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Alveolar Recruitment Maneuvers and Noninvasive Positive Pressure Ventilation in Obese Patients: A Quality Improvement Project

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ALVEOLAR RECRUITMENT MANEUVERS AND NONINVASIVE POSITIVE PRESSURE VENTILATION IN OBESE PATIENTS: A QUALITY IMPROVEMENT PROJECT

by

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ABSTRACT

Obesity is considered a complex, and often difficult to manage the disease that develops due to many factors. Over one-third of the U.S. population is considered to be obese with Mississippi ranked as second highest in adult obesity (WHO, 2016). With the increased prevalence of obese patients, it is inevitable that these patients will be presenting for surgical procedures. Obesity and its comorbidities can prove to be challenging for anesthesia providers. These patients often will have compromised respiratory function due to an accumulation of adipose tissue on the abdominal, thoracic, and diaphragmatic structures (Nagelhout, 2014). General anesthesia causes atelectasis and reductions in lung volume in the obese surgical patient (Futier et al., 2011). To combat the physiological challenges this patient population presents with, anesthesia providers must stay up to date with current evidence-based practice to prevent negative outcomes. Current evidence-based practice and literature support the utilization of noninvasive positive pressure ventilation (NIPPV), alveolar recruitment maneuvers (ARM), and positive end-expiratory pressure (PEEP) to improve obese surgical patient outcomes (Forgiarini, Rezende, & Forgiarini, 2013).

A quality improvement project was implemented which included the comparison between using NIPPV, ARM, and PEEP on induction of general anesthesia and traditional pre-oxygenation techniques. Over the course of a four-week time period, 14 participants meeting the inclusion criteria were included in this intervention. Seven participants, group one received the intervention and seven, group two did not. Group one showed an improvement in postoperative room air saturation over the preoperative room air saturation. Group two showed no improvement in postoperative room air

saturation versus the recorded preoperative room air saturation. The usage of NIPPV, ARM, and PEEP resulted in improved post-operative room air saturated oxygen level (SpO_2) on arrival to the post-anesthesia care unit as compared to the preoperative room air saturation.

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I would like to thank Dr. Marjorie Geisz-Everson for her guidance throughout this project. I am grateful for her positive feedback, words of encouragement, and motivation to complete this project in a timely manner. I would also like to thank Dr. Mary Jane Collins for her advice in preparing this project for implementation. Although she was not directly involved in this project, Dr. Nina Mclain would offer advice and guidance if needed throughout the entire process. Lastly, I would like to offer a special thanks to the Certified Registered Nurse Anesthetist (CRNA) that implemented this intervention and carried out the comparison. The failure or success of this intervention relied heavily on her willingness to help. She performed flawlessly and offered advice and guidance throughout the intervention.

DEDICATION

I would like to thank my Lord and Savior for His guidance, not only throughout this project but throughout every aspect of my life. Without Him, I would not be where I am today. I dedicate this project to my mother who unexpectedly passed away four months into the anesthesia program. Her prayers and the way she lived her life guided me in many decisions and she is greatly missed. To my wife, thank you for the burden you have had to endure throughout this endeavor, you handled it with grace and patience. To my two daughters, both of you and Mommy are the reasons I do what I do and I am so very proud of you both.

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LIST OF ABBREVIATIONS

APL	Adjustable Pressure Limiting
APN	Advanced Practice Nursing
ARM	Alveolar Recruitment Maneuver
BMI	Body Mass Index
CAD	Coronary Artery Disease
CO_2	Carbon Dioxide
CRNA	Certified Registered Nurse Anesthetist
CT	Computed Tomography
DNP	Doctor of Nursing Practice
FeO_2	Forced Expiratory Oxygen
FRC	Functional Residual Capacity
HTN	Hypertension
IRB	Institutional Review Board
LOS	Length of Stay
NIPPV	Noninvasive Positive Pressure Ventilation
O_2	Oxygen
PACU	Post Anesthesia Care Unit
PaO_2	Partial Pressure of Oxygen
$PaCO_2$	Partial Pressure of Carbon Dioxide
PEEP	Positive End-Expiratory Pressure
OSA	Obstructive Sleep Apnea
SpO_2	Saturated Peripheral Oxygen

CHAPTER I – INTRODUCTION

According to the World Health Organization (WHO) (2016), over one-third of the US adult population is considered to be obese. The State of Obesity in Mississippi reports that Mississippi is ranked as the second highest in adult obesity (The State of Obesity, 2017). In August of 2017, the percentage of Mississippi adults considered obese was over 37% (The State of Obesity, 2017). The Body Mass Index (BMI) is the tool utilized to distinguish between overweight and obese. WHO considers an individual with a BMI of greater than or equal to 25, overweight, and individuals with a BMI of greater than or equal to 30, obese (WHO, 2016).

Obesity is considered a complex chronic disease that develops due to many factors and is often associated with diabetes mellitus, hypertension (HTN), obstructive sleep apnea (OSA), coronary artery disease (CAD), and various types of cancers (Nagelhout, 2014). With an increased prevalence of obesity, anesthesia providers may encounter higher numbers of obese patients presenting for surgical procedures. Obesity and its associated co-morbidities can prove to be challenging for anesthesia providers in their efforts to administer safe anesthetic techniques.

Many of the co-morbidities associated with obesity can potentially be life-threatening to the patient. For the purpose of this project, the focus was on the respiratory considerations of the obese surgical patient. Respiratory function is compromised in the obese patient due to increasing accumulation of fat on abdominal, thoracic, and diaphragmatic structures (Nagelhout, 2014). According to Futier et al. (2011), general anesthesia causes a greater reduction in lung volume and increases the formation of atelectasis in the obese patient. Atelectasis decreases the surface area of the lung that is needed for the adequate exchange of oxygen (O_2) and carbon dioxide (CO_2) (Ray, Bodenham, & Paramasivam, 2013). Obesity is associated with increased adipose tissue around the pharyngeal airway that can lead to the inability to maintain patency of the upper airway (Sasaki, Meyer, & Eikermann, 2013). Increased abdominal adipose tissue leads to difficulty in expanding the thorax of an obese patient and causes a decrease in the inspiratory volume leading to atelectasis (Sasaki et al., 2013).

Atelectasis is the incomplete expansion or collapse of the lung leading to a loss of lung volume (Ray et al., 2013). The natural tendency for alveoli is to collapse (Coruh & Niven, 2018). Surfactant is secreted by the alveoli and contributes to the elastic properties of pulmonary tissue to prevent the collapse of open-air spaces (Coruh & Niven, 2018). Atelectasis can occur in up to 15% of the entire lung during anesthesia but primarily occurs in the basal region (Talab et al.,2009). Talab et al. (2009) report that within five minutes of induction, increased density in the dependent areas of the lungs can be seen on a chest radiograph. Obese patients are more likely to develop slowly resolving atelectasis during general anesthesia and immediately post-op than non-obese patients (Talab et al., 2009).

Two types of atelectasis associated with obesity are compression atelectasis and absorptive atelectasis. Compression atelectasis is due to the accumulation of abdominal adipose tissue making it difficult to expand the thorax and can occur during a surgical procedure (Ray et al., 2013). Absorptive atelectasis refers to nitrogen being washed out of the alveoli. Nitrogen is needed to maintain the proper function of the alveoli, and if replaced with large amounts of oxygen, the alveoli will collapse (Bodenham & Paramasivam, 2013). Dyspnea, hypoxemia, and respiratory distress can develop if atelectasis is extensive and left untreated (Coruh & Niven, 2018). Hypoxemia can lead to arrhythmias, tachypnea, cyanosis, altered level of consciousness (LOC), and respiratory failure (Madappa & Sharma, 2017). On arterial blood gas (ABG) evaluation, decreased partial pressure of oxygen (PaO_2) and low to normal partial pressure of carbon dioxide (PaO_2) indicates hypoxemia (Madappa & Sharma, 2017).

One major component of the increased cost in the obese population is hospital length of stay and is significantly increased in the obese population (Mason, Moroney, & Berne, 2013). Atelectasis is associated with prolonged length of stays in the intensive care unit (ICU) and hospitals (Hartland, Newell, & Damico, 2014). Resource utilization determined by costs per day were reported as higher in obese patients due to a greater number of therapeutic and diagnostic procedures that were utilized postoperatively. Hospital expenditures are estimated to be $160 million higher in obese patients than in comparison groups of non-obese surgical patients (Mason et al., 2013).

Significance and Purpose

Anesthesia providers must stay up to date on current techniques in order to provide a safe and effective anesthetic for any patient they encounter. The primary goal of this quality improvement project was to see if obese patients had improved postoperative room air oxygen saturation when non-invasive positive pressure ventilation (NIPPV) recruitment maneuvers (ARM) were utilized.

During induction of general anesthesia, patients experience a period of apnea prior to intubation. With the decreases in vital capacity, expiratory reserve volume, inspiratory capacity, and functional residual capacity that obese patients have, this period of apnea to desaturation are shorter than in normal healthy individuals (Sirian & Wills, 2009). A study reported by Sirian and Wills (2009), showed that the mean apnea to desaturation time in the normal healthy adult was 6.06 minutes and in the obese patient was only 2.72 minutes.

To prepare the patient for a period of apnea during induction of general anesthesia, the patient is pre-oxygenated with 100% oxygen with the goal of replacing nitrogen in the lungs with oxygen and is referred to as denitrogenation (Sirian & Wills, 2009). Removing nitrogen from the lungs improves the body's oxygen store and allows for an increased tolerance of apnea during induction (Sirian & Wills, 2009). Removing nitrogen from the lungs can cause alveolar collapse but can be corrected with the use of positive end-expiratory pressure (PEEP) and an alveolar recruitment maneuver (ARM) after intubation. One way an anesthesia provider can assess pre-oxygenation is to monitor end-tidal oxygen fraction (FeO_2). The FeO_2 provides the approximate alveolar oxygen fraction (FaO2), which correlates with the amount of oxygen in the lungs (Sirian & Wills, 2009). Ideally, the FeO_2 should correlate with the amount of inspired oxygen but can be difficult to achieve in obese patients and patients with pulmonary disease (Sirian & Wills, 2009).

The functional residual capacity (FRC) is the amount of oxygen stored within the lungs and is the most important oxygen store for the body but it is often decreased in the obese population (Sirian & Wills, 2009). With a decreased FRC and a higher prevalence of atelectasis, the obese patient is at high risk for desaturation during induction of general anesthesia. Non-invasive positive pressure ventilation and alveolar recruitment maneuvers have been shown to aid in the adequate pre-oxygenation of the obese patient by increasing FRC and prolonging the apnea to desaturation time.

Obese patients often have longer hospital stays and increased healthcare costs (Hartland et al., 2014). According to Economic Costs of Obesity (2017), the estimated annual costs of obesity-related illnesses is over $192 billion. This annual cost equates to 21% of the annual medical spending in the United States ("Economic Costs of Obesity", 2017). With an increased prevalence of obesity, it is imperative that anesthesia providers stay up to date on the safest techniques to avoid adding to the costs of surgical procedures.

Utilization of Alveolar Recruitment Maneuvers and Noninvasive Positive Pressure Ventilation (NIPPV)

Noninvasive positive pressure ventilation (NIPPV) is a type of ventilation used to administer positive pressure without the use of an artificial airway (Soo Hoo, 2017). The use of positive pressure ventilation dates back to the 1950s when it replaced the predominately used negative pressure ventilation (Soo Hoo, 2017). This new method of ventilation utilized intermittent positive pressure delivered through tracheostomy tubes (Soo Hoo, 2017). In the ensuing 30 years, positive pressure delivery via a mask developed to assist patients with obstructive sleep apnea (Soo Hoo, 2017). The success of this new development led to its adoption in other conditions such as chronic obstructive pulmonary disease and has become the first line therapy in some medical facilities (Soo Hoo, 2017).

In the surgical setting, the use of NIPPV can aid with the pre-oxygenation by washing out CO_2 and nitrogen and providing 100% O_2 to the alveoli. Using NIPPV corrects atelectasis and increases the inspired volume allowing for improved gas exchange at the alveolar level (Georgescu, Tanoubi, Fortier, Donati, & Drolet, 2012). Anesthesia providers must be sure that the oxygen mask is sealed on the patient's face to prevent any leaks. The anesthesia machine is programed to deliver pressure support ventilation (PSV). Settings are programmed to insure adequate tidal volumes by increasing or decreasing the inspiratory pressure. In this mode of ventilation, the anesthesia machine delivers the preset pressure causing an increase in tidal volume when the patient initiates an inspiratory breath (Georgescu et al., 2012).

Another way to provide positive pressure is for the anesthesia provider to manually assist the patient with inspiration during pre-oxygenation (Futier et al., 2011). Manually applying positive is performed utilizing the reservoir bag on the anesthesia machine. The adjustable pressure limiting (APL) valve can be adjusted to 5-15 cmH_2O, and when the patient initiates a breath, the reservoir bag is squeezed to generate positive pressure (Futier et al., 2011). The pressure delivered should be adequate enough to accentuate spontaneous respiration but should not be uncomfortable to the patient or cause air to enter the esophagus. Mask ventilation in an obese patient can be difficult and often times these patients can be more of a challenge to intubate (Futier et al., 2011). Utilizing NIPPV during pre-oxygenation may provide the patient with a safer induction and prolong the apnea to desaturation time.

An alveolar recruitment maneuver (ARM) consists of administering a large breath using the reservoir bag after the patient has been intubated (Futier et al., 2011). To perform this technique, the APL valve is adjusted to 30-40 cmH20 and the breath is administered and held for 30-40 seconds. This maneuver has been shown to open collapsed alveoli and allow for enhanced oxygenation during the surgical procedure. After the ARM is performed, positive end-expiratory pressure (PEEP) of 5 to

10 cmH_20 is added to the ventilator setting to prevent the alveoli from collapsing (Futier et al., 2011).

Clinical Question/ Needs Assessment

The use of NIPPV and ARMs have been shown to be effective in decreasing postoperative pulmonary complications within the obese surgical population (Futier et al., 2011). With a large population of obese patients in Southeast Mississippi, these interventions may be beneficial to those patients who present for surgical procedures. The purpose of this project was to see if these techniques will increase postoperative room air oxygen saturation in the obese population. These interventions were currently in use at the location that this intervention was implemented; however, the parameters that were utilized are different than those proposed by this project. The primary goal of this project was to assess if obese patients have an improved room air saturation using lower PEEP pressure of 5 cmH_2O and a shorter duration of time for the ARM. Prior to the implementation of this project, a PEEP pressure of 7.5 cmH_2O was being utilized. Also, the previous policy being used had the anesthesia provider hold the ARM for 45 seconds; with this intervention, the ARM was held for 30 seconds.

The clinical question for this project was: Does the utilization of NIPPV and alveolar recruitment maneuvers (ARM), using lower PEEP pressure and shorter duration of ARM time increase postoperative room air oxygen saturation. The use of NIPPV and alveolar recruitment maneuvers have been shown to aid in longer apnea to desaturation times in the obese patient who is otherwise shortened by physiological changes seen in this population. It may also help maintain higher post-intubation oxygen saturation, intra-operative oxygen saturation, and postoperative oxygen saturation in the recovery room. A higher room air saturation in the recovery room has been shown to decrease recovery room and hospital stays (Hartland et al., 2014).

Justification for PEEP 5 cmH_2O

Research indicates that utilizing PEEP at 10 cmH_2O is the best way to maintain adequate recruitment of alveoli in the obese surgical patient. Using PEEP with mechanical ventilation and ARM can have hemodynamic effects related to increases in intrathoracic pressure (Naglehout, 2014). PEEP increases central venous pressure (CVP), decreases venous return, decreases left and right ventricular preload, and increases right ventricular afterload. Decreases in cardiac output are seen as a result of these effects (Nagelhout, 2014). Reduction in systemic blood pressure and organ hypoperfusion can occur as a result of decreased cardiac output (Nagelhout, 2014). Luecke and Pelosi (2005) agree that the decrease in cardiac output is a consequence of a reduction in the left ventricular stroke volume. They go on to include that mechanical ventilation with PEEP primarily affects cardiac function by altering lung volumes and intrathoracic pressure (Luecke & Pelosi, 2005). These effects are generally seen in patients with hypovolemia and/or preexisting pulmonary diseases and can occur with PEEP levels as low as 7.5 cmH_2O (Nagelhout, 2014). The deleterious effects of PEEP can be seen in normal healthy patients but the influence is contingent on the amount of PEEP used (Naglehout, 2014). Due to the potentially deleterious effects of increasing intrathoracic pressure, it may be best to utilize the lowest, most effective PEEP, lower pressure and shorter duration of time for the ARM possible, to prevent negative effects.

Review of the Evidence

An evidence search was performed using Medline, PubMed, and Google Scholar. The search focused on articles related to alveolar recruitment maneuvers, the utilization of positive end-expiratory pressure (PEEP), and non-invasive positive pressure ventilation (NPPV) in obese surgical patients. The search consisted of utilizing search terms *obesity, alveolar recruitment maneuvers*, *non-invasive positive pressure ventilation, positive end-expiratory pressure, anesthesia techniques for obese patients, and induction techniques*.

The inclusion criteria consisted of articles that evaluated different induction techniques for obese patients. Articles that were published in the last 12 years were included in this project. Over 300 articles dated 2006 to 2016 were found. The articles meeting the criteria were narrowed down to those related to alveolar recruitment maneuvers, NPPV, and PEEP utilization in obese surgical patients. The articles were related to obesity, complications due to obesity during surgical procedures, postoperative complications of the obese patient, and interventions used to combat respiratory complications. Once the articles were narrowed down to those significant for this project, a total of five articles were used.

Summary of Evidence

The evidence reviewed for this project supports that alveolar recruitment maneuvers and NIPPV help improve pre-oxygenation in obese surgical patients. NIPPV and ARMs prevent atelectasis allowing for adequate gas exchange and proper denitrogenation of the lungs. Applying PEEP after induction was shown to help maintain adequate oxygenation throughout the procedure.

Noninvasive Positive Pressure Ventilation

In 2016, Hu conducted a systematic review of the literature to assess ventilation techniques used in obese patients undergoing bariatric surgery. She evaluated 13 randomized control studies and found that utilizing NIPPV during induction can prevent atelectasis and prolong non-hypoxic apnea time. Two of the studies she reviewed utilized NIPPV on induction. In the group of patients in which NIPPV was used, the studies found that it was more effective in preventing atelectasis than in the control group that used conventional pre-oxygenation techniques. These studies also revealed that these patients had better oxygenation as well as higher end-expiratory lung volumes in groups than those who did not receive NIPPV (Hu, 2016).

Futier et al. (2011) conducted a prospective study to determine if NIPPV improves arterial oxygenation and end-expiratory lung volume (EELV) when compared to conventional pre-oxygenation techniques. The authors also wanted to assess if NIPPV followed by ARM would further improve oxygenation when compared to NIPPV alone. In this study, patients were randomly assigned to three groups. Group one consisted of conventional pre-oxygenation with face mask, Group two received the NIPPV, and group three received NIPPV followed by ARM. Prior to intubation and immediately after intubation and five minutes after the initiation of mechanical ventilation, arterial blood gases were drawn. After pre-oxygenation and immediately before intubation results were as follows: group 1 PaO_2 was 306 mmHg, group 2 PaO_2 was 375 mmHg, and group 3 was PaO_2 of 425 mmHg. Immediately after tracheal intubation, the results were: group one, a PaO_2 of 150 mmHg, group two, a PaO_2 of 221 mmHg, and group three, a PaO_2 of 225 mmHg. Five minutes after initiation of mechanical ventilation the PaO_2 ranged from, group one, a PaO_2 of 93 mmHg, group two, a PaO_2 of 128 mmHg and in group three, a PaO_2 of 234 mmHg. The study revealed that with obese patients, NIPPV followed by ARM improved arterial oxygenation when compared to NIPPV alone. NIPPV followed by ARM also improved EELV when compared to NIPPV alone.

Alveolar Recruitment Maneuver/ PEEP

Another study reported using ARM followed by PEEP in one group versus a group that utilized PEEP alone. The ARM group showed higher PaO_2/FiO_2 ratio and exhibited an increase in lung compliance compared to the group with PEEP alone (Hu, 2016). These findings indicate that with the use of ARM and PEEP, patients were experiencing higher oxygen levels with lower supplemental oxygen flow than in patients who did not receive the intervention.

Hu (2016) also reviewed a study that investigated four different ventilation strategies. Group P used PEEP of 10 cmH_2O, group R used an ARM with 40 cmH_2O for 15 seconds, group RP utilized ARM once followed by PEEP, and group RRP used ARM plus PEEP but performed ARM every 10 minutes. The results were as follows: Group RRP showed the best PaO2, highest oxygen saturation, and shorter hospital stays, Group RP had the second best results but were not maintained, and Group R and Group P showed no improvement (Hu, 2016).

Multiple studies revealed no significant benefits of ARM alone without using PEEP. When PEEP alone was utilized, some studies revealed improved oxygenation and lung compliance but results were not consistent. Studies that used ARM followed by

PEEP showed consistent improvements in lung compliance, improved oxygenation, and atelectasis reduction (Hu, 2016).

Talab et al. (2009) performed a double-blind controlled study of 66 obese patients with a BMI between 30 and 50. These patients were randomly selected for three groups according to the ventilation technique used. The first group called zero end-expiratory pressure (ZEEP) received an ARM alone. The second group, PEEP 5, was administered an ARM followed by PEEP of 5 cm H2O. Group PEEP 10 was administered an ARM followed immediately by PEEP of 10 cm H2O. Chest computed tomographic (CT) imaging was performed on all subjects in this study prior to the surgical procedure and following the procedure. Preoperative CT scans on all the patients in this study were reported as normal and all participants had similar co-morbidities. Postoperatively, group PEEP 10 showed significantly less atelectasis than groups ZEEP and PEEP 5. Recovery room stays were reported as being dramatically shortened in group PEEP 10 than in the other groups although no specific times were reported. Only one patient in the PEEP 10 group required supplemental oxygen in the recovery room compared to five subjects in the ZEEP group and three in the PEEP 5 group. Forty-eight hours after surgery revealed no bronchospasm, significant desaturation, or chest infection in the PEEP 10 group versus four in the ZEEP group and three in the PEEP 5 group. The overall study revealed that the use of ARM followed by PEEP of 10 cmH_2O leads to fewer pulmonary complications, better oxygenation, and shorter recovery room stays (Talab et al., 2009).

Forgiarini, Rezende, and Forgiarini (2013) conducted a literature review on the topic of ARM and ventilation strategies in the obese surgical population. The articles were narrowed to the studies that addressed the topics of ventilation strategies in obese patients. A few of these studies utilized various PEEP pressures, ranging from five to 15 throughout the surgical procedures. These studies also showed that without ARM, only varying degrees of improvement of oxygenation and atelectasis prevention was found. They found that performing ARM and adding PEEP can result in short-term improvements but should be repeated at different intervals throughout the procedure. One study used 60 patients allocated into three groups: conventional technique, single ARM with 40 cmH2O for seven seconds, and ARM repeated 30 minutes. All groups were placed on PEEP of 10 cmH2O throughout the surgical procedure. The group that utilized ARM repeated throughout the procedure showed improved gas exchange and better lung mechanics throughout the postoperative period. The studies presented in this article revealed that the use of ARM is an effective technique to improve oxygenation and decrease pulmonary complications in obese patients. Most studies showed that PEEP of 10 cmH_2O is the best way of maintaining improved oxygenation that is achieved by ARM. It also showed that NIPPV in the post-operative setting is a good alternative to continue the positive effects achieved with the ARM and PEEP (Forgiarini et al., 2013).

Reinius et al. (2009) report a study performed on 30 obese patients presenting for gastric bypass surgery. The purpose of this study was to assess the effects of general anesthesia and to measure three different ventilation strategies to reduce the amount of atelectasis. The authors hypothesized that a recruitment maneuver followed by PEEP would produce the most beneficial effects for the patient.

They, therefore, evaluated the aeration of the lung by using CT while awake, five minutes after induction of anesthesia, and five minutes and 20 minutes after three different ventilation strategies. These patients were placed into three groups: group one utilized PEEP of 10 cmH_2O only, group two used a recruitment maneuver with 55 cmH_2O for 10 seconds followed by zero PEEP, and group three used a recruitment maneuver with 55 cmH_2O followed by PEEP of 10 cmH_2O. Prior to induction of general anesthesia, patients were pre-oxygenated for five minutes with 100 % O_2 and a tight-fitting mask. General anesthesia was induced with the same weight-based medications for all the patients in the study. After induction, the patients were ventilated with volume controlled ventilation, inspired oxygen fraction was 0.5, and zero PEEP was applied. Tidal volumes were set at 10 ml/kg with a respiratory rate of 12 breaths per minute. The tidal volumes remained the same for all patients, however, the respiratory rate was adjusted to maintain $ETCO_2$ between 34 to 41 mmHg.

The patients were then randomly selected by using a sealed envelope as to which intervention would be used. The recruitment maneuver followed by PEEP showed an increase in the PaO_2/FIO_2 ratio at five minutes and was maintained at 20 and 40 minutes. PEEP alone or a recruitment maneuver followed by zero PEEP did not cause a change in the PaO_2/FIO_2. No significant difference in oxygenation was noted within the three groups before the intervention, while awake, or after induction of anesthesia. The PaO_2/FIO_2 ratio was reduced by 40% after induction and paralysis compared to the awake PaO_2. No significant difference between the three groups regarding lung compliance was noted. Recruitment maneuver followed by PEEP caused an increase in compliance evident at five minutes but this increase in compliance was less significant at 40 minutes. The intervention of PEEP alone also caused a similar increase in compliance but was not seen in the recruitment maneuver followed by zero PEEP group. Using Spiral CT, the end-expiratory lung volume (EELV) was measured. Approximately 50%

reduction in EELV was noted after induction of anesthesia and paralysis in all subjects. In the PEEP group, the EELV increased 32% and in the recruitment maneuver followed by PEEP group, the EELV increased 64%. No change was observed in the recruitment maneuver followed by zero PEEP group. A single slice CT was performed in all 30 patients while awake, after induction, and five and 20 minutes after the three different interventions.

Atelectasis was shown in all patients after induction and paralysis in the dependent portions of the lungs. A reduction in atelectasis was shown after five and 20 minutes after recruitment maneuver followed by PEEP. In the PEEP alone group or recruitment maneuver followed by zero PEEP group, no reduction in atelectasis was seen at five and 20 minutes

The study revealed that in morbidly obese patients, induction of anesthesia and paralysis reduced EELV, promoted atelectasis in the most dependent areas of the lung, and caused a fall in arterial oxygenation. It also showed that recruitment maneuver followed by PEEP increased EELV, effectively recruits alveoli, increases lung compliance, and improves arterial oxygenation. The increased arterial oxygenation remained stable during the 40-minute study time. Recruitment maneuver or PEEP alone did not effectively improve respiratory function (Reinius et al., 2009).

Theoretical Framework

The Donabedian Model was the framework for this project. The Donabedian model contains three main parts: structure, process, and outcomes. Structure is considered to be the environment that the services or interventions are provided. This project took place in a healthcare facility operating room in rural

Mississippi. Donabedian's definition of process is the framework of the interaction with the patient and the provider and how the care is given. The process of this quality improvement project included anesthesia providers performing ARMs, NIPPV, and utilizing PEEP with obese surgical patients. Outcomes are the results of the intervention. The outcome of this project was post-operative room air saturation in obese surgical patients. Evaluation of the outcomes aided in assessing the significance or insignificance of this intervention and helped evaluate the need for future studies.

Doctor of Nursing Practice Essentials

Doctor of Nursing Practice Essentials outline competencies that are required in advanced practice nursing programs. These competencies are fundamental to all advanced practice nursing roles. Essentials I through VIII are the foundational outcomes needed for all DNP graduates regardless of the specialty.

Essential I: Scientific Underpinnings for Practice

Essential I provides the healthcare provider with the scientific understanding of evidence-based interventions used to improve the quality of health care. The most current evidence-based practice was used to propose a protocol to improve obese patient outcomes in the postoperative setting. The evidence-based information used was steeped in scientific underpinnings.

Essential II: Organizational and Systems Leadership for Quality and Systems Thinking

Organizational and systems leadership are essential for improvement in healthcare and patient outcomes by using the most up to date practices for target populations. This project was focused on the obese population and techniques utilized to prevent respiratory complications while undergoing a surgical procedure. This essential was used throughout this project to ensure the most current and up to date practices were included. This project utilized evidence-based information found in the literature that showed NIPPV, PEEP, and ARMs improve post-operative outcomes for obese surgical patients.

Essential III: Clinical Scholarship and Analytical Methods for Evidence-based Practice

This essential equates to the DNP prepared nurse having the ability to evaluate literature and obtain new knowledge for practice problems. Previous research was utilized in the foundation of this project. Analytical methods were used to assess the benefits of using alveolar recruitment maneuvers and NIPPV in the obese surgical patient. By reviewing and assessing the importance of the literature, this project paralleled previous research showed the benefits of ARMs and NIPPV.

Essential IV: Information Systems/Technology and Patient Care for the Improvement and Transformation of Healthcare.

This essential entails the DNP prepared nurse should have the ability to use information systems/technology to improve healthcare systems and provide leadership. Throughout this project thorough evidence searches were performed through online libraries, medically based databases, and scholarly search engines. With this project, an intervention was constructed that was implemented over a one-month period to assess the benefits of NIPPV and ARMs. Upon the completion of the intervention, the data obtained was assessed to see if the NIPPV and ARMs improve postoperative room air saturation in obese patients.

Essential V: Healthcare Policy for Advocacy in Healthcare.

Healthcare policy is used to facilitate the delivery of healthcare services. It also gives the provider the ability to participate in the delivery of those services. This project provided education to anesthesia providers related to current techniques that are proven to effectively increase postoperative room air saturation in obese patients.

Essential VI: Inter-professional Collaboration for Improving Patient and Population Health Outcomes.

Today's healthcare environment is more complex than in years past. Patients no longer have one provider. They often have multiple providers to treat various medical issues they face. To effectively treat a patient, these providers must collaborate with one another to ensure safety for the patient. The same is true for the DNP prepared nurse. They must be able to communicate in a professional way to other members of the healthcare team. Anesthesia providers, surgeons, and operating room (OR) personnel were instructed on the benefits of the intervention with this project.

Essential VII: Clinical Prevention and Population Health for Improving the Nation's Health.

Clinical prevention is used to decrease the risk of health-related problems in individuals and families. Population health includes reduction of health-related problems within communities. This project focused on improving the health of the obese surgical population by using ventilation techniques proven to enhance oxygenation during and after a surgical procedure. This population often presents with respiratory complications and this intervention will aid in preventing any further decline in respiratory function.

Essential VIII: Advanced Nursing Practice.

Increased technology and knowledge of the healthcare system has resulted in the growth of nurses with advanced degrees to ensure competence in a highly complex health system. Doctor of Nursing Practice programs provide the student with distinct specialties to master one area of nursing practice. To master a specific area, the DNP prepared nurse must have the ability to utilize evidence-based practice. The most current and up to date ventilation techniques were found utilizing research skills obtained while in a DNP program. After locating the research, the most current and valid sources available at the time of this project were utilized. The findings were reported to anesthesia providers and will help them provide a safer anesthetic for the obese surgical population.

Summary

Obesity has increased in prevalence throughout the State of Mississippi and throughout the U.S. The obese patient will often have multiple comorbidities that will present a challenge for anesthesia providers. Respiratory complications are some of the highest concerns for these patients undergoing a surgical procedure and often lead to complications in the post-operative setting. Poor post-operative outcomes lead to increased healthcare costs for the patient and the facility due to increased recovery room stays and hospital stays.

General anesthesia can cause atelectasis in any patient, but atelectasis is increased in an obese patient. Evidence indicates that atelectasis can be decreased by utilizing NIPPV, ARM, and PEEP during induction of general anesthesia and throughout the surgical procedure. Decreasing atelectasis in the obese patient can help prevent postoperative complications in the obese surgical patient.

CHAPTER II- METHODOLOGY

Study Design

Upon approval from The University of Southern Mississippi Institutional Review Board (18071904) and a letter of support from the head of the anesthesia group at the intervention location, the project was implemented. One CRNA from the group carried out the intervention and collected all data on patients meeting the inclusion criteria. The inclusion criteria included patients with a BMI of 30-39.9 undergoing a surgical procedure requiring endotracheal intubation. The exclusion criteria included patients not meeting the inclusion criteria and those with acute or chronic respiratory illnesses or Physical Status (PS) score greater than 3. The intervention was to use NIPPV with pre-oxygenation, ARM after intubation, and the addition of PEEP of 5 cm H2O NIPPV assisted the patient by providing larger inspiratory tidal volumes and opening collapsed alveoli. After the patient was intubated, the ARM was administered by closing the APL valve to 30 cmH2O and squeezing the reservoir bag and holding the breath for 30 seconds. PEEP of 5 cmH2O was programmed on the ventilator and ventilation began. Two groups were included in the intervention. Group 1, a total of 7 patients, was administered the intervention and Group 2, also 7 patients, received traditional pre-oxygenation technique. Demographic data were collected on each patient including the pre-operative room air oxygen saturation and postoperative room air saturation. After completion of the intervention, the post-operative room air oxygen saturation was compared between the two groups. The comparison revealed that the use of NIPPV, ARM, and PEEP improved post-operative room air saturation in obese patients. After the intervention was concluded, the results were presented to the anesthesia providers at the site of the intervention.

Target Outcome

The goal of this project was to improve patient post-operative room air saturations through utilization of NIPPV and ARM. The secondary goal of this project was to educate current anesthesia providers on the most up to date ventilation techniques have proven to be effective in preventing pulmonary complications in the obese population.

Data Analysis Plan

Upon completion of the data collection period, the post-operative room air saturation of the NIPPV, ARM, and PEEP group was compared to post-operative room air saturation of the traditional ventilation technique group. The results were evaluated using descriptive statistics and Cohen's D. The Cohen's D was calculated by using each group's mean, standard deviation (SD), and sample size. A difference score was also used to assess the amount of change between the two study groups.

Summary

This intervention was carried out on fourteen participants meeting the inclusion criteria over a one-month period in a rural hospital setting. Seven participants received the intervention and seven received traditional pre-oxygenation techniques. The participants receiving the intervention showed an improvement in post-operative room air saturation compared to the pre-operative room air saturation. The participants who did not receive the intervention showed a decline in post-operative room air saturation.

CHAPTER III - RESULTS

Over the course of 4 weeks that the intervention was conducted, a total of 14 patients were included in the study. Seven patients received the intervention and 7 did not. The results of the intervention showed that using NIPPV, ARM, and PEEP improve post-operative room air saturation in obese patients with a BMI of 30-39.9.

Table 1

Group 1- NIPPV

Patient Number	Preoperative SpO_2	PACU SpO_2	BMI	Gender
1	90	96	38.6	F
3	92	96	35.8	F
5	90	96	37.2	M
7	91	96	36.7	F
9	89	92	39.4	M
11	94	94	34.5	M
13	93	98	34.8	F

Table 2

Group 2- Traditional Pre-oxygenation Technique

Patient Number	Preoperative SpO_2	PACU SpO_2	BMI	Gender
2	93	92	36.6	M
4	96	91	33.2	F
6	96	90	39.1	M
8	94	92	32.9	F
10	92	89	38.9	F
12	95	92	36.8	M
14	97	93	32.5	M

Group one had four females and three males that met in the inclusion criteria for this intervention. Group two had four males and three females who were also included in this intervention. Group one had two members who were considered class one obesity having a BMI of 30 to less than 35 and five members who were considered class two obesity having a BMI of 35 to less than 40. Group two had three members who were considered class one obesity and five members considered class two obesity. All members in group one regardless of their obesity class showed improvement in postoperative room air saturation with the exception of one member. This member had the same postoperative room air saturation as their preoperative saturation. Group two members had the same or lower postoperative room air saturation than preoperative room air saturation. The results of this intervention revealed that utilizing NIPPV, ARM, and PEEP in obese surgical patients improves postoperative room air saturation.

Summary

The results of this intervention revealed that participants receiving NIPPV, ARM, and PEEP had a higher post-operative room air saturation than those participants who did not receive the intervention. The group that received traditional preoxygenation techniques had a lower post-operative room air saturation versus their pre-operative room air saturation. The results show that atelectasis caused by general anesthesia in obese patients can be minimized by using NIPPV, ARM, and PEEP. The participants included in the intervention were only assessed for room air saturation and not followed throughout their hospital stay.

CHAPTER IV – DISCUSSION

Two groups of patients meeting the inclusion criteria for this intervention were assessed to see if using NIPPV, ARM, and PEEP showed improvement in post-operative room air saturation over traditional pre-oxygenation techniques. After completion of this project, it was concluded that the utilization of NIPPV, ARM, and PEEP did show improvement in post-operative room air saturation in obese patients over traditional pre-oxygenation techniques. The results confirmed what the literature states, that obese patients are better oxygenated and have better outcomes using these techniques.

The CRNA who performed the intervention was not at any risk and performed within her scope of practice to conduct an induction in this manner. With the inclusion criteria set forth for the patients who received the intervention, there was no risk of harm to the patient. If at any point the patient did not tolerate the intervention, it would have been aborted and traditional pre-oxygenation techniques would have been utilized. This intervention was not an experimental technique and no reports of injuries were reported in this project or in any of the articles used for this intervention. The participants were known only by inclusion criteria and no patient identifiers were collected or reported in this project.

Limitations

This intervention was carried out on a relatively small sample size of 14 patients. With a sample size this small, it is difficult to determine if the results are representative of this patient population as a whole. A larger sample size would be helpful in determining if the results represent this population.

Future Studies

The results of this project clearly show the benefits of using NIPPV, ARM, and PEEP in obese surgical patients. To get a clearer indication a larger sample size may need to be used in future studies. The BMI inclusion criteria for this intervention was between 30 and 39.9. Larger or smaller BMI criteria can also be used to see if the same result is achieved. This project utilized PEEP of 5 cmH_2O after intubation. PEEP of 5 cmH_2O is lower than most of the studies used in this project. Future projects could use even lower PEEP to assess if the results are the same. The ARM pressure and NIPPV pressure could be assessed in the same manner. Studies on the effects of using these techniques individually can be conducted to assess the benefits of one technique over the other.

The results of this study should not be limited to obese surgical patients. Research shows that atelectasis can result in any patient undergoing general anesthesia regardless of body habitus. These patients can also benefit from these techniques and should be utilized at the anesthesia provider's discretion.

Conclusion

The results of this quality improvement project revealed using NIPPV, ARM, and PEEP improve post-operative room air saturation in the obese surgical patient. Implementing safer techniques for anesthesia is paramount for the continuation of the practice and safety of the patient. Studies used for this project support and encourage using these techniques with the obese population and show that oxygenation is improved and pulmonary complications are reduced. Continuing to seek and utilize the latest evidence-based practice techniques leads to safer anesthetic and better outcomes.

APPENDIX A – Data Collection Tool

1. Body Mass Index: _____________
2. Gender, Circle one: Male Female
3. Pre-oxygenation technique: Circle one
    - A. NIPPV w/APL valve and assist w/handbag, Alveolar recruitment maneuver (30 cmH_2O for 30 seconds, followed by PEEP of 5 cmH_2O
    - B. Normal tidal volume breathing
4. Pre-op SpO_2 on room air __________
5. Post-op SpO_2 on room air _________

APPENDIX B – Letter of Support

[redacted] CRNA CEO

[redacted] ANESTHESIA, INC

P.O. BOX [redacted]

MOUNT OLIVE, MS 39119

I, [redacted], SUPPORT RYAN MILES, DNP PROJECT "ALVEOLAR RECRUITMENT MANEUVERS AND NONINVASIVE POSITIVE PRESSURE VENTILATION IN OBESE PATIENTS: A QUALITY IMPROVEMENT PROJECT.

[redacted]

APPENDIX C – IRB Approval Letter

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

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

NOTICE OF COMMITTEE ACTION

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

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

PROTOCOL NUMBER: 12345678
PROJECT TITLE: How to Achieve IRB Approval at USM
PROJECT TYPE: New Project
RESEARCHER(S): Jonas Doe
COLLEGE/DIVISION: College of Education and Psychology
DEPARTMENT: Psychology
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 01/02/2015 to 01/01/2016
Lawrence A. Hosman, Ph.D.
Institutional Review Board

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