Preoxygenation of Patients with Class Three Obesity

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Abstract

Patients with class three obesity, formerly defined as morbid or extreme obesity, presenting for anesthesia come with an increased risk of experiencing complications. The oxygen storage capabilities and the functional residual capacity (FRC) in the lungs are reduced, making this patient population at risk for rapid oxygen desaturation with apnea. This patient population also has an increased risk for complications to occur while securing the patient's airway during induction of anesthesia and are at risk for difficult airway management. Preoxygenation is performed before the induction of anesthesia to replace nitrogen in the lungs with oxygen, this will increase the time a patient can tolerate apnea without desaturating. Due to the increased risks which present with the class three obesity population, it is important to optimize preoxygenation prior to the induction of anesthesia and to consider providing apneic oxygenation during the intubation process to prevent desaturation.

There are many studies and recommendations found in the literature concerning optimizing preoxygenation, patient positioning, and providing apneic oxygenation to the class three obesity patient population as means to prevent desaturation during induction of anesthesia. The objective of this project was to utilize the Iowa Model of Research-Based Practice to Promote Quality Care (IOWA Model) to perform a review of the literature concerning preoxygenation of obese patients and examine current preoxygenation practices at Hendricks Regional Health Hospital (HRH). Current practice at HRH was examined via retrospective chart review of three months of data. During September, October, and November of 2019, HRH had 82 patients with a BMI of 40 or greater receive anesthesia which required endotracheal tube (ETT) placement for airway management. 16 (20%) of these patients experienced a desaturation measured by a peripheral capillary oxygen saturation (SpO2) less than 90%. Data extracted from the retrospective chart review produced descriptive as well as parametric statistics. The results of the data analysis did not offer significant results identifying differences between the group of patients who experienced a desaturation and the group of patients who did not have a desaturation. Because of this, it is suggested each patient at risk for desaturation, including those with class three obesity, be treated as though they are going to experience a desaturation and measures to prevent this desaturation be taken. Techniques to decrease the percentage of patients who experiencing a desaturation during the induction of anesthesia at HRH are discussed in this paper.

Keywords: preoxygenation, morbid obesity, class three obesity

Preoxygenation of Patients with Class Three Obesity

Providing anesthetic care to the obese patient population can be challenging due to the anatomical and physiological changes present in this patient population. The Centers for Disease Control and Prevention (CDC) defines obesity as a body mass index (BMI) greater than 30 (CDC, n.d.). The CDC further divides obesity into three categories: class one is BMI 30 to less than 35, class two is BMI 35 to less than 40, and class three is BMI greater than 40 (CDC, n.d.). This project will focus on the class three obesity category, formally known as morbid or severe obesity, which includes patients whose body mass index (BMI) is 40 or greater (CDC, n.d.). Proper preoxygenation prior to the induction of anesthesia is critical in this patient population in order to prolong the safe apneic time before desaturation while securing the patients airway via endotracheal intubation (ETI) (Schumann, 2019). This scholarly project examined current preoxygenation practices in the class three obese population at Hendricks Regional Health Hospital (HRH) and assessed whether practice change is indicated based on past patient data.

Background

SpO_2, measured by pulse oximetry, is an indirect measurement of the amount of oxygen in the blood bound to hemoglobin available to the body's tissues (Crawford Mechem, 2020). A clinically significant desaturation of oxygen is considered an SpO_2 less than 90%, in which supplemental oxygen should be provided to the patient (Feller-Kopman & Schwartzstein, 2020). Using pulse oximetry reduces the need for direct measurement of the patient's arterial oxygen saturation (SaO_2) and arterial partial pressure of oxygen (PaO_2) measured via an invasive arterial blood draw and blood gas analysis (Feller-Kopman & Schwartzstein, 2020).

The partial pressure of oxygen (PO_2) in arterial blood after oxygenation has occurred in the lungs is 80 to 100 mmHg (Collins et al., 2015). Deoxygenated venous blood returning to heart has a PO2 of 40 mmHg (Collins et al., 2015). The oxygen-hemoglobin dissociation curve is a sigmoid representation of the relationship between arterial blood saturation and the PO2 in the blood (Collins et al., 2015). A representation of the oxygen-hemoglobin dissociation curve can be found in Appendix A. The oxygen-hemoglobin dissociation curve is relatively flat when the SpO2 is greater than 90% (Collins et al., 2015). However, when the SpO2 falls below 90%, the curve displays a steep decline in the partial pressure of oxygen, the actual oxygen content available to the tissues (Collins et al., 2015). Prolonged oxygen desaturation will lead to dysrhythmias, hemodynamic instability and decompensation, hypoxic brain injury, and eventually death if not treated (Patel & Gilhooly, 2019). During the induction of anesthesia, a patient undergoes a period of apnea, or cessation of breathing, from the point which the anesthetic medications take effect until the successful insertion of an ETT by which the patient can be ventilated (Patel & Gilhooly, 2019). The administration of oxygen prior to the induction of anesthesia, known as preoxygenation, is an essential component which ideally prevents hypoxemia during induction or at least prolongs the patient's safe apneic time—the time a patient can be apneic before desaturation occurs (Patel & Gilhooly, 2019). To increase the safe apneic time, preoxygenation increases the oxygen storage in the lungs, primarily in the functional residual capacity (FRC) (Patel & Gilhooly, 2019). The FRC is the lung volume that remains in the lungs and is not exchanged during normal tidal volume breathing (Patel & Gilhooly, 2019). Through increasing the oxygen storage in the FRC via preoxygenation to an end-tidal oxygen concentration (EtO2) of 90%, theoretically, a healthy patient can be apneic for eight minutes before desaturation occurs (Patel & Gilhooly, 2019). However, a number of factors including patient age, sex, posture, body habitus, and body size can reduce the FRC (Patel & Gilhooly, 2019). Therefore, it is not safe to assume a patient who is preoxygenated to an EtO2 of

90%, has eight minutes of safe apneic time before desaturation occurs. Rather, it is important to note those with a decreased FRC, including class three obesity patients, are at an increased risk of rapid desaturation during the induction of anesthesia.

The literature supports the use of a number of techniques in addition to standard preoxygenation to optimize oxygenation in high risk patients like those with class three obesity. These techniques include patient positioning techniques to increase the FRC and to improve glottic view during intubation, the use of non-invasive positive pressure ventilation (NIPPV) during preoxygenation, and the use of apneic oxygenation methods throughout the intubation process (Couture et al., 2018; Edmark et al., 2016; Futier et al., 2011; Georgescu et al., 2012; Harbut et al., 2014; Heard et al., 2016; Ramachandran et al., 2010; Sinha et al., 2013; Wong et al., 2019). Supplemental oxygenation techniques require additional steps be carried out by the anesthesia provider and additional time necessary for the anesthesia provider to implement the extra techniques. The use of additional supplies could increase the supply costs for the hospital, as well as costs related to increased time the patient will spend in the operating room. The findings of this scholarly project are valuable to hospitals similar to HRH, where cost savings are highly valued and the cost of routinely using extra supplies needs evidence-based justification. This project examined if current preoxygenation techniques used at HRH are sufficient in preventing desaturation in the class three obesity patient population during induction of anesthesia and if practice change to improve preoxygenation techniques should be explored and implemented.

Problem Statement

Adequate preoxygenation is crucial in order to prevent significant desaturation during the induction of anesthesia and to prolong the safe apneic time before desaturation in the event of an unexpected difficult intubation (Patel & Gilhooly, 2019). Adequate preoxygenation is vital in the cannot ventilate and cannot intubate emergent situation where time is necessary in order to get the patient spontaneously breathing again (Patel & Gilhooly, 2019). Therefore, the question examined in this project was—in patients with a BMI of 40 or greater, are the current preoxygenation techniques used at HRH effective in preventing a desaturation of SpO2 less than 90%?

This project utilized a retrospective chart review of patient data to answer this question and assessed whether practice improvement is suggested at HRH.

Organizational "Gap" Analysis of Project Site

The prevalence of obesity, including class three obesity, is increasing across the United States (Hales et al., 2020). HRH has a large volume of patients presenting for surgery with class three obesity. It is important to ensure proper preoxygenation for this patient population to prevent desaturation during the induction of anesthesia. Literature suggests the use of additional preoxygenation techniques in this patient population, however, additional techniques may present with additional steps the anesthesia provider must complete, additional supply costs, or increased operating room time. For healthcare organizations who have small financial margins, these additional costs can make a large impact on their budget. This project examines current preoxygenation techniques used at HRH to assess whether practice improvement which may come with additional supply costs or additional operating room time is needed. The findings of this scholarly project are valuable to HRH and hospitals with similar characteristics, where cost savings are highly valued and the cost of routinely using extra supplies needs proper evidence-based justification.

Review of the Literature

There are a variety of preoxygenation methods which can be performed prior to the induction of anesthesia. The goal of preoxygenation is to replace the nitrogen in the FRC with oxygen, therefore, increasing the body's oxygen store (Nimmagadda, Salem, & George, 2017). Two of the most common preoxygenation techniques are normal tidal volume breathing for three minutes or four vital capacity breaths (maximum exhalation followed by maximum inhalation) within 30 seconds (Nimmagadda, Salem, & George, 2017). Both of these preoxygenation techniques are considered standard preoxygenation with the same goal of an EtO2 of 90%--signifying adequate nitrogen washout and replacement with oxygen (Nimmagadda, Salem, & George, 2017). The American Society of Anesthesiologists Task Force on Management of Difficult Airways includes these standard preoxygenation techniques in their practice guidelines for managing difficult airways (ASA, 2013). The guidelines for managing difficult airways also recommends administering supplemental oxygen throughout the intubation process via nasal cannula, facemask, laryngeal mask airway (LMA), or oxygen insufflation (ASA, 2013). A study by Sinha et al. (2013) found utilizing an LMA to ventilate after induction of anesthesia significantly increased the oxygenation in obese patients compared to patients who were mask ventilated without the LMA.

Patients with class three obesity have a greater risk of difficult intubation, complicated by less time before desaturation during periods of apnea due to the decrease in their FRC (Schumann, 2019). This makes adequate preoxygenation of upmost importance in this patient population. UpToDate is a resource for medical professionals which provides evidenced-based recommendations based on rigorous synthesis of the most recent medical information available in the literature (UpToDate, n.d.). It is a recommendation from UpToDate that the preoxygenation of obese patients should be performed in the reverse Trendelenburg position, rather than supine due to the reduction in lung volume in the supine position (Schumann, 2019). A recent study by Couture et al. (2018) found positioning the patient's head above their feet by tilting the operating table 25 degrees into slight reverse Trendelenburg position significantly increases the FRC volume and oxygen storage capacity of the lungs when compared to the supine position.

It is also an UpToDate recommendation to administer preoxygenation with non-invasive positive end-expiratory pressure (PEEP) in the obese population to improve oxygenation prior to and during induction (Schumann, 2019). A study by Edmark et al. (2016) found the patients who received preoxygenation with 10 cm H2O CPAP had significantly increased oxygenation compared to those who received traditional preoxygenation without CPAP. Similar studies by Futier et al. (2011), Georgescu et al. (2012), and Harbut et al. (2014) also found utilizing NIPPV techniques during preoxygenation significantly improved the oxygenation of participants when compared to those who did not receive NIPPV during preoxygenation.

There are several passive apneic oxygenation techniques studied for use during laryngoscopy to prolong the safe apneic time for high risk patient populations, including patients with obesity (Schumann, 2019). Apneic oxygenation works on the premise that oxygen can flow through the airway to the alveoli allowing oxygen diffusion into the bloodstream to occur even during apnea (Patel & Gilhooly, 2019). Apneic oxygenation can be provided via face mask, nasal cannula, or a number of other devices which have been developed to insufflate oxygen into the trachea, pharyngeal, and nasal passages (Patel & Gilhooly, 2019). A study by Ramachandran et al. (2010) found prolonged safe apneic period in simulated difficult airway scenarios with apneic oxygenation provided by nasal cannula at five liters per minute. A similar studied by Heard, et al. (2016) found a prolonged safe apneic period with oxygen insufflation via buccal rae tube at

10 L/min following standard preoxygenation. Likewise, a study by Wong et al. (2019) found utilizing high flow oxygen via Optiflow delivery device for preoxygenation at 40 L/min and apneic oxygen insufflation with the Optiflow at 60 L/min following induction of anesthesia significantly increased the safe apneic period compared to the control group who received standard preoxygenation and no apneic oxygenation.

The literature review performed for this project includes research studies which were the result of a PubMed search of terms “preoxygenation” and “obesity” in all search fields. This search produced 82 articles which were then filtered to include only randomized controlled trials and clinical trials published within the last 10 years, narrowing the search results to 13 articles. Four of the remaining 13 articles were excluded for not involving obese patients as the study population. The remaining nine randomized controlled trials examining preoxygenation in the obese patient population have been included in this literature review and are also summarized in the literature review matrix which can be found in Appendix B.

Evidence-Based Practice: Verification of Chosen Option

This scholarly project does not implement practice change; therefore, no verification of chosen evidence-based practice option will be discussed. However, this literature review is included to summarize current practices which could be implemented to improve practice at HRH in the future.

Theoretical Framework

The Iowa Model of Research-Based Practice to Promote Quality Care (IOWA Model) is a theoretical framework which was developed in the 1990’s to help clinicians evaluate current processes, research findings, and incorporate best practices into their patient care (IOWA Model Collaborative, 2017). The IOWA Model was used in this scholarly project to determine if there is sufficient evidence for HRH to implement practice improvement by utilizing a systematic review of the literature and through a retrospective chart review of patient data at HRH. The first step of the IOWA Model is to identify a triggering issue or opportunity (IOWA Model Collaborative, 2017). The triggering issue or opportunity can be identified by a number of methods including clinically identified issues, national initiatives, new evidence available in the literature, or accrediting agency requirements or regulations (IOWA Model Collaborative, 2017). The triggering opportunity for this scholarly project was identified based on the wide variety of preoxygenation techniques utilized for this patient population identified via clinical observation and the amount of evidence and recommendations concerning this topic available in the literature.

The second step in the IOWA Model is to formulate a question or purpose (IOWA Model Collaborative, 2017). By formally identifying the question or purpose, the approach to gathering evidence on the topic is more focused and direct (IOWA Model Collaborative, 2017). The question examined in this project is—in patients with a BMI of 40 or greater, are the current preoxygenation techniques utilized at HRH effective in preventing a desaturation of SpO2 less than 90%? After formally stating the question or purpose, the IOWA Model presents the first decision point of the model—is the chosen topic a priority (IOWA Model Collaborative, 2017)? After a discussion with faculty at Marian University and members of the anesthesia department at HRH, the topic of preoxygenation techniques recommended for class three obesity patients was determined to be a priority.

After determining the topic as a priority, the next step when following the IOWA Model is to form a team (IOWA Model Collaborative, 2017). The team formed for this project consists of one student registered nurse anesthetist at Marian University, two faculty advisors at Marian

University, and one clinical mentor, a certified registered nurse anesthetist at HRH. After forming a team, the next step in the IOWA Model is to assemble, appraise, and synthesize the evidence (IOWA Model Collaborative, 2017). This step was completed in this project by performing the literature review included in this paper. The second decision point in the IOWA Model follows the synthesis of evidence and literature and asks whether or not there is sufficient evidence to conduct research (IOWA Model Collaborative, 2017)? It was determined there is enough evidence available in the literature to warrant a retrospective chart review of patient data at HRH. The IOWA Model was used to guide this this scholarly project up to the third decision point of the model—is change appropriate for adoption into practice (IOWA Model Collaborative, 2017)? The outcomes of this project were made available to the anesthesia department at HRH and recommendations for potential areas of practice improvement identified by data assessment are discussed in this paper. A diagram of the IOWA Model utilized in this scholarly project can be found in Appendix C.

Goals, Objectives, and Expected Outcomes

The goal of this project was to assess current preoxygenation practices at HRH and determine if they are adequate in preventing SpO2 less than 90% during induction of anesthesia in class three obesity patients. A chart review was performed for all patients with class three obesity who underwent general surgery requiring endotracheal tube intubation at HRH from September 2019 through November 2019. The data and analysis from this scholarly project will be made available to the anesthesia department at HRH. The outcome of this project will provide evidence to either support current practices at HRH or it will serve as a basis for future clinical practice guideline formation at HRH to improve patient safety. Key stakeholders for this project include anesthesia providers, other healthcare disciplines with goals to increase patient safety, and individuals with obesity undergoing surgical procedures.

Project Design

This project consists of a retrospective chart review of patient data. A retrospective chart review is a project design which utilized pre-recorded patient data in order to answer a research question (Vassar & Holzmann, 2013). The data collected from a retrospective chart review can be gathered from a variety of patient record documents including electronic charting databases—which is the method of data collection utilized in this project (Vassar & Holzmann, 2013). All data collected for this project was found in the anesthesia record located in the EPIC electronic medical record used at HRH.

Project Site and Population

This project was completed at HRH in Danville, IN a suburb of Indianapolis. HRH is a 160-bed county hospital offering a 24-hour emergency room, childbirth center, outpatient surgery center, rehabilitation services, women's center, and laboratory and radiology services (Avon Chamber of Commerce, n.d.). HRH has eight surgical suites at their main campus where data for this project was collected. Surgery specialties that take place at HRH include general, urological, gynecological, and orthopedic surgeries. The anesthesia department at HRH practices as a care-team model consisting of CRNAs and physician anesthesiologists. The anesthesia department at HRH consists of 12 full-time, two part-time, and three supplemental CRNAs and five full-time and two part-time physician anesthesiologists.

Setting Facilitators and Barriers

HRH uses an electronic medical record named EPIC which provides ease of access to the data which was collected for this project. A potential barrier to the integrity of data collection is the possibility of a discrepancy between what preoxygenation and induction actions were performed and what actions were charted. The overarching goal of this project is to assess if the current actions being performed are able to prevent desaturation less than 90%. The potential reality/chart discrepancy barrier can be overcome by examining whether or not the patient experienced desaturation despite what preoxygenation techniques were charted.

Methods

Measurement Instrument

The data examined in this project is quantitative data found in the electronic health record. Data of interest was discussed amongst the project team, and it was determined the following data points would be collected from the electronic health record for each patient: BMI, age, gender, American Society of Anesthesiologists (ASA) physical status classification, preoperative history of lung disease, smoking status, Mallampati score, preoperative SpO2, preoxygenation techniques charted by the anesthesia provider, ease of mask ventilation, method of intubation (direct laryngoscopy or use of video laryngoscope), number of intubation attempts, and the presence of a SpO2 reading less than 90%. If desaturation less than 90% did occur, the time until SpO2 reached greater than 90% was also collected.

Data Collection Procedure

All data was collected during a retrospective review of patient charts. Inclusion criteria for this chart review were patients with a BMI of 40 or greater undergoing general anesthesia requiring an endotracheal tube for airway management. This project excluded patients with a BMI less than 40 and patients with a BMI of 40 or greater not requiring an endotracheal tube for airway management.

To perform the retrospective chart review, the surgery schedule for the eight main operating rooms at HRH was accessed for each day in September, October, and November of 2019. Next, each patient with a BMI of 40 or greater was selected and only those requiring endotracheal tube intubation were included. The anesthesia record for the surgery performed was accessed and all data points were pulled from this record. Patient data was entered into an Excel spreadsheet, documenting each patient's BMI, age, gender, ASA physical status classification, preoperative history of lung disease, smoking status, Mallampati score, preoperative SpO2, preoxygenation techniques utilized by the anesthesia provider, ease of mask ventilation, method of intubation (direct laryngoscopy or use of video laryngoscope), number of intubation attempts, and the presence of a SpO2 reading less than 90%. If desaturation less than 90% did occur, the time until the SpO2 reached greater than 90% was also recorded.

Data Analysis

Analysis of the data collected will provides descriptive results as well as parametric statistics. The analysis of parametric data is of a two-group design, independent t-test to test the numerical variables age, BMI, ASA classification, and pre-operative SpO2 utilizing Microsoft Excel.

Results

In September, October, and November of 2019, HRH had 82 patients undergo anesthesia for surgery which required an ETT for airway management. Characteristic data describing the total sample in this project is located in Appendix D. Of the 82 patients, 16 patients (20%) experienced a desaturation less than 90% during the induction of anesthesia. These 16 patients experienced desaturations ranging from 72% - 89%. Five of the patients who experienced a desaturation, experienced a desaturation for greater than one minute in duration–the longest desaturation occurring was six minutes. The lowest SpO2 reading and the duration of desaturation for the 16 patients experiencing desaturation is displayed on the scatter plot in Appendix D.

A variety of preoxygenation techniques were charted for this patient sample. Techniques charted for the sample include standard preoxygenation, BMI guided preoxygenation, placing the patient in sniffing position, reverse Trendelenburg position, ramping the patient, and many combinations of these techniques. BMI guided preoxygenation is a preoxygenation technique available to chart at HRH, described as prolonged preoxygenation administration for five minutes. Graphical display of the preoxygenation techniques can be found in Appendix D.

The total number of patients intubated with the use of a video laryngoscope was 34 (41%), compared to 47 (57%) patients who were intubated via direct laryngoscopy and one patient had two attempts of direct laryngoscopy followed by a successful attempt with a video laryngoscope. Of the patients experiencing desaturation, direct laryngoscopy was performed for seven patients, eight patients were intubated with the use of video laryngoscope, and one patient experienced both techniques. Descriptive statistical display of the ease of mask ventilation charted by the anesthesia provider, grade of laryngoscopic view, and number of intubation attempts can be found in Appendix D.

Independent t-tests were performed for the numerical variables age, BMI, ASA classification, and pre-operative SpO2. No significance was found based on this testing as p-values for these tests were 0.5, 0.6, 0.2, and 0.2, respectively.

Interpretation/Discussion

Preoxygenation, an essential component of airway management, is used to increase the oxygen reserves in order to prevent hypoxemia during the apneic period of the induction of anesthesia (Patel & Gilhooly, 2019). Standard preoxygenation is usually sufficient in preventing desaturation in patients without concern for difficulty of mask ventilation, intubation, or concern of rapid desaturation (Patel & Gilhooly, 2019). Many novel techniques have been studied and developed to improve preoxygenation and provide continued oxygenation to patients who are at risk for difficult mask ventilation, intubation, or are at risk of rapid desaturation—such as the obese patient population (Patel & Gilhooly, 2019). While a variety of techniques are utilized to improve preoxygenation at HRH, 20% of their patient population experienced desaturation to SpO2 less than 90% in the three-month period analyzed in this project.

The data collected in this project did not suggest any identifiable characteristics for which patients were going to experience desaturation. Nor could the data collected in this project suggest any combination of preoxygenation techniques which could prevent desaturation in this patient sample. Based on the data collected in this project, it is not possible to identify which patients will experience a desaturation prior to the induction of anesthesia, therefore every patient who presents with a BMI of 40 or greater should be treated as though they are going to desaturate and measures to prevent the desaturation must be taken. It is likely many patients from this sample population would have experienced a desaturation without the techniques which were taken to optimize preoxygenation and patient positioning prior to induction of anesthesia. Identification of patients at risk for rapid desaturation with apnea and patients at risk for difficult airway management is key to planning management of this patient population (ASA, 2013).

To improve the percentage of patients experiencing desaturation, anesthesia providers at HRH could consider ramping each patient with a BMI greater than 40 to optimize glottic view and placing them in a reverse Trendelenburg position while they are preoxygenated per their BMI guidelines (ASA, 2013; Couture et al., 2018; Patel & Gilhooly, 2019). Implementing these preoxygenation and positioning techniques do not come with an additional supply cost to the hospital and adds only minimal time to the induction process. If these preoxygenation techniques do not improve the rate of patients experiencing desaturations, the anesthesia providers at HRH could consider implementing other techniques not utilized for the patients in this project. Other techniques not utilized by HRH include the use of NIPPV during preoxygenation or the variety of different apneic oxygenation devices designed to provide oxygenation to the apneic patient (Couture et al., 2018; Edmark et al., 2016; Futier et al., 2011; Georgescu et al., 2012; Harbut et al., 2014; Heard et al., 2016; Ramachandran et al., 2010; Sinha et al., 2013; Wong et al., 2019).

Cost-Benefit Analysis/Budget

This project consists solely of a retrospective chart review, therefore, there are no financial costs to completing this project.

Timeline

The timeframe from submitting request to Marian University's international review board (IRB) to finalizing this scholarly project is projected to take seven months. This allowed three weeks to gain Marian University and HRH IRB approval, three months to collect and analyze data, and an additional two months to summarize the findings and to finalize this scholarly paper. This timeline also allows for one month to receive final project approval. A detailed project timeline is included in Appendix E.

Ethical Considerations/Protection of Human Subjects

The Marian University IRB and HRH IRB approval was obtained prior to initiating this DNP Project. The patient data extracted from the electronic medical record was de-identified and Health Insurance Portability and Accountability Act of 1996 compliant to protect patient privacy.

Conclusion

Class three obesity patients present with additional risk for complications which must be considered prior to and during the administration of anesthesia. Obesity decreases the lungs FRC and oxygen storage capability, making obese patients at risk for rapid desaturation with apnea. Obesity also increases the risk of difficulty securing a patient's airway during the induction of anesthesia. Therefore, it is important to optimize preoxygenation of this patient population prior to the induction of anesthesia and to consider providing apneic oxygenation in order to prevent desaturation during the apneic period of induction.

The sample assessed in this project received a variety of combinations of preoxygenation techniques and techniques to optimize the oxygenation and the intubation procedure. 16 patients did experience a desaturation less than 90%. Areas which could improve the percentage of patients experiencing desaturation with the induction of anesthesia at HRH were identified from analyzing the data extracted from this retrospective chart review. Areas for improvement include treating every patient with a BMI 40 or greater as though they are going to desaturate. Each patient should be placed in the ramped position to improve glottic view and intubation conditions. Each patient should receive BMI guided preoxygenation while in the reverse Trendelenburg position. These suggestions do not come with additional supply costs and deliver minimal risk to the patient. Anesthesia providers at HRH could also consider utilizing a video laryngoscope for this specific patient population to help aid intubation conditions. If HRH would like to improve their percentage of patients experiencing desaturation, they could also use apneic oxygenation techniques to provide oxygen to the patient during the apneic period. Apneic oxygenation techniques may come with additional supply costs which may not be justified for routine use on every patient.

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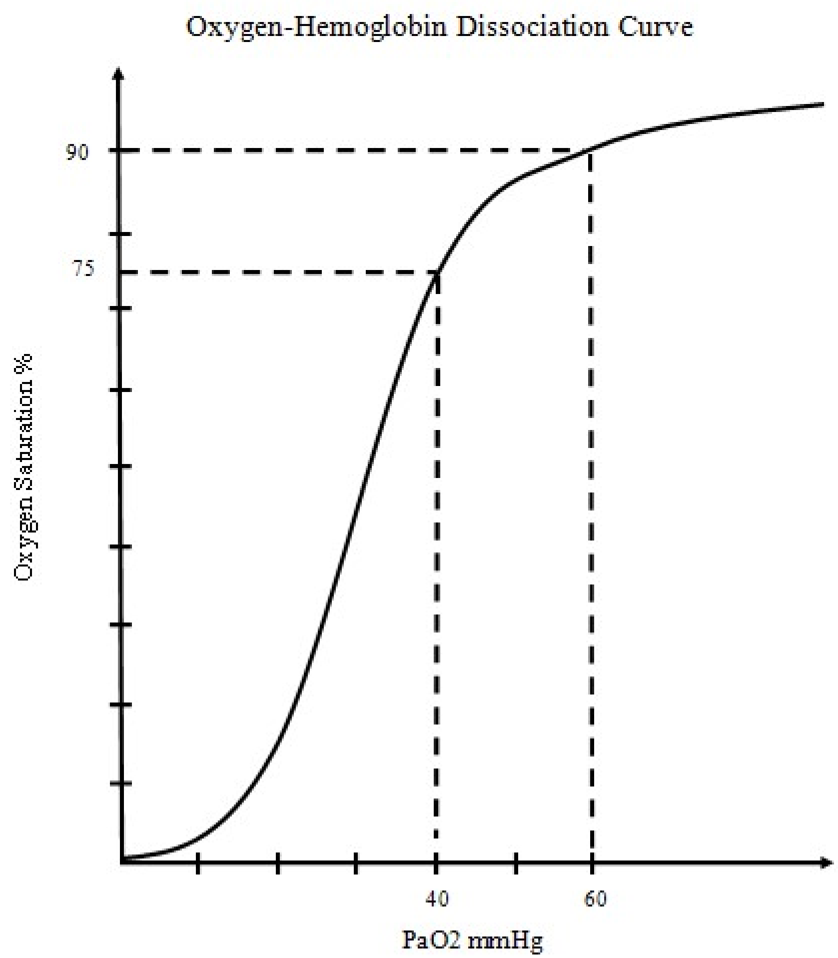
Appendix A

Figure 1
Oxygen-Hemoglobin Dissociation Curve



Appendix B

Table 1
Literature Review Matrix

Citation	***Research Design & Sample Size***	***Variables of Interest***	***Methods***	***Key Findings***	***Limitations & Clinical Relevance***
Couture, E., Provencher, S., Somma, J., Lellouche, F., Marceau, S., & Bussieres, J. (2018). Effect of position and positive pressure ventilation on functional residual capacity in morbidly obese patients: A randomized trial. *Canadian Journal of Anaesthesia, 65*(5), 522-528. doi: 10.1007/s12630-018-1050-1	Crossover Randomized Controlled Trial 17 patients [BMI 40 or greater]	FRC measurement with helium dilution method	FRC measured in each participant in three different positions (supine, back up tilt 25 degrees, whole table tilt 25 degrees) with two different ventilation methods (spontaneous breathing without positive pressure, and spontaneous breathing with 8 cm H20 inspiratory pressure and 10 cm H20 expiratory pressure)	Significant increase in FRC when using positive pressure with spontaneous ventilation and increase FRC with whole table tilt 25 degrees but no difference in FRC from supine and back up 25 degrees.	Increased FRC could theoretically increase safe apneic time. However, this study was performed on awake spontaneously breathing patients and does not take into consideration apnea and muscle relaxation that occurs during induction.
Edmark, L., Ostberg, E., Scheer, H., Wallquist, W., Hedenstierna, G., & Zetterstrom, H. (2016). Preserved oxygen in obese patients receiving protective	Randomized Controlled Trial 40 patients [BMI greater than 35 but less than 50]	Oxygenation by estimated venous admixture calculation	**Control:** supine position, 30 degree head up table tilt, 100% O2 for 3 min **Experimental:** Same as control with addition of	Use of CPAP during induction significantly increased oxygenation compared to no CPAP	Increased oxygenation can increase safe apneic time during induction. Positive pressure is not always

ventilation during laparoscopic surgery: A randomized controlled study. *Acta anaesthesiologica Scandinavica, 60*(1), 26–35. doi: 10.1111/aas.12588		**study was not only looking at positive pressure effects on preoxygenation but also positive pressure on emergence--not discussed here	10 cm H_2O CPAP with induction		tolerated well in awake patients.
Futier, E., Constantin, J., Pelosi, P., Chanques., Massone, A., Petit, A., Kwiatkowski, F., Bazin., J., & Jaber, S. (2011). Noninvasive ventilation and alveolar recruitment maneuver improve respiratory function during and after intubation of morbidly obese patients: A randomized controlled study. *Anesthesiology, 114*(6), 1354-1363. doi: 10.1097/ALN.0b013e31821811ba	Randomized Controlled Trial 66 patients [BMI greater than 40]	Arterial blood O_2 1-2 min before and immediately following preoxygenation, immediately after intubation, and 5 min after ventilation	**Control:** in beach chair position preoxygenation with 100% O_2 via 15L facemask for 5 min TV breathing **Experimental:** 2 groups in beach chair position -NIPPV (PSV adjusted to 8 ml/kg, Peep 6-8, PIP < 18) -NIPPV and recruitment maneuvers following ETI	Statistically significant results of higher PaO_2 following preoxygenation and following ETI. NIPPV in addition to RM following ETI is also supported in improving ventilation following ETI.	Beach chair position for ETI can be difficult for some providers. NIPPV is not tolerated well by all patients (claustrophobia).

Georgescu, M., Tanoubi, I., Fortier, L., Donati, F., & Drolet, P. (2012). Efficacy of preoxygenation with non-invasive low positive pressure ventilation in obese patients: Crossover physiological study. *Annales francaises d'anesthesie et de reanimation, 31*(9), 161-165. doi: 10.1016/j.annfar.2012.05.003	Crossover Randomized Controlled Study 30 patients [BMI 30 or greater]	Expired oxygen concentration (EtO2), time to reach EtO2 > 90%, and patient comfort with two different preoxygenation techniques	*Each patient received both methods in randomly selected order with 20 min rest in between* **Control:** supine position, TV breathing at 12 L/min flow for 3 minutes **Experimental:** supine position, NIPPV of 4 cm H2O inspiratory positive pressure and 4 cm H2O of PEEP, 100% O2 for 3 minutes	Providing NIPPV improved patient EtO2, more patients at achieved EtO2 > 90 with NIPPV, no difference in patient comfort level	Increased EtO2 could increase safe apneic time. No difference in patient comfort level suggestions NIPPV can be tolerated by awake patient.
Harbut, P., Gozdzik, W., Stjernfalt, E., Marsk, R., & Hesselvik, J. (2014). Continuous positive airway pressure/pressure support pre-oxygenation of morbidly obese patients. *Acta Anaesthesiologica Scandinavica, 58*, 675-680. doi: 10.1111/aas.12317	Randomized Controlled Trial 44 patients [BMI greater than 35]	Arterial blood O2 concentrations at baseline and following preoxygenation and intubation SpO2 monitoring during induction and intubation	**Control**: preoxygenation 80% O2 at 15 L/min facemask for 2 min., HOB elevated 25-30 degrees **Experimental**: preoxygenation with noninvasive CPAP/PSV (5 + 5 cm H2O) 80% O2 for 2 min., HOB elevated 25-30 degrees	Statistically significant results of higher PaO2 in experimental group after intubation and minimum SpO2 reading was significantly higher in experimental group as well	This study used 80% O2 where clinically 100% O2 is used This study used 2 min. of preoxygenation rather than recommended 3 min.

Heard, A., Toner, A., Evans, J., Aranda Palacios, A., & Lauer, S. (2016). Apneic oxygenation during prolonged laryngoscopy in obese patients: A randomized, controlled trial of buccal RAE tube oxygen administration. *Anesthesia Patient Safety Foundation Journal, 124*(4), 1162-1167. doi: 10.1213/ANE0000000000001564	Randomized Controlled Trial 40 patients [BMI 30-40]	Onset of apnea to SpO2 less than 95%	**Control**: preoxygenation w/ HOB elevated 30 degrees, w/ 100% O2 via face mask until EtO2 80% **Experimental**: same, with addition of 10 L/min oxygen insufflation via buccal rae tube after preoxygenation *DL performed and grade III view maintained until desaturation or 750 seconds passed	Control: average time to desaturation 296 seconds Experimental: average time to desaturation 750 seconds	In difficult airway scenarios, glottic view is not maintained, therefore passive oxygenation is not guaranteed.
Ramachandran, S., Cosnowski, A., Shanks, A., & Turner, C. (2010). Apneic oxygenation during prolonged laryngoscopy in obese patients: a randomized, controlled trial of nasal oxygenation. *Journal of Clinical Anesthesia, 22*(3), 164-168. doi: 10.1016/j.jclinane.2009.05.006	Randomized Controlled Trial 30 male patients [BMI 30-35]	Simulated difficult intubation, grade IV glottic view maintained until SpO2 < 95% or 6 minutes passed following succinylcholine administration, time	**Control:** reverse Trendelenburg position, no additional O2 via nasal prongs, preoxygenation with TV breathing via facemask until EtO2 was greater than 90% or within 10% of the inspired O2 concentration **Experimental:** reverse Trendelenburg position, 5L O2 via nasal cannula, TV breathing	Apnea time to SpO2 less than 95 was significantly shorter in control group, the lowest SpO2 in control group was significantly lower, both supporting the use of additional O2 via NC	Study excluded grade III, IV glottic views BMI 30-35 (not morbidly obese)

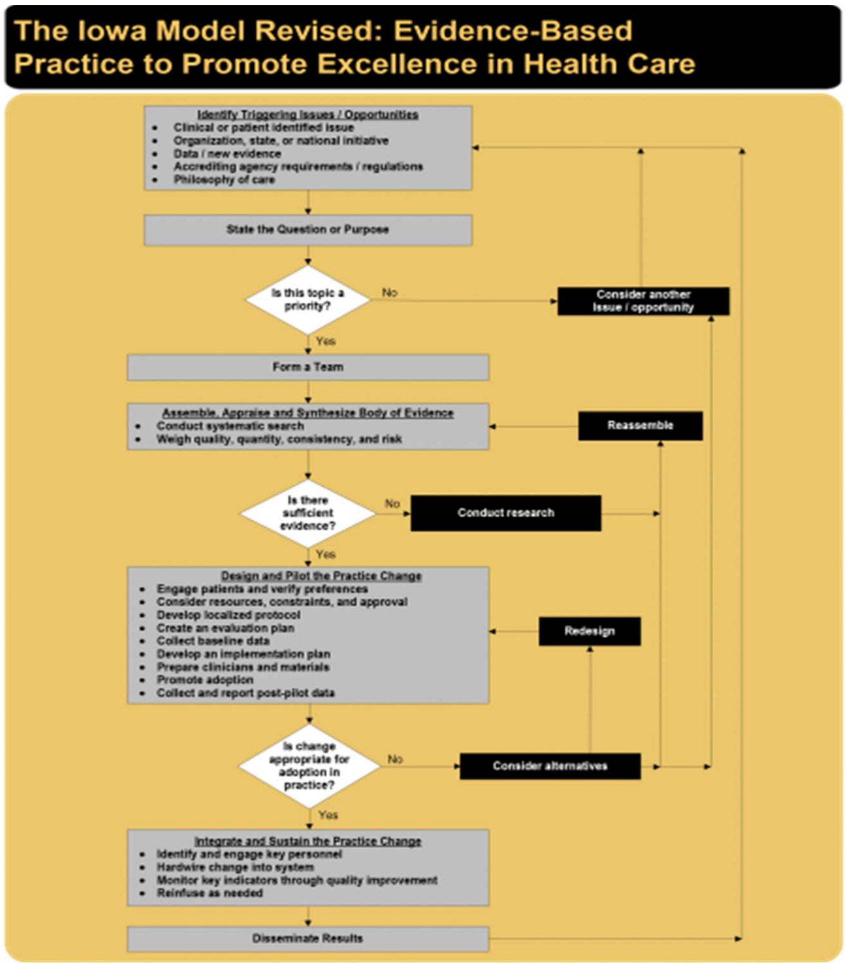
		documented as well as time to recovery of O2 following ETI to a SpO2 of 100%	preoxygenation via facemask until ETO2 was >90% or within 10% inspired O2 concentration		
Sinha, A., Jayaraman, L., Punhani, D., & Panigrahi, B. (2013). Proseal laryngeal mask airway improves oxygenation when used as a conduit prior to laryngoscope guided intubation in bariatric patients. *Indian Journal of Anaesthesia, 57*(1), 25- 30. doi: 10.4103/0019-5049.108557	Randomized Controlled Trial 40 patients [BMI greater than 35]	Arterial blood oxygen concentration at baseline, following preoxygenation, and following intubation	**Control**: positioned in ramp position, preoxygenated with 100% O2 via CPAP 10mm H20 for 5 min., after apnea oropharyngeal airway inserted and ventilated for additional 5 minutes, then intubation **Experimental**: positioned in ramp position, preoxygenated with 100% O2 via CPAP 10mm H2) for 5 minutes, after apnea PLMA inserted and ventilation continued for additional 5 minutes, then intubated	Results statistically significant supporting use of PLMA to increase arterial O2 concentration in order to increase time to desaturation	Results show oropharyngeal airway is also effective in increasing PaO2, just not to same extent. PLMA use comes at additional supply costs and steps for anesthesia provider. PLMA clinically useful in difficult airway scenarios, but not routine use.
Wong, D., Dallaire, A., Singh, K., Madhusudan, P.,	Randomized Controlled Trial	Apneic time measured until SpO2	**Control:** supine, 30 degree head up position on Troop-pillow, 100%	Safe apneic time was significantly longer in the group receiving	Simulated difficult airway, not clinically

Jackson, T., Singh, M., Wong, J., & Chung, F. (2019). High-flow nasal oxygen improves safe apnea time in morbidly obese patients undergoing general anesthesia: A randomized controlled trial. *Anesthesia & Analgesia, 129*(4), 1130-1136. doi: 10.1213/ANE.0000000000003966	40 patients [BMI 40 or greater]	reached 95% or 6 min. elapsed	O2 via facemask at 15 L/min **Experimental:** preoxygenation for 3 min. at 40 L/min flow utilizing Optiflow delivery method, which was increased to 60 L/min after loss of consciousness	high-flow oxygenation and the lowest SpO2 was higher in the high-flow group	realistic to maintain grade I-II glottic view, passive oxygenation is not guaranteed in true difficult airway. The Optiflow device is not standard operative room equipment.

Appendix C

Figure 1

The Iowa Model



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Appendix D

Table 1
Sample Characteristics

	NO DESATURATION SAMPLE (N=66)	DESATURATION SAMPLE (N=16)
BMI		
RANGE	**40-57**	**40-55**
MEAN	**45.3**	**46.3**
AGE		
RANGE	**18-80**	**25-72**
MEAN	**49.0**	**51.0**
GENDER		
MALE	**17 (20%)**	**4 (25%)**
FEMALE	**65 (80%)**	**12 (75%)**
ASA CLASSIFICATION		
I	**1 (1%)**	**0 (0%)**
II	**13 (20%)**	**2 (13%)**
III	**46 (70%)**	**11 (69%)**
IV	**6 (9%)**	**3 (19%)**
HISTORY OF LUNG DISEASE		
Y	**38 (58%)**	**9 (56%)**
N	**28 (42%)**	**7 (44%)**
SMOKING STATUS		
CURRENT	**11 (17%)**	**2 (13%)**
FORMER	**23 (35%)**	**3 (19%)**
NEVER	**32 (48%)**	**11 (69%)**
MALLAMPATI		
I	**7 (11%)**	**1 (6%)**
II	**37 (56%)**	**8 (50%)**
III	**20 (30%)**	**6 (38%)**
IV	**2 (3%)**	**1 (6%)**

Table 2
Data Specific to Induction Period

	NO DESATURATION SAMPLE (N=66)	DESATURATION SAMPLE (N=16)
PREOPERATIVE SPO2		
RANGE	**90-100**	**88-100**
MEAN	**96.2**	**95.2**
EASE OF MASK VENTILATION		
EASY	**47 (71%)**	**9 (56%)**
MODERATE	**8 (12%)**	**3 (19%)**
DIFFICULT	**5 (8%)**	**0 (0%)**
NOT ATTEMPTED	**4 (6%)**	**4 (25%)**
DID NOT SPECIFY	**2 (3%)**	**0 (0%)**
LARYNGOSCOPIC GRADE VIEW		
I	**36 (54%)**	**8 (50%)**
II	**21 (32%)**	**7 (44%)**
III	**3 (5%)**	**0 (0%)**
IV	**3 (5%)**	**1 (6%)**
DID NOT SPECIFY	**6 (9%)**	**0 (0%)**
INTUBATION ATTEMPTS		
1	**61 (92%)**	**10 (63%)**
2	**3 (5%)**	**5 (31%)**
3	**0 (0%)**	**1 (6%)**
DID NOT SPECIFY	**2 (3%)**	**0 (0%)**

Figure 1

Scatter Plot Display of Each Desaturation Value and the Duration of Desaturation

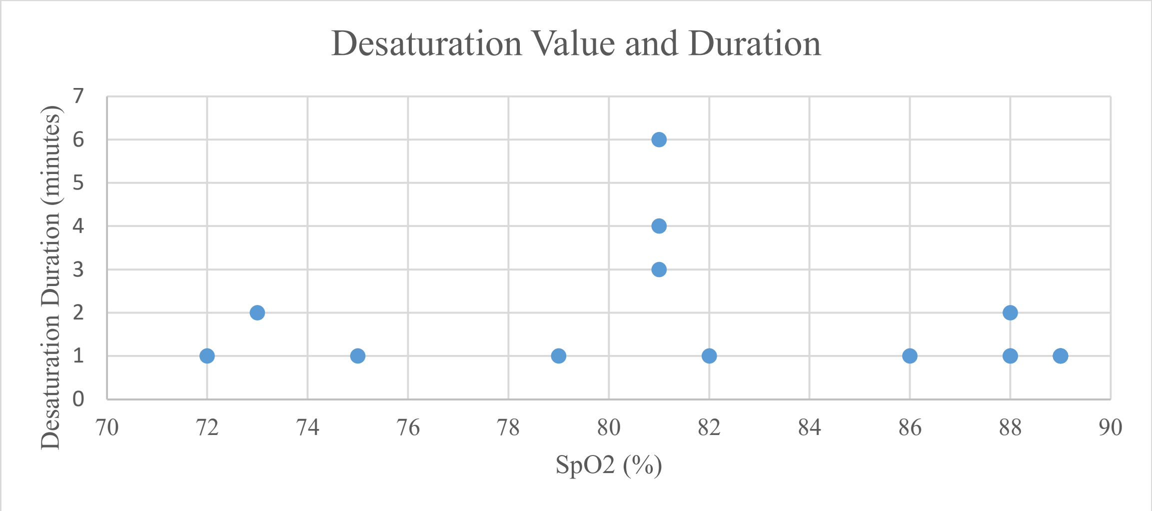
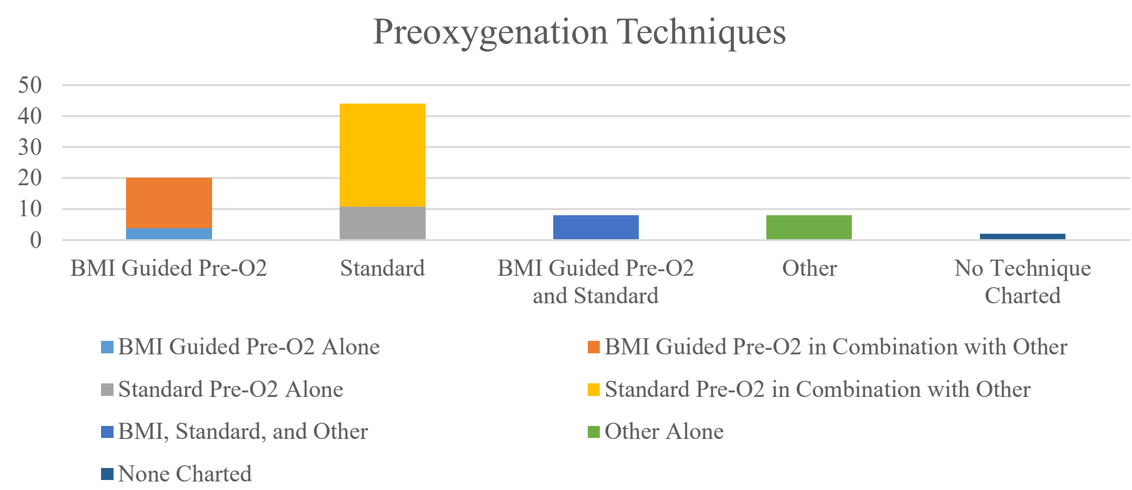


Figure 2

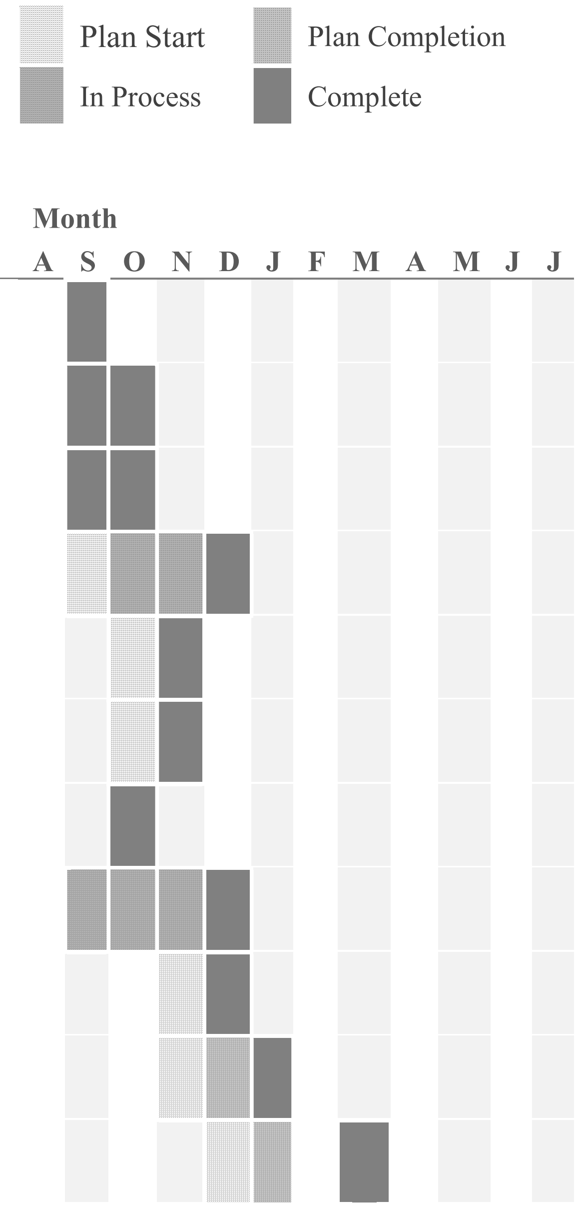
Five Major Categories of Preoxygenation Techniques



Appendix E

DNP Scholarly Project Timeline

ACTIVITY	PLAN START	PLAN COMPLETION	ACTUAL START	ACTUAL COMPLETION	% COMPLETE
Identify PICO Question	08/19	09/19	09/19	09/19	100%
Liturature Review Matrix	08/19	10/19	09/19	10/19	100%
Annotated Bibliography	08/19	10/19	09/19	10/19	100%
Project Team Form	09/19	10/19	09/19	12/19	100%
Framework	10/19	11/19	11/19	11/19	100%
SWOT Analysis	10/19	11/19	11/19	11/19	100%
CITI Training	11/19	11/19	10/19	10/19	100%
Proposal Draft	11/19	12/19	09/19	12/19	100%
Marian IRB	11/19	01/20	12/19	12/19	100%
Hendricks IRB	11/19	01/20	01/20	01/20	100%
Collect Data	01/20	02/20	03/20	03/20	100%



Data Analysis	02/20	03/20	03/20	75%
Interpretation/Discussion	03/20	04/20	04/20	25%
Completion of Project	05/20	06/20	04/20	25%
Submission/Approval	06/20	07/20		0%