. After conducting our literature review, decision making/implementation was performed through summarizing data and determining if it was feasible to use for developing our LPV protocol. The data was statistically significant, determining that individualized PEEP and ARMs were important components of a LPV guideline. During the application phase, we created a lung protective protocol, focusing on individualized PEEP and ARMs. A pre-test survey was administered to determine baseline knowledge and confidence utilizing LPV. A badge card, power point, and reference flyers were administered to the anesthesia providers at our clinical site of interest. Our education tools were created based on current research articles and studies that have already implemented these guidelines. Multiple education sessions were presented and individuals who could not attend these sessions were educated one-on-one. Additionally, anesthesia providers were emailed copies of the educational tools created in case hand-outs were lost. Finally, we evaluated confidence and knowledge in a post analysis survey.

Setting. The clinical site is located in the southeastern part of the United States. The hospital is a Level II trauma center with 196 total beds. There are 10 operating rooms not including out-ofdepartment procedure areas. This hospital is known for their laparoscopic bariatric surgery and performed 2,654 laparoscopic surgeries from October 2020-September 2021. Of these 2,654 laparoscopic surgeries, 701 were bariatric (gastric sleeve, gastrectomy, gastric bypass, duodenal switches, single/double anastomosis, Roux-En-Y and gastric revisions). Permission to conduct this project was obtained by the clinical coordinator at the site of interest. IRB approval was obtained at the clinical site of interest and the contact information was provided through the site coordinator. The educational aspect of the project was conducted in the anesthesia breakroom through the use of an hour-long lecture with a slideshow presentation about the current guidelines regarding lung protective ventilation. The studies reviewed in our review of literature involved obese patients undergoing laparoscopic or bariatric surgery like the patient population at this clinical site.

Sample. A convenience sample utilizing anesthesia providers providing direct care for obese patients undergoing laparoscopic procedures was used for this project. CRNAs were invited to participate, including both female and male participants. CRNAs 18+ regardless of ethnicity, were invited to participate. CRNAs were recruited via e-mail and were notified face to face on the date of implementation. Exclusion criteria involved non anesthesia providers and anesthesia providers who are not CRNAs. Incentives were not provided; however, badge cards were provided with badge holders as a reference tool for future guidance.

Data Collection

Procedures. A pre/post survey was administered. Data collection for the knowledge and confidence survey was collected online via Qualtrics. Our powerpoint presentation consisted of 32 slides, starting with our QR code for participants to take our pre survey questionnaire via

Qualtrics. Data was paired from pre and post surveys through the use of a unique identifier code that was selected by each participant. We instructed each participant to select four unique numbers to identify themselves for the survey. The pretest survey was conducted immediately prior to our two separate education sessions. We gave participants ten minutes to complete the pre survey questionnaire and then started our education session on the difference between conventional and LPV ventilation guidelines. Afterwards, we discussed the significance of obesity, the difficulties associated with ventilating these patients, and positioning challenges during laparoscopic surgery. Lastly, we discussed the staircase recruitment method and how to apply individualized PEEP for obese laparoscopic patients. Our badge card was discussed in detail, describing how to apply our recommended interventions. After describing the steps in our badge card, questions were answered regarding the literature and use of lung protective ventilation. Immediately following the educational session and distribution of badge cards, CRNAs received another link to complete the post-survey after their education to collect our post survey data.

The educational sessions were conducted on two “late-start” days in the CRNA breakroom and hospital conference room. These education sessions consisted of a 45 minute powerpoint presentation by the researchers followed by time for answering any questions from the participating CRNAs. Education sessions were provided on two separate days and the information presented was the same to ensure participants received the same education. Clinical education days were coordinated with clinical site coordinators to ensure adequate participant turnout.

Instruments. The Qualtrics survey, Assessing Knowledge and Confidence in Anesthesia Providers, was administered to the participants in this study. The survey (Appendix A) was created and administered by myself and my co-partner Andrew Jimenez. The instrument allowed me to collect data regarding confidence using LPV strategies. In addition, my co-partner utilized the same instrument to collect information on utilization and knowledge regarding LPV strategies. The instrument consisted of questions designed to assess four domains of interest. The demographics section would allow us to obtain information on the anesthesia participants involved in this study. This section included six demographic questions, all multiple choice questions about “age,” “sex,” “education,” and “work experience.” The second domain allowed us to determine how often the participants used LPV strategies. This section consisted of two questions assessing the frequency with which the provider used certain LPV strategies. These questions utilized a 5-point Likert scale. Our third domain assessed knowledge regarding LPV strategies and consisted of four multiple choice questions. Lastly, confidence was assessed using a 5-point Likert scale designed to allow the participant to rate their level of confidence in performing certain LPV strategies.

Confidence was rated on a scale of 1-5 with 1 being very uncomfortable and 5 being extremely comfortable. For the purposes of visual representation of the paper and recommendation from our statistician, the 5-point Likert scale data was converted to a 3-point Likert scale to display cleaner results. Initially, our 5-point Likert scale incorporated “somewhat comfortable,” “very comfortable,” “neutral,” “somewhat uncomfortable,” and “very uncomfortable” to measure confidence levels in our study. The 3-point Likert scale values were changed to “uncomfortable,” “neutral,” and “comfortable” to allow for ease of visualization of changes in confidence and likelihood of utilization. In the development of the survey, questions were grouped into several “domains.” Questions 6 & 7 represented the “Utilization” domain;

questions 8,10, & 11 represented the “Confidence” domain. The accompanying charts were created by grouping the domains together to achieve one chart per domain (Appendix A)

Data Analysis

Measures of central tendency such as means were used to calculate and display the data in our demographics table. Also, percentages and frequencies were used to calculate responses in the demographics and confidence sections. These percentages and frequencies were constructed into graphs for better visual representation (see Appendices C and D). A paired T test was utilized to compare the mean difference between the pre/post survey results of knowledge and confidence utilizing LPV strategies. The statistical significance was set at an alpha level of $p \leq 0.05$. Frequencies and percentages were used to organize the data as displayed in our graphs. A Statistical Package for the Social Sciences (SPSS) software, Version 28, was utilized to conduct the paired t- test results and G-Power results to determine an adequate sample size. Professor Mittal, a professor of Biostatistics at UNC Greensboro was the statistical consultant for this project.

Results

Demographic Information

A total of 17 CRNAs attended the education sessions and participated in the study. All the participants completed the pre and post survey for a 100% participation rate. Demographic data for the participants is presented below in Table 1. Of the 17 participants, 14 (82%) were 31-50 years old, one (6%) was 25-30 years old, and two (12%) indicated that their age was greater than 50 years old. Female respondents totaled 11 (65%) of participation, while the remaining six (35%) indicated they were male. Of the 17 participants, 100% identified as having a master’s degree in anesthesia. Regarding anesthesia experience, nine (53%) had 6-10 years, five (29%)

had 11-20 years, one (6%) had 3-5 years and two (12%) had more than 21 years of experience. Among the 17 participants who reported years of experience at WakeMed Cary Hospital, seven (41%) had less than one year, five (29%) had 2-4 years, three (18%) had 6-8 years, and two (12%) had more than eight years of experience at this hospital.

Table 1 Demographics

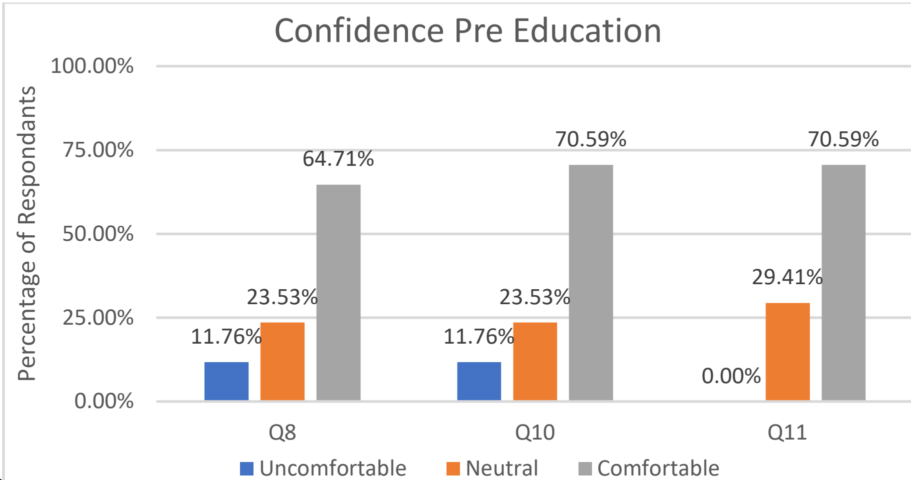
Characteristic	n	%
Age in years		
19-24	0	0
25-30	1	6
31-40	7	41
41-50	7	41
Above 50	2	12
Gender		
Male	6	35
Female	11	65
Education Level		
Doctorate Degree	0	0
Master's Degree	17	100
Years of Experience		
0-2 years	0	0
3-5 years	1	6
6-10 years	9	53
11-20 years	5	29
More than 21	2	12
Years of Experience at Clinical site		
0-1 years	7	41

2-4 years	5	29
4-6 years	0	0
6-8 years	3	18
More than 8 years	2	12

Willingness to Utilize LPV Strategies

The results from our survey were gathered and represented graphically through the bar charts pictured below. Question 6 on our pre survey read as follows: How often do you currently utilize individualized PEEP? On the post survey it read: how often do you plan to utilize individualized PEEP?. Question 7 read: How often do you utilize alveolar recruitment maneuvers? And how often do you plan to utilize alveolar recruitment maneuvers in the future? For the pre-survey, question 6 had 0 responses of "Never", 1 response of "Rarely", 10 responses of "Sometimes", 3 responses of "Very Frequently", and 2 responses of "Almost always". The post survey had the following responses: 0 responses of "Never", 2 responses of "Rarely", 6 responses of "Sometimes", 5 responses of "Very Frequently", and 5 responses of "Almost always". For Question 7 on our pre-survey, we recorded 0 responses of "Never", 2 responses of "Rarely", 10 responses of "Sometimes", 3 responses of "Very Frequently", and 2 responses of "Almost always". On our post survey for question 7, re recorded 1 responses of "Never", responses of "Rarely", 4 responses of "Sometimes", 11 responses of "Very Frequently", and 1 response of "Almost always".

Figure 1


Confidence Pre Education
Percentage of Respondants
100.00%
75.00%
50.00%
25.00%
0.00%
11.76%
23.53%
64.71%
11.76%
23.53%
70.59%
0.00%
29.41%
70.59%
Q8
Q10
Q11
Uncomfortable
Neutral
Comfortable

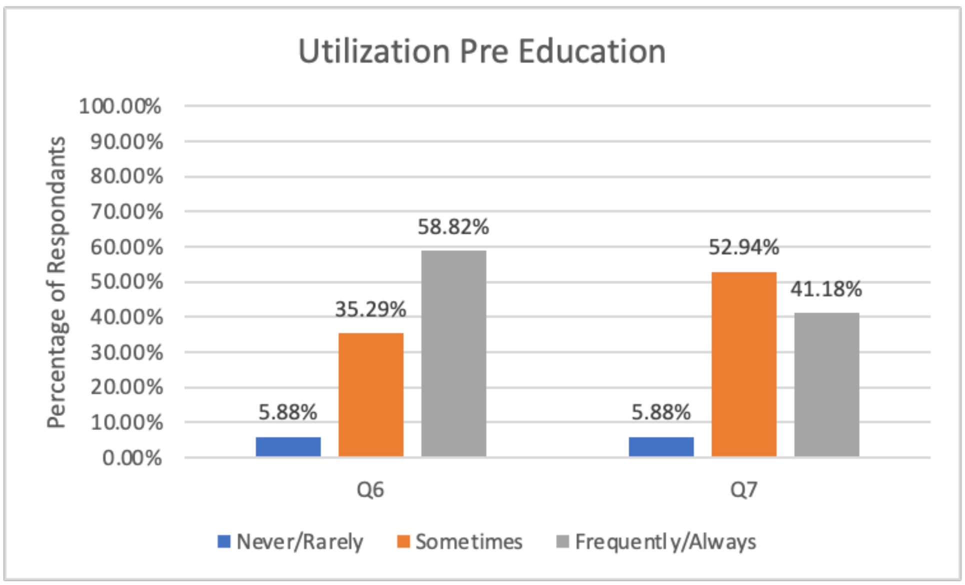
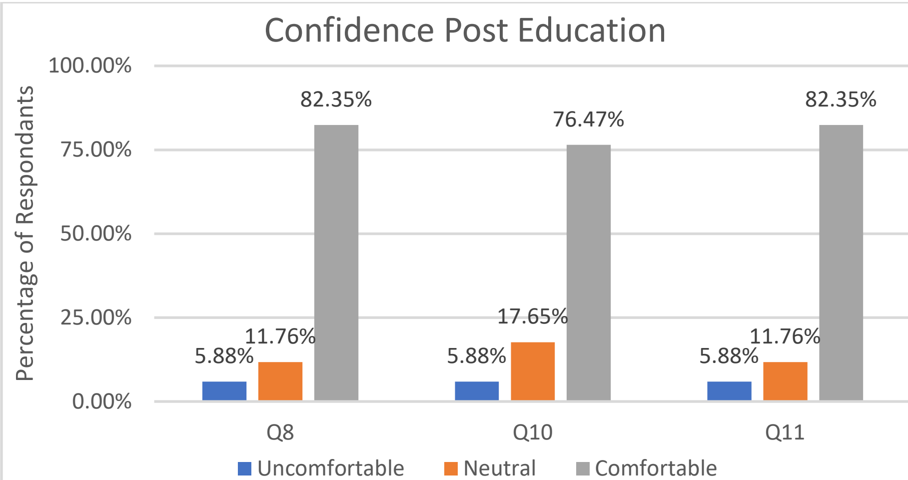
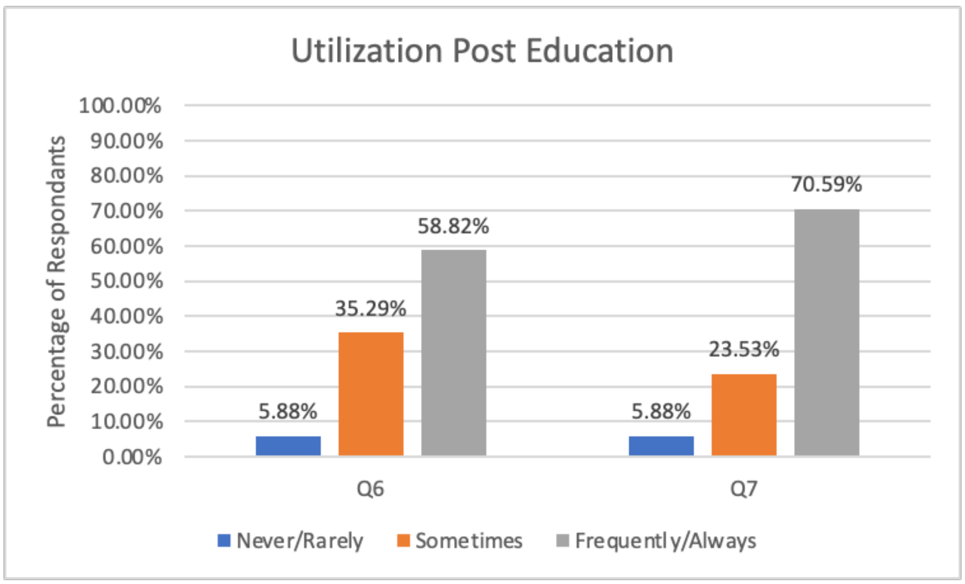

Utilization Pre Education
Percentage of Respondants
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
5.88%
35.29%
58.82%
5.88%
52.94%
41.18%
Q6
Q7
Never/Rarely
Sometimes
Frequently/Always

Figure 2.





The results were paired through the use of a unique identifier code and a paired T-test was performed. The p value was greater than 0.05 indicating that we did not have sufficient evidence to suggest that our intervention had a clinically significant impact on the willingness of CRNAs to implement LPV following our intervention. P-value=0.168.

Discussion

The goal of this project was to measure the change in the willingness of a CRNA to utilize LPV strategies before and after an educational session. While there are many components of LPV, the educational session specifically emphasized the practice of using individualized PEEP and ARMs, so our survey asked about willingness to use those specific techniques. Our expectation was that CRNAs were not familiar with the current guidelines, and thus less likely to utilize LPV in their current practice, but that after receiving education, their willingness to use LPV would increase. In Trethway et al. (2021), the authors found significant changes in actual adherence to LPV guidelines following implementation of LPV education. The authors of the Trethway study completed their implementation through the use of several in person sessions. Following the sessions, LPV "champions" would be present for assistance on site and in the OR.

While our study data demonstrated increases in plans to increase utilization, the results were not significant. CRNAs had increase of 31% in their willingness to perform alveolar recruitment maneuvers "Almost always" or "Very frequently". The success that Trethway et al. achieved could be partially attributed to the incremental rollout, as well as the fact that they had providers available to assist in the operating room. The extended rollout allowed for a gradual process for CRNAs to get acclimated to changes in their practice. Our educational sessions were performed once for each CRNA participant and were not hands on demonstrations. This did not allow for the CRNAs to see perform their new practice in a real world scenario in order to see the safety of performing LPV and its benefits. I would recommend future education regarding LPV to be supplemented with having CRNA champions to increase the comfort level and buy in among other CRNAs in order to increase willingness to perform the components of LPV. I would also recommend an assessment of perceived barriers to implementing such strategies so that future educational sessions would be able to be adjusted to attempt to overcome these barriers.

Conclusion

Lung Protective Ventilation techniques have a number of benefits for obese patients undergoing laparoscopic surgery. Namely in that they promote improved pulmonary mechanics and reduce post operative pulmonary complications. Despite literature supporting the use of LPV, it's actual frequency of use in the OR is estimated to be under 50%. This DNP project was developed with the goal of assessing the impact that education would have on a CRNA's likelihood of using LPV. Our results showed an increase in willingness to increase their utilization of LPV following education, but not in a clinically significant manner. Education about LPV strategies should be performed in a way that addresses multiple ways of learning in order to ensure CRNA comfort with changing their practice. Trethway et al. (2021) demonstrated that the right type of education along with support from champion CRNAs increased adoption of LPV. In our clinical site of interest, improved and more varied education is needed to increase the adoption of individualized PEEP and alveolar recruitment maneuvers.

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Appendices

Appendix A. Lung Protective Questionnaire

Demographics

1. Circle your age
   a. 19-24
   b. 25-30
   c. 31-40
   d. 41-50
   e. Above 50
2. Circle your gender
   a. Male
   b. Female
4. Circle Education Level
   a. Doctorate
   b. Masters
   c. Certificate
5. How long have you practiced at this clinical site?
   a. 0-1 years
   b. 2-4 years
   c. 4-6 years
   d. 6-8 years
   e. More than 8 years
6. Circle how many years you have been practicing anesthesia:
   a. 0-2 years
   b. 3-5 years

c. 6-10 years

d. 11-20

e. More than 21

Utilization of LPV:

How often do you currently utilize individualized PEEP?

A. Never
B. Rarely
C. Sometimes
D. Very Frequently
E. Almost Always

How often do you utilize alveolar recruitment maneuvers

A. Never
B. Rarely
C. Sometimes
D. Very Frequently
E. Almost Always

Confidence:

1) Rate your confidence interval choosing an initial individualized PEEP for laparoscopic obese patients?

A. Very Uncomfortable
B. Slightly Uncomfortable
C. Neutral
D. Slightly Comfortable
E. Very Comfortable

2) How comfortable do you feel ventilating patients with a BMI >55?

A. Very Uncomfortable
B. Slightly Uncomfortable
C. Neutral
D. Slightly Comfortable
E. Very Comfortable

3) Rate your comfort level with performing alveolar recruitment maneuvers in obese patients undergoing laparoscopic surgery

A. Very Uncomfortable
B. Slightly Uncomfortable
C. Neutral
D. Slightly Comfortable
E. Very Comfortable

Knowledge:

1) Your patient is a 170cm male, 115kg, with a BMI 40 receiving anesthesia for a laparoscopic gastric sleeve. What would be the initial PEEP for them? (based on current LPV recommendations)

A. 12
B. 8
C. 5
D. 14
E. 10

2) Following question: What would the initial Pinsp and PEEP be for utilizing the staircase method?

A. Pinsp: 18 PEEP: 15
B. Pinsp: 22 PEEP: 22
C. Pinsp: 20 PEEP: 20
D. Pinsp: 15 PEEP: 15
E. Pinsp: 15 PEEP: 10

3) How often should you perform recruitment maneuvers (select all that apply)

A. After intubation

B. Before induction

C. After insufflation

D. Every 30min-1hr

E. Before extubation

F. Before insufflation

4) In establishing the initial settings for PEEP, what variable do you consider most important?

A. Sex

B. Ideal body weight

C. Total body weight

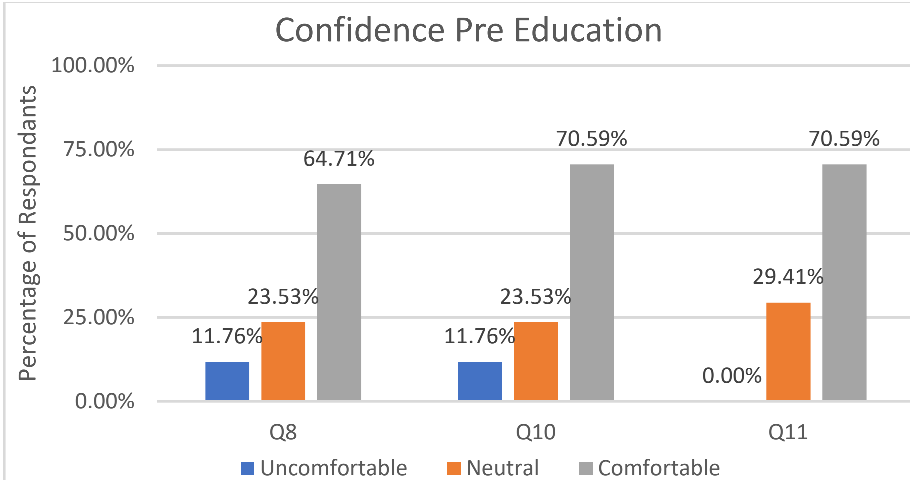
D. Whether surgery is laparoscopic or not

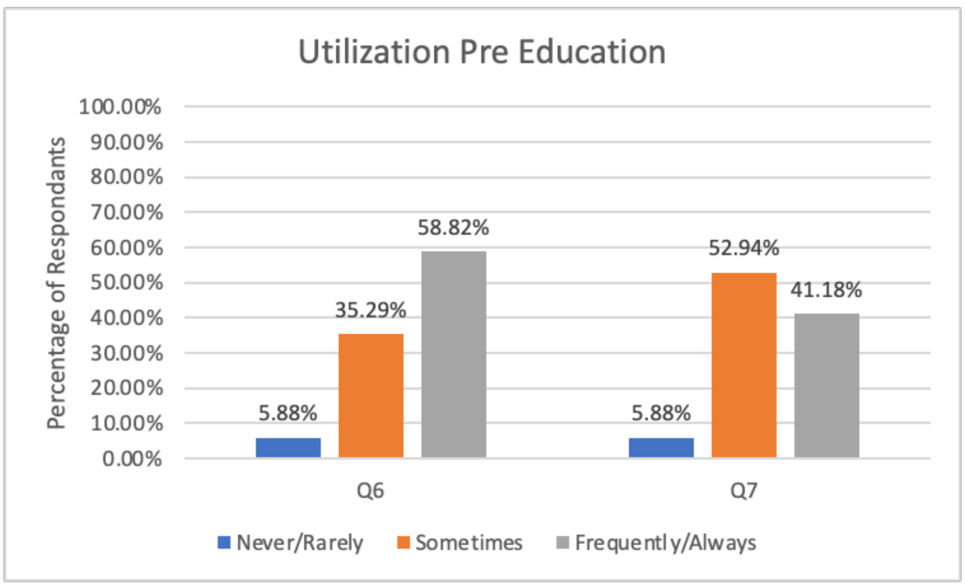
E. BMI

Appendix B. Table 1 Demographics

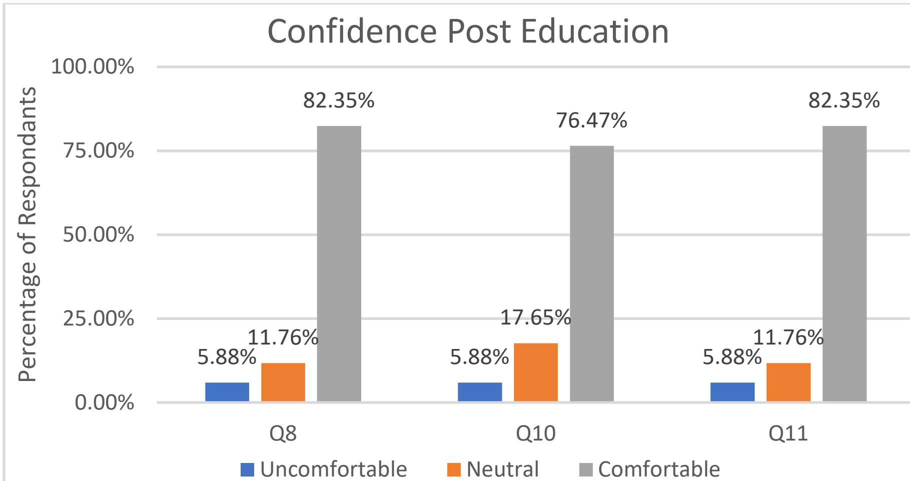
Characteristic	n	%
Age in years		
19-24	0	0
25-30	1	6
31-40	7	41
41-50	7	41
Above 50	2	12
Gender		
Male	6	35
Female	11	65
Education Level		
Doctorate Degree	0	0
Master's Degree	17	100
Years of Experience		
0-2 years	0	0
3-5 years	1	6
6-10 years	9	53
11-20 years	5	29
More than 21	2	12
Years of Experience at WMC		
0-1years	7	41
2-4 years	5	29
4-6 years	0	0
6-8 years	3	18
More than 8 years	2	12

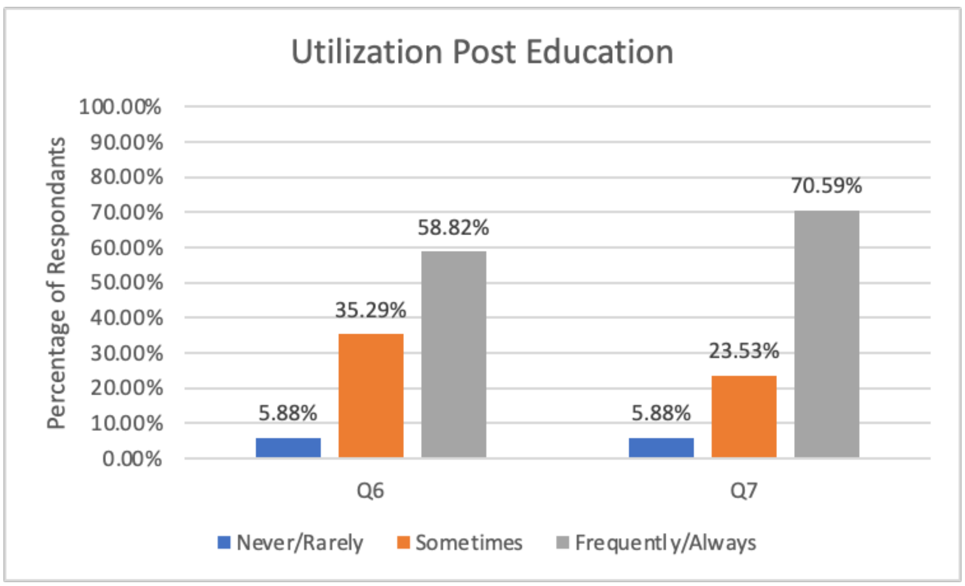
Appendix C. Figure 1 Utilization Pre Education





Appendix D. Utilization Post Education





Appendix E. Badge Card

Individualized PEEP and ARM	
1) Vent Settings	**2) After Intubation (5 min after…**
Mode: PCV **V_T:** 6-8 mL/kg IBW **RR:** 10-15 bpm **I:E** BMI < 45 = 1:1.5 BMI ≥ 45 = 1:1	Perform **"Vital Capacity"** via ventilator **Use graph to set opening pressure **based on BMI**** *(Performed to restore lungs back to "normal" habitus* ***** Set Time on "Vital Capacity" breath to 10 seconds*****
3) Staircase Recruitment	**4) Staircase Recruitment cont…**
PIP Max: 40-50 (ideally) **1. Set driving pressure to 20 cmH_2O** **2. Set PEEP to 5 cmH_2O (5-6 breaths)** **3. Titrate PEEP to 10 H_2O (5-6 breaths)** **4. Titrate PEEP to 15 H_2O (5-6 breaths)**	**5. Titrate PEEP to 20 H_2O (for 10 breaths)** **6. Driving pressure and PEEP at 20 and 20 (see figure above for opening pressure max)** **7. Maintain above levels for 10 breaths** **(Max compliance/ opening pressure determined here)**

Individualized PEEP and ARM	
5) Decremental PEEP/iPEEP	**Additional Information**

1. ↓ driving pressure by 2 cmH₂O (5-6 breaths) until IBW VT achieved **2. ↓ PEEP by 2 cmH₂O (5-6 breaths until 10% ↓ in compliance, VT, or 1%** **(Alveolar closing pressure determined here)** **7) Second Staircase Recruitment** 1. Perform after closing pressure 2. Set driving pressure 20 **cmH₂O and PEEP 20 cmH₂O** 3. Repeat section 5) above EXCEPT set PEEP 2 **cmH₂O above closing pressure PEEP** **(Recruitment maneuvers performed after intubation, after closing pressure and before extubation)** **8) Down and Dirty Example** • **BMI 40 – set pressure to 20 and PEEP to 20 for 10 breaths then perform decremental approach number 5)**	**IF NEEDED:** Steep) Trendelenburg: PEEP ↑ by **2 cmH2O** Reverse Trendelenburg: **PEEP ↓ by 2 cmH2O** See # 2) for determining driving pressure and peep (i.e. BMI 50 would need 50 PIP so pressure 25 cmH₂O and PEEP 25 cmH₂O) May need additional recruitment breath after insufflation (poor compliance, SaO2 < 97%)