Fall 2022

Objective Structured Clinical Evaluation for Volume Control and Pressure Control Ventilator Modes

Brian Bailey

Anthony Newsom
University of Southern Mississippi

OBJECTIVE STRUCTURED CLINICAL EXAMINATION FOR VOLUME CONTROL AND PRESSURE CONTROL VENTILATOR MODES

by

Brian Bailey and Anthony Newsom

A Doctoral Project
Submitted to the Graduate School,
the College of Nursing and Health Professions
and the School of Leadership and Advanced Nursing Practice
at The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Nursing Practice

Approved by:

Dr. Stephanie Parks, Committee Chair
Dr. Mary Collins, Committee Member

December 2022

Published by the Graduate School

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

ABSTRACT

The purpose of this doctoral project was to create a tool to teach student registered nurse anesthetists (SRNAs) in The University of Sothern Mississippi's (USM's) anesthesia program about pressure control and volume control ventilator modes, and how to use them. To accomplish this goal an Objective Structured Clinical Examination (OSCE) was developed. The framework used for creating this OSCE was Kolb's Theory. Kolb's Theory uses a four-stage learning cycle in which the learner encounters a new experience, reflects on the observations of said new experience, conceptualizes or modifies a concept based on this experience, and then applies their idea to the world around them (Kurt, 2020).

Kolb's Theory was applied to this doctoral project by the learner first encountering and reflecting on the topics of pressure control and volume control modes of ventilation in didactic teaching and assigned readings. After being introduced to the material, the student could reflect on how they might use the two modes in a practice setting. The learner was then provided with a scenario to practice what was learned in a controlled environment. Lastly, the student could reflect on their performance and repeat the process as many times as needed for mastery of the concept.

A template that laid out the material that needed to be reviewed before completing the OSCE and provided a guide to evaluate the student's performance was created. A video that reviewed the two modes and provided a scenario for practice was also produced. A survey was sent out to a group of peers to evaluate the effectiveness of the OSCE, and all participants agreed that the OSCE was beneficial to learning about and practicing the use of volume control and pressure control ventilator modes.

ACKNOWLEDGMENTS

We would like to thank our committee chair, Dr. Stephanie Parks, for her guidance, support, and patience throughout this process. We would also like to thank our committee member, Dr. Mary Collins, for her input and encouragement.

DEDICATION

I would like to give thanks to God for his mercy and guidance throughout this experience in my life, without Him, none of this would be possible. I would also like to acknowledge my loving wife, Morgan Newsom. She has been a steady rock for me to lean on whenever things seemed overwhelming, and I would have never made it this far without her love and support. Finally, I would like to thank my parents, Dana and Tony Newsom. They instilled a strong foundation in me that gave me everything I needed to make it through this journey. Thank you to all the people who kept me in their prayers and offered their priceless encouragement to keep me pushing forward. *Anthony Newsom*

I want to dedicate this achievement to my wife, Bethany, and my three children, Weston, Selah, and Lincoln. This would not have been possible without their love, support, and patience. I would especially like to thank Bethany for always believing in me and pushing me to accomplish my dreams. I would not have been able to do this without her in my corner. I would also like to thank my and Bethany's families for their help and support throughout this endeavor. I love you all very much! *Brian Bailey*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

AACN	American Association of Colleges of Nursing
ARDS	Acute Respiratory Distress Syndrome
BMI	Body Mass Index
cm H20	Centimeters of Water
CRNA	Certified Registered Nurse Anesthetist
DNP	Doctorate of Nursing Practice
ETT	Endotracheal Tube
FiO2	Fraction of Inspired Oxygen
FRC	Functional Residual Capacity
I: E Ratio	Inspiratory Expiratory Ratio
ICU	Intensive Care Unit
IRB	Institutional Review Board
ml/cm H_2O	Milliliters per Centimeter of Water
NAP	Nurse Anesthesia Program
OR	Operating Room
OSCE	Objective Structured Clinical Examination
PCV	Pressure Control Ventilation
PEEP	Positive End Expiratory Pressure
PLV	Pressure Limited Ventilation
RR	Respiratory Rate
SRNA	Student Registered Nurse Anesthetist
USM	The University of Southern Mississippi `

V/Q	Ventilation and Perfusion
V_T	Tidal Volume

CHAPTER I - INTRODUCTION

Undergoing surgery requires most patients to be under general anesthesia. General anesthesia inhibits the respiratory system in every patient to varying degrees; therefore, most patients undergoing surgery require ventilator support via an endotracheal tube. Each patient requires individualized ventilator settings to achieve optimal ventilation. In anesthesia, it is imperative to know what ventilator mode is ideal for each patient and to be able to make this decision quickly. Several factors associated with incorrect selection of ventilator modes can cause a patient to experience barotrauma, hypoxia, hypercarbia, and a host of other ailments that could be avoided by selecting the most optimal settings for that patient (Jiang et al., 2016).

Deciding when to use volume control ventilation (VCV) or pressure control ventilation (PCV) requires a quick assessment of a patient's health and body habitus. Providing students with the information necessary to quickly determine if VCV or PCV is best for their patients will aid them in their success as future anesthetists.

Problem Description

Proper training is essential to assist providers in selecting the ventilator mode they deem necessary for their patients. Research has shown that this training can be accomplished through didactic, simulation, and clinical experience (Brescia et al., 2009). The purpose of this doctoral project was to develop an Objective Structured Clinical Examination (OSCE) to assist with the education and training of students in the University of Southern Mississippi's (USM) Nurse Anesthesia Program (NAP).

Background of the Problem

VCV and PCV have distinct advantages and disadvantages that can change homeostasis for a patient depending on their lung characteristics (Rittayamai et al., n.d.). To help choose which mode to use and provide optimal ventilation, the provider needs to know the type of surgery planned, a patient's underlying conditions, body habitus, and position required for surgical exposure. Often, an anesthetist does not have much time to think through all variables and situations. Hence, an engrained understanding of how each ventilatory mode reacts with a patient and the physiology of how the ventilation mode works is essential to making fast, effective decisions in the operating room (OR).

Statement of the Problem

A student registered nurse anesthetist (SRNA) often does not completely understand all of the variables between PCV and VCV. Didactic work alone does not explain the differences in these two modes to a degree in which most SRNAs can grasp this knowledge well enough to apply it to practice immediately. This knowledge gap can lead SRNAs to have a slow start to their clinical experience and cause potential injury to a patient. This doctoral project intends to create an OSCE that will better teach and evaluate SRNAs in a simulation environment on their abilities to differentiate different scenarios in which a specific ventilator mode would be optimal.

Significance of the Problem

It is essential to create this OSCE to improve SRNA's understanding of ventilator mechanics at an earlier stage of their education in anesthesia. Having an earlier grasp on the basics of ventilator mechanics can potentiate a faster growth in their proficiency with a ventilator. This proficiency with the ventilator can be obtained by using this OSCE in a simulation environment, having hands-on experience with the ventilator, and being placed in simulated scenarios where the quick determination of ventilator settings is crucial to the simulated patient's perioperative outcomes.

Available Knowledge

Anesthesia Effects on Ventilation

Anesthesia affects respiratory muscle tone, lung volume, compliance and resistance, and airway closing capacity and can cause atelectasis (Hedenstierna & Edmark, 2015). During general anesthesia, a patient can breathe spontaneously or be entirely mechanically ventilated, such as if the procedure requires complete relaxation. In either scenario, general anesthesia will cause some degree of respiratory impairment.

A typical adult patient has decreased resting lung volume or functional residual capacity (FRC) of 0.8-1.01 liters with a change in body position from upright to supine and a further decrease of 0.4-0.5 liters under general anesthesia. Due to this decrease, there is a reduction in end-expiratory lung volume from approximately 3.5 liters in the upright and awake patient to 2 liters in the supine anesthetized person. The decrease in FRC happens regardless of whether the patient is breathing spontaneously and with inhaled and intravenous anesthetics. The loss of respiratory muscle tone causes a reduction in lung volume, which upsets the balance between the elastic recoil force of the lungs and the outward forces of the chest wall leading to a lower lung volume. One of the few anesthetics that does not reduce muscle tone or FRC is ketamine. Another factor contributing to the lower volume is the cranial displacement of the diaphragm that occurs under anesthesia. This decrease in FRC can contribute to an altered distribution of ventilation and impaired oxygenation (Hedenstierna & Edmark, 2015).

In addition to the decrease in muscle tone, anesthesia causes the static compliance of the total respiratory system to fall by an average of 60-95 milliliters per centimeter of water (ml/cm H_2O). Several studies indicate a decrease in lung compliance from a mean of 187 ml/cm H_2O when awake to 149 ml/cm H_2O when a patient is anesthetized. Though past studies suggest that the induction of anesthesia causes this increase in resistance, further investigation is needed to be sure. The possibility that the reduction in compliance is related to the decrease in FRC has not been completely ruled out yet (Hedenstierna & Edmark, 2015).

Airway closure during expiration is a normal phenomenon that occurs prematurely in the expiratory phase in the very young and increasingly earlier every year after twenty. Closing volume decreases from six to a peak at age twenty, where even maximum expiration cannot provoke airway closure. After age twenty, there is a linear increase in closing volume with age, independent of other variables. This biphasic relationship is because narrow airways are less supported in the immature lung and the loss of elastic tissue every year after age twenty (Hedenstierna & Edmark, 2015).

The drop in FRC that accompanies anesthesia promotes airway closure, and while some airways will reopen with succeeding inspirations, others may remain continuously closed. This closure is due to higher extra-than intraluminal pressure and occurs more commonly in the dependent portion of the lung. Once airway closure occurs, ventilation to that area of the lung becomes impaired. However, perfusion to this area persists, leading to a mismatch between ventilation and perfusion (V/Q). On average, airway closure occurs at an expiratory airway pressure of 6 centimeters of water (cm H_2O) in the anesthetized patient with an average body mass index (BMI) (Hedenstierna & Edmark, 2015).

Airway closure from the mechanism, as mentioned earlier, will impair tissue oxygenation during general anesthesia. Increasing the fraction of inspired oxygen (FiO_2) may be necessary to promote oxygenation of poorly ventilated lung regions. However, high FiO_2 will also speed up gas reabsorption and promote atelectasis and further shunting (Hedenstierna & Edmark, 2015).

Atelectasis occurs in around 90% of anesthetized patients during spontaneous breathing and mechanical ventilation, regardless of whether the provider uses intravenous or inhalation anesthetics. On average, 10-20% of the lung regularly collapses at the base during uneventful anesthesia. This collapse is independent of the surgical procedure the patient is having. More than 50% of the lung can collapse in patients undergoing thoracic surgery and cardiopulmonary bypass. This collapse can persist for several hours after the operation (Hedenstierna & Edmark, 2015). For the reasons mentioned above, the anesthesia provider must possess adequate knowledge about ventilator settings and respiratory mechanics to ensure that the patient maintains optimal ventilation, oxygenation, and perfusion during anesthesia and post-operatively.

Mechanical Ventilation and Surgical Use

Ventilation is the process by which gases are moved into and out of the lungs. Mechanical ventilation involves using a machine to support patients' breathing when they cannot adequately do so independently. An endotracheal tube (ETT) or a supraglottic airway device connects the patient to the ventilator during mechanical ventilation. Once connected, the machine pushes air, oxygen, and other inhalation agents into the lungs. The ventilator allows the provider to completely take over ventilation if necessary, adjusting inspired volumes, pressure, rate of respiration, and the ratio of inspiration to expiration as needed to optimize conditions for the best possible patient outcomes. Alternatively, it can simply assist the patient's intrinsic respiratory pattern until they are strong enough to breathe without it (Hill, 2020).

Most of the drugs used during the induction and maintenance of general anesthesia impair respiratory function, as mentioned in the previous section. Patients under the effects of general anesthesia can lose the ability to adequately ventilate themselves and maintain airway patency, which is why they require mechanical ventilator support. Due to these adverse effects, more than 230 million patients undergoing surgical procedures require mechanical ventilation each year (Ball et al., 2015).

Historically the ventilators on the anesthesia workstation delivered gases to the patient through a closed-circuit system using a bellows system. However, the machines used in the modern-day operating room have integrated modes and technologies previously only available on ventilators used in the intensive care unit (ICU). With these technological advancements, and because postoperative pulmonary complications are a significant determinant of post-procedure morbidity and mortality, it is paramount that the anesthesia provider has a working knowledge of the capabilities of the available equipment and the modes that can be used (Hill, 2020).

Pressure Control Ventilation

PCV, also called pressure limited ventilation (PLV), is one of the two main modes of ventilation used in the operating theater. PCV was initially used in the ICU to help prevent barotrauma in patients suffering from acute respiratory distress syndrome (ARDS). However, it has also been proven to be a valuable option for the operating room. In PCV mode, the clinician sets the inspiratory pressure, inspiratory time, and respiratory rate (RR). The provider can also add positive end-expiratory pressure (PEEP) and adjust the inspiratory expiratory ratio (I: E ratio) as needed to optimize oxygenation and gas exchange. Some ventilators will also allow adjustments to inspiratory flow. In PCV, the tidal volume (VT), the amount of air that moves in and out of the lungs with each respiratory cycle, becomes the dependent variable. In this mode, the VT is inconsistent and will depend on lung compliance and the set inspiratory pressure (Gertler, 2021).

With PCV, there is a rapid initial flow of air into the lungs. Due to this initial rush of air, the pressure gradient between the proximal airways and the alveoli peaks early in the inspiratory phase. This high-speed flow will deliver the VT early in the inspiratory phase and help recruit unstable alveoli. After the initial burst, a flow deceleration keeps the inspiratory pressure constant. Keeping the pressure constant reduces inhomogeneity by allowing a more even distribution of the VT among the alveoli. PCV provides a lower peak airway pressure, reduces intrathoracic pressure, and reduces vascular resistance in the lungs. Due to these changes, there will be less strain on the right ventricle, and the patient may have an improved V/Q ratio and better oxygenation (Gertler, 2021).

The ability to adequately ventilate lungs with inhomogeneous mechanical properties can be beneficial in the operating room. These abnormal mechanics are a common problem in the operating room where certain positions, the use of muscle relaxants, obesity, underlying lung disease, and specific surgical interventions such as laparoscopy can cause adverse changes in regional ventilation and perfusion relationships. With its high initial flow, PCV provides the maximum V_T from the start of ventilation; this makes PLV helpful when gas leaks from somewhere in the patient circuit. Typical examples of when a leak might be present include using an uncuffed ETT, a bronchopleural fistula during thoracic surgery, and fiberoptic bronchoscopy (Dosch, 2021).

Though there are many scenarios where PCV is helpful during surgery, it is not without its disadvantages. The major one is the variable and unreliable VT delivery. During ventilation with PCV, VT is variable and a product of the set inspiratory pressure level, lung compliance, airway resistance, and circuit tubing resistance. Therefore, VT will be significant when set inspiratory pressures are high, compliance is good, and there is little resistance in the airways and the ventilator tubing. PCV allows tight peak inspiratory pressure control, but adequate minute ventilation to remove carbon dioxide is not guaranteed. When using this ventilation mode, the provider must pay close attention and set alarms to ensure that appropriate volumes are delivered at all times. For example, PCV is useful during laparoscopic procedures to ensure that peak pressures do not exceed a safe level. However, the higher-pressure setting needed while the abdomen is insufflated will deliver a dangerously high VT once the pneumoperitoneum is released. The anesthesia provider must remain vigilant and anticipate the need to adjust the inspiratory pressure setting (Ball et al., 2015).

Volume Control Ventilation

VCV, also known as volume-limited or volume-cycled ventilation, is a mode of ventilation that primarily focuses on the volume of inspired gas the patient is receiving. This ventilation mode is commonly recognized as the most popular and well-understood mode of ventilation amongst clinicians. When using VCV, the clinician sets the VT and RR, controlling the patient's minute ventilation. Minute ventilation is the volume of inspired or expired gas a patient breathes from their lungs in one minute, which is usually measured in liters per minute. VCV delivers this set minute ventilation unless peak airway pressures exceed the limit set on the ventilator (Gertler, 2021).

VCV mode has several parameters that can be adjusted to achieve optimal ventilation for the patient. These parameters include VT, RR, I: E ratio, PEEP, and the pressure limit. These parameters combined set certain limits and change the characteristics of how the set volume of gas is delivered to the patient. The circuit compliance and fresh gas flow through the ventilator can also affect the delivered VT. This effect on tidal volume is especially significant when making adjustments for infants and neonates. A high volume delivered to non-compliant lungs can cause barotrauma and uneven gas distribution. In VCV, the provider can adjust the I: E ratio and add PEEP to further adjust the ventilator mechanics (Gertler, 2021).

Parameters for ideal baseline settings in VCV include a VT of 5-7 milliliters per kilogram of ideal body weight for the patient. A RR of 6-12 breaths per minute is a good starting point for VCV settings but should be titrated based on the patient's end-tidal carbon dioxide readings. PEEP of 0-5 centimeters of water (cm H2O) is an ideal starting point. Still, several scenarios can indicate reasons to add PEEP to ventilation, including trouble oxygenating, obesity, using a compromising respiratory position such as Trendelenburg, or using the lower end of the VT range for the patient (Dosch, 2021).

VCV is widely accepted as the most optimal ventilation mode for surgical patients; however, this sentiment is not scientifically proven. While there are several positive aspects to VCV, there are also many negatives. One of the most significant negatives is that VCV can be associated with reaching higher peak pressures to achieve a specific inspired volume compared to PCV (Gertler, 2021). VCV is set to reach a particular VT and to push that set amount of volume through the circuit into the patient until a set pressure trigger is activated, in which case the ventilator discontinues its efforts to deliver that amount of volume. Another striking negative to using VCV is that atelectasis is more likely to occur in this ventilation mode. Atelectasis occurs when the pressure outside a section of the lung is greater than the pressure inside that section. This scenario happens more frequently when a practitioner keeps the patient on lower VT during VCV (Ball et al., 2015).

Rationale

OSCEs have been utilized for years, and research has proven them to be effective in increasing students' confidence and preparedness when entering the clinical portion of their education. The utilization of OSCEs is evidence-based and created from strenuous research. This intervention is expected to be successful due to its goal of improving the knowledge and skill level of SRNAs. This OSCE will increase patient safety, decrease the time delay for patient care, and increase student confidence. Kolb's Theory was used as the framework for the OSCE. Utilizing Kolb's Theory as a framework discourages students from simple memorization and strives to create a concrete understanding of the subject matter so that the students can confidently carry the simulated information into clinical practice.

Framework and Theory

The framework used for this OSCE is Kolb's Theory. Kolb's Theory uses a four-stage learning cycle in which the learner encounters a new experience, reflects on the observations of said new experience, conceptualizes or modifies a concept based on this experience, and then applies their idea to the world around them (Kurt, 2020). The learner is also encouraged to absorb the provided information in a four-stage cycle. These stages are concrete experience, reflective observation, abstract conceptualization, and active experimentation. Simplified even further, these four cycles encourage the learner to absorb the information by feeling, watching, thinking, and performing whatever skill is taught.

The four-stage learning cycle describes in Kolb's Theory integrates well into this topic. This theory actively discourages memorization and encourages a concrete understanding of the material and the ability to actively use the learned material in real-life scenarios (Kurt, 2020).

Doctor of Nursing Practice Essentials

The Doctor of Nursing Practice (DNP) degree prepares Advanced Practice Nurses to perform at the highest level in their chosen field of study. According to the American Association of Colleges of Nursing (AACN), students must meet eight essential foundational criteria before being awarded a DNP degree (AACN, 2006). The essentials that were met by this doctoral project are discussed below.

Essential I: Scientific Underpinning for Practice

"Scientific Underpinnings for Practice focuses on taking the body of knowledge gained through scientific research and implementing that knowledge into the nursing profession" (AACN, 2006, pp. 8-9). This doctoral project met this essential by using relevant scientific research as the basis for the subject matter.

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

"Organizational and Systems Leadership for Quality Improvement and Systems Thinking focuses on assimilating nursing science and practice with the complex needs of humankind" (AACN, 2006, pp. 8-9). This doctoral project met Essential II by using evidence-based practice to better educate students on ventilator modes, and this information can be taken and used in their practice.

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

"Information Systems/ Technology and Patient Care Technology for the Improvement and Transformation of Health Care focuses on the graduate's ability to utilize technologies to support practice leadership and clinical decision-making" (AACN, 2006, p. 13). This doctoral project met Essential IV by explaining modes on the ventilator and helping DNP students better utilize the ventilator for their practice.

Essential VI: Interprofessional Collaboration for Improving Patient and Population Health Outcomes

"Interprofessional Collaboration for Improving Patient and Population Health Outcomes involves communicating and collaborating with other professionals to implement the best possible patient care" (AACN, 2006, p. 14). This essential was met by using input and suggestions from faculty and other stakeholders to develop and refine this doctoral project.

Essential VIII: Advanced Nursing Practice

"Advanced Nursing Practice focuses on conducting comprehensive needs assessments, mentoring other nurses, and guiding patients through complex situational transitions" (AACN, 2006, p. 14). This doctoral project met Essential VIII by mentoring future DNP students on ventilator modes and the situations they should be utilized.

Summary

Deciding when to use VCV or PCV requires a quick assessment of a patient's health and body habitus. Providing students with the information necessary to quickly determine if VCV or PCV is best for their patients will aid them in their success as future anesthetists. Proper training is essential to assist providers in selecting the ventilator mode they deem necessary for their patients. Research has shown that this training can be accomplished through didactic courses, simulation training, and clinical experience (Brescia et al., 2009).

An SRNA often does not fully understand the variables between PCV and VCV. Didactic work alone does not explain the differences in these two modes to the degree that most SRNAs can grasp well enough to apply the knowledge immediately in clinical practice. This knowledge gap can lead SRNAs to have a slow start to their clinical experience and cause potential injury to a patient. This doctoral project intends to create an OSCE that will better teach and evaluate SRNAs in a simulation environment on their abilities to differentiate different scenarios in which a specific ventilator mode would be optimal.

CHAPTER II – METHODOLOGY

Introduction

An SRNA often does not completely understand all the variables between PCV and VCV. Didactic work alone does not explain the differences in these two modes to a degree in which most SRNAs can grasp this knowledge well enough to apply it to practice immediately. This knowledge gap can lead SRNAs to have a slow start to their clinical experience and cause potential injury to a patient. Proper training is essential to assist providers in selecting the ventilator mode they deem necessary for their patients. Research has shown that students can gain this knowledge through didactic, simulation, and clinical experience (Brescia et al., 2009). The authors created this doctoral project to develop an OSCE to serve as a training and evaluation tool for students in USM's NAP.

Context

This OSCE will be utilized at USM by first-year SRNA students during their didactic portion of education before beginning their clinical experience. Students can also use the OSCE in the second and third years of the program to solidify their didactic education further. This program is a three-year program where students receive a doctorate of nursing degree with a focus in anesthesia at graduation. Every year, 20 students are admitted and are educated by four practicing certified registered nurse anesthetists (CRNAs). Students in this program receive much of the didactic portion of their education in the first year of study, followed by two years of intensive clinical experience and some didactic education. Hands-on experience is minimal before the second year of study. The program provides simulation experiences throughout the three years of study; however, most of the simulated practice is in the program's first year, which helps prepare the students for clinical practice beginning in the second year.

The NAP, which is part of the School of Leadership and Advanced Practice Nursing and the College of Nursing and Health Professions, is housed in Asbury Hall at USM. The students in the NAP have access to an advanced simulation laboratory with intensive care, medical-surgical, nursing home, and OR simulation experience. The OR portion provides an authentic OR experience for students to safely hone their skills before they begin practicing at clinical sites. The college designed the OR portion of the simulation lab to provide an authentic and safe environment for anesthesia students to practice their craft. The lab is accessible for independent practice or guided practice with professors present. The simulated OR houses two authentic anesthesia machines with ventilators that resemble those commonly seen in current anesthesia practice.

OSCE Development

An extensive literature review on ventilator and respiratory science was conducted. The literature search focused on peer-reviewed scholarly databases and sources. The literature search focused on databases such as EBSCO Host, Digital Public Library of America, Data USA, PubMed, Cochrane Library, and Google Scholar. Some keywords used in the search included ventilation during anesthesia, VCV, PCV, improved outcomes due to ventilation mode selection, and CRNA preference of ventilation mode for specific patients and cases.

This doctoral project focused on improving the preparedness of NAP students in identification and utilization of optimal ventilator modes. This issue was identified by the USM NAP faculty. This OSCE was created to provide an additional educational tool for

NAP students to gain the knowledge necessary to enter clinical practice. Before the development of this OSCE, evidence-based practice recommendations for ventilator modes were extensively researched. The OSCE was developed based on the results of this research.

Measures

The expected outcome of this doctoral project utilized current research to guide SRNAs in their selection of ventilator settings, specifically choosing between VCV and PCV. The researchers designed the OSCE to benefit SRNAs in both didactic and clinical practice by assisting them in furthering their knowledge about the ventilator. After completing the OSCE, SRNAs should be more confident in their ability to properly use both PCV and VCV. Throughout gathering research, the OSCE proved to be an essential learning tool for SRNAs. The stakeholders were given a survey to answer following the completion of the OSCE. The survey measured and evaluated the OSCE's effectiveness and allowed an opportunity for constructive feedback. The survey provided to the stakeholders contained the following items:

1. Do you consent to participate in the evaluation of the OSCE for PCV and VCV?
2. Did this OSCE clearly explain both PCV and VCV modes?
3. After participating in this OSCE are you able to identify the independent and dependent variables when using PCV and VCV modes?
4. Did this OSCE clearly explain situations where PCV and VCV modes might be useful?

5. In your opinion, does this OSCE include all of the necessary information to help SRNAs be successful in the clinical setting?
6. Please add any recommendations or comments that you have that would make this OSCE for PCV and VCV easier to understand for future SRNAs.

After committee approval, the doctoral project was submitted to the Institutional Review Board (IRB) for approval before the survey was sent to the stakeholders. The IRB approved the doctoral project (Protocol #22-889), which the researchers then sent via email invitation to the stakeholders. The completed doctoral project was also presented to the public at the Fall 2022 USM School of Leadership and Advanced Nursing Practice DNP Scholarship Day.

Data Collection and Analysis

The information collected from the participants was arranged to regard a part of quantitative and qualitative results. All the responses to the direct yes or no questions were organized into a bar chart for straightforward interpretation. Only a few participants provided feedback on the final open-ended question, and those responses were organized into a table for clarity. The measures and data analysis aimed to discern whether or not the participants thought the OSCE was easy to understand, thoroughly explained the material and would help educate current and future SRNAs. The open-ended question also allowed for feedback and suggestions to improve the OSCE.

Ethical Considerations

"Certified Registered Nurse Anesthetists follow the American Nurses Association Nursing Code of Ethics in the daily practice and abide by the American Association of Nurse Anesthetists Code of Ethics in guiding ethical decision-making" (Nagelhout &

Elisha, 2018, p. 1145). Ethical considerations should be placed at the center of patient safety by healthcare providers. Using this OSCE, students will increase their mindfulness towards patient safety while selecting ventilator modes.

Ethical differences were not deciding factors in the participation and creation of this doctoral project. Surveys were conveyed to participants by email, and the results were anonymous. This doctoral project did not require direct contact with patients. Also, there were no conflicts of interest in creating this OSCE. A proposal was prepared and submitted to IRB for approval to ensure that this doctoral project was ethically sound.

Summary

This OSCE was created to improve SRNA readiness to select proper ventilation modes in a clinical setting, which will help strengthen the curriculum of the NAP and ensure SRNAs are adequately prepared for the clinical setting with the appropriate knowledge and skillset specific to ventilator selection. This OSCE was submitted to the IRB after the appropriate evidence-based research was conducted. Based on the evaluation data, improvements were made to the OSCE. The OSCE was then presented to the NAP committee for assessment and possible inclusion into the NAP curriculum.

CHAPTER III – RESULTS

Introduction

Nurse anesthesia professors at USM have identified the need and lack of an OSCE for VCV and PCV. When the SRNA is not well versed in the differences between the two basic modes of mechanical ventilation and when and how to use them, there is a potential for adverse patient outcomes and loss of confidence in the SRNA's abilities. This doctoral project aimed to provide SRNAs with a structured and standardized assessment tool in the foundational skills of knowing how VCV and PCV work, the advantages and disadvantages associated with each mode, and when to use each method based on a patient's condition and surgical procedure.

By creating an evidence-based OSCE that focuses on these two basic modes of mechanical ventilation, students will have a resource they can use to practice their ventilator skills in the simulation lab repeatedly. This OSCE provides the student with an instructional video, a challenge scenario, and an assessment tool to evaluate what was learned. Utilization of this OSCE before entering the clinical settings and throughout their clinical education aims to better prepare SRNAs for post-graduation practice and gain confidence in their abilities before and throughout their clinical experiences. The ultimate goal is to increase student competence and confidence and improve patient safety and outcomes.

Steps of the Intervention

In efforts to formally create this OSCE for practice, evidence-based research and guidelines were reviewed and summarized in Chapter I. The researchers analyzed the material to aid in developing the tasks for the OSCE. The OSCE was constructed by first stating the outcomes and objectives of the doctoral project, then providing background knowledge needed to complete the skills, and finally, creating an assessment tool and debriefing form to evaluate learned skills. After completing the written OSCE, the researchers produced a video to serve as a visual aid. After approval by the DNP project committee members, the researchers submitted the OSCE to the IRB. Once IRB approval was obtained the OSCE was ready to be evaluated by a peer panel.

The OSCE template, evaluation tool, and demonstration video were electronically forwarded to a group of stakeholders, which consisted of second and third-year anesthesia students, anesthesia instructors, and clinical instructors. After reviewing the material, the respondents completed the brief six-question survey attached to the email. The participants had to first consent to the questionnaire, and the consent assured participants that no identifying data was collected. The participants completed the surveys via Qualtrics®, and their responses were recorded and stored in a password-secured database.

Survey results were collected two weeks after the initial invitational email was sent out and one week after a reminder email. A total of 37 responses were received after these two weeks. The results were unanimous, as everyone who responded answered yes to all survey questions. The questions and results are summarized in Table 1 below. Three of the participants provided feedback on question 6, and those responses are provided in Table 2.

Table 1

Survey Results

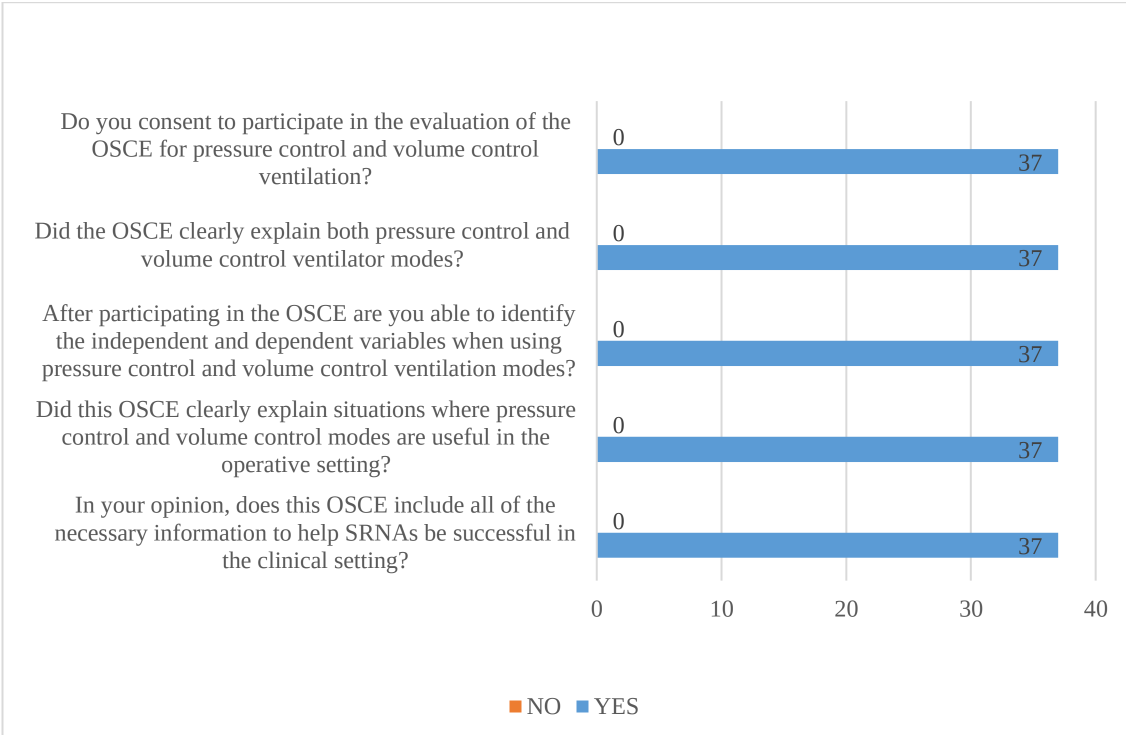

Table 2

Responses to Question 6: Participant Feedback

Participant	Feedback
1	"The video was well done. The scenario with pauses for intervention will be helpful for students who are applying didactic knowledge to clinical application."
2	"Good job!"
3	"Excellent job!! Very well organized!"

Summary

This OSCE aimed to provide SRNAs with a way to practice using and evaluate their knowledge of PCV and VCV modes. The OSCE tool and the video with the practice scenario will provide SRNAs with a way to practice using these two basic ventilator modes in a controlled environment before entering and during the clinical practice portion of their education. The overall goal of this doctoral project is to provide a tool to improve SRNA competency and patient safety. Based on the survey results and participant feedback, the OSCE accomplished this goal.

CHAPTER IV – Discussion

This doctoral project aims to develop an OSCE that enhances the current curriculum of USM's NAP program. This OSCE will also provide SRNAs with simulated patient care, improving their patient care skills and confidence in the OR. This doctoral project was developed from evidence-based practice data for developing OSCEs and peer-reviewed research on the selection and use of ventilator modes. All methodology used in creating this OSCE meets the AACN DNP Essentials.

Survey participants were able to respond anonymously, and they unanimously agreed that this VCV and PCV OSCE was clearly and easily understood. The participants involved in the doctoral project included USM NAP staff members, who currently practice anesthesia, and USM NAP SRNAs in their second and third years of the program. Survey participants agreed that this OSCE provided the needed information to understand ventilator mode selection, and the scenario provided excellent practice for ventilator mode selection.

Interpretation

The feedback provided by the survey participants revealed a unanimous agreement that the ventilator mode selection OSCE, supplementary information, and scenario video support EBP and thoroughly prepare SRNAs for future clinical experience. Using this OSCE in the simulation lab allows SRNAs to learn how to properly evaluate and correct different surgical and patient-related variables that can affect proper ventilation through a hands-on approach. From the gathered information, it can be concluded that implementing the VCV and PCV OSCE into the USM NAP curriculum will better prepare SRNAs for the transition into the clinical setting.

Limitations

One limitation of this study was its small sample size, potentially affecting the amount of critique received from the survey participants. The sample size of participants consisted of five USM NAP faculty members, SRNAs currently involved in the clinical setting, and a pool of clinical preceptors. These participants were considered experienced with ventilator modes, enhancing their feedback quality. Also, these participants are associated with the USM NAP. Therefore, there is a potential for a biased response from their feedback. The USM NAP faculty practices independently in a clinical setting and have education experience, which would provide them with expertise in assessing clinical readiness in SRNA students. The lack of evidence and research on OSCE implementation at other NAPs poses another limitation to this study. Still, OSCEs are routinely used to evaluate nurse practitioners and should be analyzed to provide feedback regarding the implementation in anesthesia programs.

To further this research in the future, researchers could add 1st-year USM NAP students to the sample size. This would add clarity to the effectiveness of the OSCE for newer SRNAs. In addition, surveys could be provided to additional CRNAs and participants outside the USM NAP to better enhance the OSCE before the implementation into the USM NAP curriculum.

Conclusion

This OSCE has been presented to USM's NAP for consideration to be included in their OSCE library. This OSCE and simulation video could be utilized in nurse anesthesia courses and other clinical preparedness modules. Also, this OSCE and all supporting documents have the potential to be used in other medical programs that study ventilator modes. If selected to be adopted into USM's curriculum, this OSCE will allow SRNAs to become more confident in ventilator mode selection inside the simulation setting and clinical practice. Practicing decision-making skills such as these in a simulation setting will enable SRNAs to make changes and practice without the potential to cause harm to patients. This format will allow them to ask questions, try new skills, debrief, and become more comfortable with their decision-making process. The purpose of this doctoral project was to provide SRNAs with a tool to help them develop the skills needed to make time-sensitive decisions between VCV and PCV confidently and correctly.

APPENDIX A – DNP Essentials

DNP Essentials	How the Essential is Applied
Essential 1- Scientific Underpinnings for Practice	Essential I was met by creating an OSCE using relevant scientific literature.
DNP Essential II- Organizational and Systems Leadership for Quality and Improvement and Systems Thinking	Essential II was met by using evidence-based practice to better educate students on ventilator modes, and this information can be taken and used in their practice.
DNP Essential IV- Information Systems or Technology and Patient Care Technology for Improvement and Transformation of Health Care.	This doctoral project met Essential IV by explaining modes on the ventilator and helping DNP students better utilize the ventilator for their practice.
DNP Essential VI- Interprofessional Collaboration for Improving Patient and Population Health Outcomes	This doctoral project met Essential VI by using input from students and faculty to develop an OSCE that focuses on an important area of patient care.
DNP Essential VIII- Advanced Nursing Practice	This doctoral project met Essential VIII by mentoring future DNP students on ventilator modes and the situations they should be utilized.

APPENDIX B -Recruitment Invitation

Dear Participant,

You are being invited to participate in a survey as part of a DNP project being conducted by Brian Bailey and Anthony Newsom at The University of Southern Mississippi. The purpose of this doctoral project is to provide SRNAs with an objective structured clinical evaluation (OSCE) on the foundational skills needed to choose between the use of pressure control and volume control ventilatory modes during surgical procedures.

The doctoral project presents no risk of harm to you and should take 10 minutes to complete. All information you share is anonymous and will be kept confidential.

Your participation is completely voluntary. If you choose not to participate, you can stop taking the survey and exit your browser at any time. There will be no repercussions for non-participation. An informed consent is required and is included in the survey. This doctoral project and the informed consent form have been reviewed by The University of Southern Mississippi Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. The IRB approval number for this doctoral project is 22-889. Refer to the informed consent for participant assurance information. The first question of the survey will ask for consent for your participation.

If you have any questions, please contact us using the information provided below. Thanks in advance for your time and cooperation.

Brian Bailey (brian.a.bailey@usm.edu)

Anthony Newsom (Anthony.Newsom@usm.edu)

Dr. Stephanie Parks (stephanie.parks@usm.edu)

Before beginning the survey, please review the attached files:

- Informed Consent
- Objective Structured Clinical Examination (OSCE) Template
- Objective Structured Clinical Examination (OSCE) Video

APPENDIX C -OSCE Template

OBJECTIVE STRUCTURED CLINICAL EVALUATION FOR

VOLUME CONTROL AND PRESSURE CONTROL VENTILATOR MODES

LEARNER OUTCOMES:

The student will be able to:
1. Identify the differences between volume control and pressure control ventilation.
2. Verbalize the benefits and risks associated with volume control and pressure control.
3. Identify the independent and dependent variables associated with each mode.
4. Describe the ventilatory pattern with each mode.
5. Appropriately select settings when using each mode in a clinical scenario

DOMAINS OF LEARNING:

COGNITIVE	PSYCHOMOTOR	AFFECTIVE
Knowledge of ventilator operation standards	Operates anesthesia monitor correctly	Follows the ventilation management OSCE for optimal ventilation delivery
Interpret ETCO2 waveforms	Prepares the ventilator for proper initial ventilation settings	Recognizes signs of inadequate ventilation
Formulate a plan to utilize either pressure or volume control modes of ventilation	Alters the ventilator mode based on the patient status during a surgical procedure	Integrates patient health history into an appropriate ventilator mode selection

PURPOSE: Exposure to ventilator modes with a demonstration of the ability to differentiate between surgical situations in which one mode is preferred over the other to improve clinical performance.

LEARNER OBJECTIVES:

1. Demonstrate understanding of volume control ventilation and pressure control ventilation
2. Identify indications for volume control ventilation and pressure control ventilation
3. Demonstrate the ability to make informed clinical decisions about which mode of ventilation is ideal for the situation

4. Analyze clinical skills and self-evaluate knowledge.

INDIVIDUAL OR GROUP OSCE: Either

REQUIRED READING and ASSOCIATED LECTURES:

1. Nagelhout, J. J., & Elisha, S. (n.d.). *Nurse Anesthesia, 6th ed*. Elsevier, 2018. p. 258-260

   & 612-613

2. Barash, P. G. (2017). *Clinical anesthesia*. Wolters Kluwer. p. 1062.

3. Apex Anesthesia Student Review .The Anesthesia Machine Mechanical Ventilation Part 1 and Part 2

REQUIRED VIDEOS: Volume Control Ventilation Versus Pressure Control Ventilation https://youtu.be/vojjgLjkyL4

REQUIRED PARTICIPANTS: SRNA volunteers, NAP faculty, clinical skills lab staff

VENUE: University of Southern Mississippi's School of Nursing Simulation Lab

STUDENT LEVEL OF OSCE: Semester 3-9

TIME ALLOTTED: 30 minutes

RECOMMENDED PRACTICE before EXAMINATION: Required readings X 2, required videos X 2, review of OSCE Scenario and expected performance.

CONTENT OUTLINE

CONTEXT: Your assignment is to provide general anesthesia for a 56yo male who is 6'1", weighs 150 kg, with a BMI of 44. The patient is undergoing a robotic prostatectomy for prostate cancer. Other medical history includes hypertension, diabetes, and sleep apnea. The patient denies any other heart or lung disease, has been NPO since midnight and uses his CPAP every night.

EQUIPMENT

- Anesthesia Machine with volume control and pressure control modes
- Simulation equipment for intubation
- Monitors:
    - EKG

    - Pulse oximeter
    - Blood pressure
    - End-tidal carbon dioxide
    - Temperature probe
- Size appropriate airway equipment
    - Face mask
    - Appropriately Sized ETT
    - Laryngoscope Handle
    - Laryngoscope Blade
- Syringe for cuff inflation
- Tape
- Suction setup (including Yankauer suction catheter)
- Sevoflurane
- Drug cart, syringes, and needles
- Stethoscope
- IV fluids
- IV start kit and angio-catheter
- Simulation equipment or second Ambu bag as an artificial lung

SITE SELECTION: N/A

TASK STATEMENT: You decide to use volume control ventilation after successfully securing the airway and confirming proper tube placement.

1. Place the patient on the ventilator in assist control mode.
2. Set an appropriate tidal volume for this patient.
3. Explain how volume control ventilation works.
4. Identify at least two advantages to the use of volume control ventilation.

TRIGGER EVENT: After several minutes of ventilation with the patient under the appropriate amount of anesthesia and fully relaxed, you notice that the PIPs vary between 30-35, and the ETCO2 varies between 40-45.

1. While still using volume control ventilation, what adjustments can be made to the ventilator to optimize the patient's condition?

TRIGGER EVENT: Your interventions were successful, and the patient's PIP fell to between 25-30, and the ETCO2 came down to 35. However, the abdomen has been insufflated with CO_2, and the patient has been positioned in a steep Trendelenburg for the procedure. Due to these changes, the PIP has again risen and is now between 37-45 and the ETCO2 is also on the rise, and O_2 sats with a FiO_2 of 100% is only 92%. Due to these changes, you decide to switch to pressure control ventilation to try again and optimize the patient.

1. Switch the ventilator into pressure control mode.
2. Set an acceptable PIP to avoid lung injury.
3. Explain how pressure control ventilation works.
   a. What variables can the anesthesia provider set and adjust when using pressure control ventilation?
   b. What variable will vary as a function of the patient's pulmonary compliance?
   c. How is inspiratory flow delivered when using pressure control ventilation?
4. What are three advantages to the use of pressure control ventilation?
5. What are two disadvantages to the use of pressure control ventilation?
6. Identify patient situations where pressure control ventilation is better than volume control ventilation.

TRIGGER EVENT: You again made excellent choices, and you were able to ventilate the patient for the duration of the procedure adequately. Upon completion of the procedure, the abdomen is deflated, and the patient is returned to a level position for closing. The ventilator is still set in pressure control mode, and it starts alarming, and you notice that your tidal volumes have increased significantly.

1. What changed that caused this to happen?
2. What adjustments do you need to make to correct the problem and avoid lung injury?

DEBRIEFING FORM:

1. What objectives were you able to demonstrate correctly?
2. Identify areas of weakness.
3. Were you satisfied with your ability to work through the simulation?
4. Do you feel that this OSCE prepared you for clinical practice?

ASSESSMENT

Rubric and key for Volume Control and Pressure Control Ventilation

	TASKS	PASS	FAIL	COMMENTS
*	1. Prepare the appropriate equipment			
*	2. Check the Anesthesia Machine			
*	3. Review the patient's medical history			

*	4. Review the procedure the patient is scheduled to undergo			
	5. Demonstrate proper placement of monitors.			
	6. Demonstrate proper preoxygenation			
	7. Place the patient in the proper position for intubation (including ramping the patient if necessary)			
	8. Demonstrate correct intravenous induction			
	9. Successfully and A-traumatically intubate the patient			
	10. Assess end tidal CO2 and breath sounds with manual ventilation			
*	11. Place the patient in assist control ventilation mode			
*	12. Set an appropriate tidal volume for this patient based on IBW 480-640 based on the pts IBW, which is 80kg			
*	13. Explain how volume control ventilation works: a. what variables can you control b. what variable will vary c. how is inspiratory flow delivered a. The anesthesia provider sets the tidal volume, respiratory rate, FiO2, PEEP, and I:E ratio. b. Peak inspiratory pressure will vary depending on pulmonary compliance. The ventilator will use the pressure necessary to deliver the preset volume.			

	c. The inspiratory flow is held constant during inspiration.			
*	14. Identify two advantages to the use of volume control ventilation. Both the tidal volume and the minute ventilation remain constant over a range of changing pulmonary characteristics.			
*	15. Following the first trigger event, correctly identify changes needed while in volume control ventilation. The anesthesia provider can decrease the tidal volume being delivered, which will decrease PIP. The respiratory rate will have to be increased to keep the ETCO2 within an acceptable range. You can also adjust the I:E ratio to allow more time for exhalation of CO2.			
*	16. After 2nd trigger event, switch the patient into pressure control ventilation.			
*	17. Set an acceptable inspiratory pressure to avoid lung injury. 20-30 cm H2O			
*	18. Explain how pressure control ventilation works: a. what variables can you control b. what variable will vary c. how is inspiratory flow delivered a. The inspiratory pressure, respiratory rate, FiO2, PEEP, and I:E ratio can be adjusted. b. The tidal volume will vary as a function of pulmonary compliance.			

	c. The inspiratory flow is delivered in a decelerating pattern. It begins high to achieve the set inflation pressure and then lower to maintain that pressure throughout the inspiratory phase.			
*	19. Identify at least three advantages to the use of pressure control ventilation. It delivers a larger tidal volume for a given inspiratory airway pressure, the inspiratory flow pattern may improve oxygenation, it reduces the risk of ventilator-associated lung injury, it is useful to compensate for leaks, and if the patient has low compliance.			
*	20. Identify two disadvantages when using pressure control ventilation. Decreased lung compliance or increased airway resistance will reduce tidal volumes. It requires the anesthesia provider to pay closer attention to events that can change pulmonary resistance or compliance.			
*	21. Correctly identify situations where pressure control ventilation may be a better choice than volume control. When the patient has decreased compliance: obesity, pregnancy, laparoscopy, ARDS, and when you need to compensate for a leak: LMA when using an uncuffed ETT in pediatrics			

*	22. Following the final triggering event, correctly identify the problem. Airway compliance has returned to baseline due to the release of the pneumoperitoneum and return to the level position, which has allowed for the delivery of much higher tidal volume with the current settings.			
*	23. Make appropriate ventilator changes to fix the issue? You can either decrease the set inspiratory pressure or switch back to volume control ventilation with your previous settings.			

Steps with ***** must be properly completed. All steps must be completed/passed to receive a passing grade.

APPENDIX D –IRB Approval Letter

Office of Research Integrity

THE UNIVERSITY OF SOUTHERN MISSISSIPPI.

118 COLLEGE DRIVE #5116 • HATTIESBURG, MS | 601.266.6756 | WWW.USM.EDU/ORI

NOTICE OF INSTITUTIONAL REVIEW BOARD ACTION

The project below 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 regulations (45 CFR Part 46), and University Policy to ensure:

- The risks to subjects are minimized and 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 involving risks to subjects must be reported immediately. Problems should be reported to ORI via the Incident submission on InfoEd IRB.
- The period of approval is twelve months. An application for renewal must be submitted for projects exceeding twelve months.

PROTOCOL NUMBER:	22-889
PROJECT TITLE:	Objective Structured Clinical Evaluation for Volume Control and Pressure Control Ventilator Mode
SCHOOL/PROGRAM	Leadership & Advanced Nursing
RESEARCHERS:	PI: Brian Bailey Investigators: Parks, Stephanie~Newsom, Anthony~Bailey, Brian~
IRB COMMITTEE ACTION:	Approved
CATEGORY:	Expedited Category
PERIOD OF APPROVAL:	12-Jul-2022 to 11-Jul-2023

Donald Sacco Jr.

Donald Sacco, Ph.D.
Institutional Review Board Chairperson

REFERENCES

The American Association of Colleges of Nursing (AACN). (2006). The essentials of doctoral education for advanced nursing practice. https://www.aacnnursing.org/Portals/42/Publications/DNPEssentials.pdf

Ball, L., Dameri, M., & Pelosi, P. (2015). Modes of mechanical ventilation for the operating room. *Best Practice & Research Clinical Anaesthesiology*, *29*(3), 285–299. https://doi.org/10.1016/j.bpa.2015.08.003

Brescia, D., Kavuru, M., Mazer, M., & Pancoast, T. (2009). Development of a New Assessment and Educational Tool for Mechanical Ventilation and Its Use to Evaluate Medical Resident Knowledge About Mechanical Ventilation. B105. Mechanical Ventilation: Modes – Weaning and Monitoring. doi: 10.1164/ajrccm-conference.2009.179.1_meetingabstracts.a3820

Dosch, M. (2021, February). *Anesthesia Gas Machine- Ventilators*. Healthprofessions.udmercy.edu. https://healthprofessions.udmercy.edu/academics/na/agm/08.htm

Gertler, R. (2021, January 27). *Mechanical ventilation during anesthesia in adults*. UpToDate. https://www.uptodate.com/contents/mechanical-ventilation-during-anesthesia-in-adults#H2510637227

Hedenstierna, G., & Edmark, L. (2015). Effects of anesthesia on the respiratory system. *Best Practice & Research Clinical Anaesthesiology*, *29*(3), 273–284. https://doi.org/10.1016/j.bpa.2015.08.008

Hill, B. (2020). Principles of mechanical ventilation for non-critical care nurses. *British Journal of Nursing*, *29*(8), 470–475. https://doi.org/10.12968/bjon.2020.29.8.470

Jiang, J., Li, B., Kang, N., Wu, A., & Yue, Y. (2016). Pressure-Controlled Versus Volume-Controlled Ventilation for Surgical Patients: A Systematic Review and Meta-analysis. *Journal of Cardiothoracic and Vascular Anesthesia*, *30*(2), 501–514. https://doi.org/10.1053/j.jvca.2015.05.199

Kurt, S. (2020, December 28). Kolb's Experimental Learning Theory & Learning Styles. Retrieved from https://educationaltechnology.net/kolbs-experimental-learning-theory-learning-styles/

Nagelhout, J., & Elisha, S. (2017). *Nurse anesthesia* (6th ed.). Elsevier.

Rittayamai, N., Katsios, CM., Beloncle, F., Friedrich, JO., Macebo, J., Brochard, L. (n.d.). Pressure Controlled vs Volume Controlled Ventilation in Acute Respiratory Failure: A Physiology-Based Narrative and systematic Review. Retrieved May 5, 2021, from https://pubmed.ncbi.nlm.nih.gov/25927671/