A COMPREHENSIVE EXTUBATION PROTOCOL TO PREVENT EXTUBATION FAILURE

by

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As members of the DNP Project Committee, we certify that we have read the DNP project prepared by Valerie Bryn Borgstrom, titled A Comprehensive Extubation Protocol to Prevent Extubation Failure and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.

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LAND ACKNOWLEDGEMENT

We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui. Committed to diversity and inclusion, the University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.

DEDICATION

I am dedicating this DNP project to my husband, Nick. Through many setbacks, you have supported me throughout this program with encouragement and love. Thank you for all the sacrifices you have made for the past three years to make this possible.

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ABSTRACT

Purpose: The purpose of this project was to determine if the modified Burns Wean Assessment Program would be appropriate to establish in three of HonorHealth's intensive care units.

Background: Mechanical ventilation is a widely used therapy in intensive care units and the decision to extubate is based on many factors that can vary among facilities and providers. A multifactorial extubation protocol can assist providers in making this decision and help identify if patients are appropriate for extubation. The modified Burns Wean Assessment Program is one protocol that can effectively identify patients who are more likely to fail extubation.

Methods: The modified Burns Wean Assessment Program was retrospectively applied to 54 patients who were extubated in three intensive care units during a two-month period. Their scores on the modified Burns Wean Assessment Program were analyzed respective to their extubation outcome to determine if higher scores on the assessment were associated with extubation success and lower scores associated with extubation failure.

Results: There were three extubation failures during the study period. The mean difference between the modified Burns Wean Assessment Program score in the extubation success and failure groups was not statistically significant.

Conclusion: Due to a small extubation failure rate, the modified Burns Wean Assessment Program score did not show a statistically significant difference differentiating between extubation successes and failures. An opportunity exists for a larger study for facilities with more extubation failures to evaluate the use of the modified Burns Wean Assessment to improve extubation outcomes.

INTRODUCTION

Mechanical ventilation is an important therapy for patients experiencing respiratory failure. When practitioners determine that the patient is ready for extubation and perform the extubation, many patients do not tolerate extubation and can experience post-extubation respiratory failure. This event often leads to the need to reintubate the patient and increases the likelihood of death and increases the intensive care unit (ICU) length of stay (Baptistella et al., 2018). Extubation failures often are multifactorial events; thus, an extubation protocol that includes many factors predicting extubation success may be effective at predicting the appropriate timing for patients to have successful extubations (Nitta et al., 2019).

Background Knowledge and Significance

Following liberation from mechanical ventilation, short-term or long-term complications may necessitate reintubation (Andreu et al., 2020). Current practice to determine eligibility for extubation varies among facilities and providers but may require a spontaneous breathing trial (SBT) and various other weaning parameters (Baptistella et al., 2018). Based on the status of various parameters, providers decide if the patient is likely to have success being extubated. If patients are extubated too early and must be reintubated, they are at risk for increased mortality, increased length of stay in the ICU, and increased length of stay in the hospital (Maggiore et al., 2018). Additionally, it is estimated that up to one in five patients who have been deemed appropriate to extubate will have respiratory failure after extubation, and up to half of those who failed extubation may die. On the other side of the spectrum, prolonged intubation can lead to increased use of sedatives and a higher incidence of ventilator-acquired pneumonia (Cove et al., 2016). Determining the optimal times to extubate patients can be complicated and highly specific to the patient's situation; however, opportunities exist to improve outcomes by implementing evidence-based practice.

The clinical practice guidelines of The American Thoracic Society recommended that patients who have been intubated and mechanically ventilated for more than 24 hours should have their extubation decision guided by an extubation protocol (Schmidt et al., 2017). The evidence used in this guideline stated that, in cases when an extubation protocol was utilized, patients spent less time on the ventilator and had fewer days spent in the ICU. Nitta et al. (2019) found that protocolized extubation could also reduce the incidence of respiratory failure after extubation, decrease mortality rates, and decrease rates of reintubation. In another study by Bobbs et al. (2019), researchers found that the application of an extubation checklist decreased the rates of reintubation occurring post-extubation and did not increase total ventilator days. The Burns Wean Assessment Program (BWAP) and the later developed modified Burns Wean Assessment Program (m-BWAP) are examples of weaning protocols that use a multifactorial approach that includes multiple parameters such as hemodynamics, nutrition, anxiety, and activity, in addition to respiratory measures (Burns et al., 1991; Jiang et al., 2014). The BWAP was developed in response to a lack of clinical guidelines for extubation decision-making. It was noted that there was no singular value that could accurately predict a successful extubation so many relevant previously studied factors were gathered to compose the BWAP scoring system. Ten studies were identified and evaluated to develop the 26 criteria that comprise the BWAP. The m-BWAP is a 20-parameter extubation protocol that uses many of the elements of the original 26 criteria from the BWAP. Some important differences include the decision to quantify many of the parameters to make scoring more objective, to add additional respiratory parameters, and to combine some parameters that could be evaluated in a single measure (Jiang et al., 2014).

The BWAP and the m-BWAP have been used in several different studies and found to be predictive of successful patient extubations. Decision-making guided by both measures has been associated with a shorter time on mechanical ventilation (Abdelaleem et al., 2020; Dehghani et al., 2016; Jeong & Lee, 2018; Sepahyar et al., 2021). In one study by Abdelaleem et al. (2020), researchers found that higher scores on the m-BWAP were associated with successful ventilator weaning in patients with a variety of respiratory conditions. Similarly, in the Jeong and Lee (2018) study higher m-BWAP scores as measured by critical care nurse practitioners, were also associated with successful ventilator weaning. Research by Sepahyar et al. (2021) demonstrated that the use of the BWAP not only decreased the incidence of reintubation but also demonstrated improvements in vital signs and laboratory values, among other measures. Furthermore, it is suggested that the use of a protocolized extubation practice may empower nurses and critical care nurse practitioners to appropriately determine the weaning readiness of mechanically ventilated patients (Jeong & Lee, 2018; Sepahyar et al., 2021).

Mechanical ventilation is often a vital therapy for patients and can help them survive many disease processes; however, the decision to extubate frequently is difficult to make in complex patients (Schmidt et al., 2017). Practitioners, bedside nurses, and respiratory therapists may have different ideas as to what constitutes criteria patients should meet before extubation. Having a standardized and comprehensive extubation protocol provides a simple evidence-based intervention to better guide practitioners in determining the appropriate time to extubate patients. Since mechanical ventilation is a very common therapy in the ICU and inappropriate extubation can lead to unintended and detrimental outcomes, it is important to evaluate and employ the elements that make extubation successful.

Local Problem

HonorHealth is a health system with six hospitals including three Level I trauma centers in Phoenix and Scottsdale, Arizona. These trauma centers include HonorHealth Osborn, HonorHealth John C Lincoln (JCL), and HonorHealth Deer Valley Medical Centers. Osborn's ICU consists of 59 beds, John C Lincoln contains 40 ICU beds, and Deer Valley has 32 ICU beds. Many of the patients in these ICUs require either short- or long-term intubation for various reasons. The current extubation criteria mainly consist of the ability of the patient to tolerate an SBT for a non-specified length of time as well as several respiratory weaning parameters. The ultimate decision to extubate depends on the decision of the provider. Beyond the current extubation criteria, individual providers make their own decision about extubation and the reasons for the decision vary by provider. The decision to use the information on the existing weaning parameters can also depend upon provider perspectives, and patients may still be extubated even if they do not meet the weaning criteria. With the variability in criteria used among providers to determine extubation timing, it may be confusing for nurses and respiratory therapists to decide when patients qualify for extubation.

As an ICU nurse, I have observed that precise and optimal conditions for patients to qualify for extubation can be elusive. Sometimes patients have seemingly serious abnormalities that may impact their ability to successfully extubate but they are extubated, regardless, and may or may not be successful. Witnessing patients fail extubation and knowing that some elements of their disease process may not have been addressed by the existing extubation parameters, calls for additional guidance and parameters. Currently, nursing staff members need additional tools to empower them to better evaluate the appropriateness of their patients' extubation. With these tools, recommendations to the provider will more likely result in improved patient outcomes. The establishment of a succinct and easy-to-use extubation protocol would enable nurses to make an assessment based on specific evidence-based criteria.

Intended Improvement

Project Purpose

The purpose of this project was to determine if the modified Burns Wean Assessment Program (m-BWAP) would be an effective program to establish in HonorHealth's three Level I trauma center ICUs in the Phoenix and Scottsdale areas. To aid in the extubation decision-making process, an established extubation protocol was applied to previously extubated patients, to determine if the score from the extubation protocol was correlated with the patient failing extubation or having a successful extubation. The current process for extubation leaves room for interpretation and having a comprehensive extubation protocol would quantify the eligibility for extubation, potentially making the decision easier. A higher m-BWAP score has been associated with successful ventilator weaning, shorter hospital stays, and shorter times on the ventilator (Jeong & Lee, 2018; Jiang et al., 2014; Abdelaleem et al., 2020). This type of assessment is easy to use, and different parts of the assessment can be useful in determining weaning times and patients' ability to maintain their airways.

Project Question

Is the retrospective application of an extubation protocol associated with patients who have had successful or failed extubations in the medical ICU?

Project Objectives

The purpose of this project was to assess if the modified Burns Wean Assessment Program would be an effective tool to use in HonorHealth Osborn, JCL, and Deer Valley's intensive care unit (ICU) mechanically ventilated patient populations. The Burns Wean Assessment Protocol (BWAP) was developed to teach users about the important concept of the weaning assessment (Burns et al., 1991). In 2014, the modified BWAP (Appendix B) was developed based on the original BWAP in such a way that some elements were combined, and several other elements were added to make a more comprehensive protocol with well-defined parameters (Jiang et al., 2014). Randomly selected, eligible, recently intubated patients during a two-month period in the three ICUs had the m-BWAP applied using data from their charts. The m-BWAP score was measured and the extubation failure or success was noted to determine if the m-BWAP was an appropriate tool to use on this patient population to predict extubation success.

Theoretical Framework

Kurt Lewin's Change Theory

Kurt Lewin's Change Theory is a three-step model developed to change organizational behavior. This theory has abundant potential applications when applied in the healthcare system (Burnes, 2004). The focus of Lewin's Change Theory is on the general variables that impact how changes occur and the details of these variables can be easily adapted to fit many situations (Schein, 1996). This seemingly simple model consists of three steps that involve dismantling current the practice (unfreezing), changing the current practice (changing or moving), and solidifying the new practice to make it a permanent change (refreezing).

Unfreezing

Unfreezing is the first step in Lewin's change theory and involves dismantling current practices (Hussain et al., 2018). In this step, which is often sparked by dissatisfaction with the existing practice, the current practice is assessed and dismantled. This requires challenging the status quo, a step that involves unbalancing the equilibrium of what current users find to be familiar and comfortable (Schein, 1996). Discomfort may arise from this process as users of a system often are hesitant to change or afraid to make mistakes while learning a new process. The old behaviors or processes must be unlearned and discarded before new practices can be established. In this project, the unfreezing step of this model was the primary focus. The current extubation practices were called into question as the new protocol evaluated extubation successes and failures in mechanically ventilated patients. The new protocol's potential is to uncover that the current practice is not the most effective, accurate, or helpful for patient care and decision-making. Evaluating potential faults in the current system initiates the unfreezing process and potentially allows a new practice to be established in the future.

This project focused on determining if the utilization of the m-BWAP could lead to a correct prediction of extubation success or failure. In other studies, with specific ICU populations, higher scores on the m-BWAP have been correlated with successful ventilator weaning (Abdelaleem et al., 2020; Jeong & Lee, 2018; Jiang et al., 2014). Findings from this project determined if the m-BWAP may be an appropriate and effective weaning protocol for this specific mixed-ICU population.

Moving or Changing

The second step of this process is called moving or changing. This portion of the model involves shifting the way the user thinks about the process and transforming the current approach to the process (Shirey, 2013). This step requires users of the desired process to make changes to their current thought process and engage in establishing a new practice. Several strategies that can be utilized in establishing this new practice include involving end-users in instituting new changes, sharing knowledge about the new process, and utilizing effective leadership (Hussain et al., 2018). This type of leadership is pivotal at this stage and an effective leader will analyze and engage the stakeholders and establish a tailored approach to inspire the application of the new practice.

For this project, the change that was performed was using this specific weaning protocol and retrospectively scoring previously intubated patients. The m-BWAP is a 20-element assessment tool that allows a numerical score to be applied to a patient who is being weaned from the ventilator (Jiang et al., 2014). The items scored include age, cardiac function, hemodynamic status, metabolic issues, arterial blood gas values, the appearance of the chest x-ray, level of consciousness, electrolyte values, fluid status, nutrition status, body strength, airway clearance, airway secretions, and several respiratory parameters (Jiang et al, 2014). For each of these items, patients were given one to five points (depending on the criteria) if the patient meets the measure and zero points if the patient does not meet the measure or if the measure was not assessed. Higher scores on this assessment are associated with successful extubation (Abdelaleem et al., 2020; Jeong & Lee, 2018; Jiang et al., 2014). This extubation protocol may impact several other important outcome measures such as hospital length of stay and cost of hospitalization, but for this project, extubation success was the outcome variable.

Refreezing

The final component of this theory is called refreezing. At this stage, the new protocol is allowed to become part of the normal practice by incorporating it into everyday processes and creating a social environment that accepts the change (Burnes, 2004). In general, it is helpful for the entire team to be involved and in agreement with the new process so that the environment is conducive to acceptance and consistency in practice. Leaders must also identify counteractive forces that are working contrary to the newly established process and work on ways to eliminate them (Shirey, 2013). Identifying and addressing issues that impact the maintenance of the newly established practice will help promote its application and longevity in future practice.

As part of this project, measures were calculated to determine if higher scores on the m-BWAP were associated with successful extubation. If this association exists in this setting, a case can be made for the establishment of this protocol for intubated patients.

Literature Synthesis

Evidence Search

A literature search was conducted to determine strategies for successful mechanical ventilation weaning. Several searches were conducted on PubMed accessed via the Arizona Health Science Library. The first search was conducted using the terms “extubation failure” and “protocol.” Results were filtered to include only articles that had been published in the last six years, were written in the English language, and had full text available. An additional search was performed with the terms “modified Burns Weaning Assessment Protocol” OR “BWAP” OR

"Burns Wean." The same filters were applied to this search. Results from both these searches were evaluated individually for relevance and applicability to the project.

The first PubMed search was performed to explore the various methods used for weaning, diverse protocols that exist to aid in ventilation weaning, and specific weaning parameters that have been evaluated. From this search, nine articles were found that met the criteria of the search. These articles discussed complications of the post-extubation period, parameters that can predict extubation outcomes, and specific extubation protocols. Several of the articles found referenced the Burns Wean Assessment Protocol and the modified Burns Wean Assessment Protocol.

The second PubMed search was performed to obtain additional information about BWAP and m-BWAP. Seven relevant articles were located. One of the articles documented the development of the original BWAP. A second article discussed the development of the m-BWAP. Another article was a review of several extubation protocols comparing the outcomes of using different protocols and scoring systems and their rate of predicting successful rates of extubation. The three remaining articles discussed the application of the BWAP and m-BWAP in various settings and discussed the efficacy and indications for the use of this protocol.

Comprehensive Appraisal of Evidence

Weaning Parameters

Many facilities and individual practitioners have a unique set of parameters that they utilize to decide if a patient is appropriate to extubate. Determining which parameter or group of parameters best predicts extubation success may be elusive. In the systematic review performed by Baptistella et al. (2018), many weaning parameters were analyzed for their value in predicting extubation success. This review analyzed 56 parameters that have a potential impact on predicting weaning or extubation success. One such parameter was the rapid shallow breathing index in which a value less than 105 could predict successful weaning. Another parameter, the maximum inspiratory pressure, could be used to estimate respiratory muscle function, which is associated with weaning success. What this review also noted was the importance of considering measures beyond respiratory functions. The review concluded that many other factors could impact ventilator weaning. These included psychological, nutritional, and renal functions, as well as neurological measures. The authors acknowledged the difficulty in utilizing only one or two of these measures. They suggested that scoring systems or protocols could be established to incorporate many of these factors into a comprehensive protocol that would have a predictive value for weaning and extubation success.

Another specific factor that was analyzed in many studies was the measurement of a cuff leak. This test involves deflating the cuff on the endotracheal tube and having the practitioner listen for air leaking around the cuff during the patient's breath cycle to assess for laryngeal edema (Kuriyama et al., 2020). In the systematic reviews and meta-analyses performed by Kuriyama et al. (2020) and Quintard et al. (2017), the measurement of the cuff leak was suggested to have some significance in the weaning process when determining if patients were appropriate for extubation. Kuriyama et al. (2020) noted that the use of the cuff leak test alone had only moderate sensitivity for the prediction of airway obstruction after extubation. Similarly, Quintard et al. (2017) suggested that the cuff leak be used (with weak evidence) to determine if patients were appropriate for extubation. It appears, however, that this single factor alone is unable to predict the success or failure of extubation.

Quintard et al. (2017) also recommend the assessment of a spontaneous breathing trial for patients. Although this is a common assessment performed for intubated patients, the authors again note that this is not a single predictor of extubation success. They note that many other factors can impact the success of extubation, and patients should be assessed for several other factors. One such factor that is often considered is the strength of the patient's cough. Duan et al. (2021) recommend measuring cough strength to help determine the risk of extubation failure. They suggest that a weak cough has moderate power for predicting extubation failure. With the wide variety of potential weaning parameters and measures, a combination of many of these measures may yield a more predictive model to assist in the decision-making to extubate a patient.

Protocolized Extubation

Having a single weaning parameter with the power to predict extubation success or failure may be elusive when considering the numerous confounding variables that can impact ventilator weaning. Many studies suggest using a broader set of criteria to evaluate patients for their potential ventilator liberation. In the Official Clinical Practice Guideline from the American Thoracic Society (Fan et al., 2017), the authors recommend utilizing an extubation protocol with the potential of reducing time on mechanical ventilation and length of stay in the ICU. Additionally, they suggest that with physician-driven ventilator management, there is often a wide variation in practice. They propose that having a protocol that can be automated or primarily driven by nursing or respiratory therapy may lead to a more consistent practice. Chan et al. (2018) also note that a nursing- or respiratory therapy-driven protocol in the setting of postoperative cardiac surgery patients was safe and could considerably reduce the time to extubation without increasing the rate of reintubation. Similarly, Cove et al. (2016) found that using an extubation protocol for postoperative cardiac surgery patients in the ICU could reduce the time to extubation in addition to decreasing the length of stay in the ICU and decreasing costs. In addition to reducing time on the ventilator and time in the ICU, the potential to reduce the rate of failed extubations is an important outcome. Bobbs et al. (2019) found that the use of an extubation checklist could reduce the rate of failed extubations in postoperative trauma patients in the ICU. In this study, the authors did find that there was an associated increase in ICU length of stay, which may have been due to patients not meeting the stipulations of the checklist which would prolong time on the ventilator. Although these studies focused on a somewhat specific patient population, similar themes can be observed across other studies.

A ventilator weaning and extubation checklist was developed and applied in the study by Nitta et al. (2019). The protocol included pre-assessments of the patients, assessments for extubation failure prevention, and reassessments after the patient was extubated. The authors suggest that this weaning protocol can prevent respiratory failure post-extubation, reduce reintubation rates, and reduce mortality.

With the wide variety of extubation protocols, often developed specifically for the study or the hospital, it is challenging to decide what protocols or scoring systems should be used in different hospital settings and which have the greatest capability of preventing or predicting extubation failure. Dehghani et al. (2016) sought to compare several standard scoring measures and protocols to evaluate the correlation with mortality, successful weaning and extubation, and length of stay in the hospital. Overall, the authors found that using a structured assessment or protocol could decrease the amount of failed extubations, shorten the time in the ICU, and reduce costs. Of the several different scoring systems examined, the authors reported that the Burns Weaning Assessment Protocol consisted of criteria beyond respiratory measures. The authors evaluated several studies focusing on the Burns Weaning Assessment Program and collectively found that a greater score was associated with extubation success and decreased time on the ventilator and in the hospital.

Modified Burns Wean Assessment Protocol

The modified Burns Wean Assessment Protocol is a comprehensive tool that guides the critical care clinician in the decision-making process surrounding the weaning and extubation of mechanically ventilated patients (Jiang et al., 2014). This 20-item protocol includes many factors beyond the traditional respiratory measurements and includes hemodynamics, nutrition, lab values, and body strength/endurance assessment. This protocol, and the original version (BWAP), have been studied and applied many times since its original development in 1991 and modification in 2014. Higher scores on this assessment have been correlated with shorter times on mechanical ventilation and fewer extubation failures.

In one study, researchers found that using the Burns Weaning Assessment Protocol increased the rate of successful ventilator weaning and reduced the frequency of extubation failure (Sepahyar et al., 2021). Researchers also suggested that this tool could be used as a method to help nurses engage in critical thinking in terms of ventilator weaning and clinical assessment. Furthermore, they suggested that using this type of extubation protocol would allow for a more consistent practice to evaluate weaning readiness rather than using one provider's opinion. Additionally, they concluded that a nursing assessment guided by this screening tool could accurately assess a patient's readiness to wean from the ventilator. In another study, Ghanbari et al. (2020) found that a nurse-led weaning protocol, using the Burns Weaning Assessment, led to shorter times on mechanical ventilation compared to the standard practice of physician-led weaning.

The m-BWAP also had positive results regarding successful ventilator weaning. The study that developed the original modification of this tool showed that it was an effective and predictive tool for patients who were on mechanical ventilation for over 21 days (Jiang et al. 2014). Also, this tool was found to be effective in predicting weaning success in patients who have been intubated for at least 48-72 hours (Abdelaleem et al., 2020; Jeong & Lee, 2018). The m-BWAP was used to assess patients' readiness for weaning at their initial spontaneous breathing trial and for patients with chronic respiratory comorbidities. Both trials suggested that the m-BWAP could be used to predict weaning success, but also that additional research should be performed in larger hospital systems.

An advantage of the m-BWAP is the specific parameters and cutoffs listed for the criteria. The original BWAP asks the question: Is the patient hemodynamically stable? (Burns et al., 1991) For these criteria on the m-BWAP, the assessment specifies that the patient should have a heart rate of less than 120 without certain arrhythmias and systolic blood pressure between 90 and 180 without the use of inotropes or vasopressors (Jiang et al., 2014). To provide clear parameters and unbiased data, the m-BWAP will be used in this project.

Strengths of Evidence

The literature reviewed here not only identifies individual weaning parameters that could be impactful when evaluating patients for extubation but provides evidence that following established weaning and extubation protocols is a safe and effective way to reduce time on the ventilator, length of stay in the ICU, and frequency of extubation failure. The American Thoracic Society supports the use of extubation protocols in their Official Clinical Practice Guidelines and suggests that nursing- or respiratory therapy-led weaning and extubation protocols can have a positive impact on patients' weaning and extubation times (Fan et al., 2017). There are several extubation protocols and scoring systems that have been studied and used successfully in a varied population of ICU patients. The Burns Weaning Assessment Program and its subsequent modification, m-BWAP, have been studied in several settings and found to be effective for predicting patients' success in ventilator weaning and reducing time on mechanical ventilation.

Weaknesses, Gaps, and Limitations of Evidence

Limitations identified from a review of the literature include the lack of large, multi-center, randomized controlled trials evaluating the m-BWAP. This design would be difficult to achieve, however, based on the difficulty of blinding the researchers in this setting. Many of the studies were performed in single ICU wards. Also, since early extubation is a focus of post-cardiac surgery patients, much of the literature was focused on this population. Barriers to the implementation of the m-BWAP may include the large number of variables nursing staff would have to evaluate on each patient. Additionally, since several variables in the Burns Wean Assessment are based on a subjective assessment, low inter-rater reliability could compromise the validity of using the BWAP. This potential limitation was not addressed in any of the studies reviewed.

One specific consideration to address is the fact that this tool has not been validated in patients with COVID-19. There have been studies that have evaluated extubation failure risk factors in patients with COVID-19, but the data on extubation is not vast and is continuously evolving (Anesi, 2022). For this reason, COVID-19-positive patients were not included in this project.

METHODS

Project Design

The use of a ventilator weaning and extubation protocol is a safe and effective method that can be used to prevent extubation failures, shorten time on mechanical ventilation, and aid practitioners in the extubation decision-making process (Nitta et al., 2019; Sepahyar et al., 2021). This quality improvement project was proposed to evaluate if the m-BWAP could be utilized as an effective tool for extubation decisions in this mixed-population ICU. A blinded retrospective approach was used to calculate the m-BWAP scores for previously intubated patients and determine if higher scores were correlated with successful extubations. The m-BWAP score of 60 normally is used as the threshold of appropriate (greater than or equal to 60) or inappropriate (below 60) for extubation (Jiang et al., 2014). In the context of this study, five of the criteria are not charted per their standard of care, so the extubation threshold was not used and the raw score was evaluated instead. This project reviewed preexisting data (inclusive of successful or unsuccessful extubation) from blinded patient data from electronic health records and the blinded data was entered into the m-BWAP scoring system. The m-BWAP items for each blinded patient record were scored and totals were calculated independently of the respective patient's success or failure of ventilator weaning while maintaining the confidentiality of the data collected. In a QI project, outcome measures allow the team to evaluate if the practice change is associated with the desired results (Institute for Healthcare Improvement [IHI], 2022).

Model for Implementation

The Institute for Healthcare Improvement's (IHI) Model for Improvement (MFI) recommends using the Plan-Do-Study-Act cycle (PDSA) to test potential improvements in the clinical setting to strive for improvements in patient safety (IHI, 2021).

Plan-Do-Study-Act (PDSA) Cycle

The Plan-Do-Study-Act (PDSA) cycle is a tool to test small changes within a setting and determine if the changes could be expanded to promote improvements (IHI, 2022). The PDSA cycle was used in this project to evaluate the modified Burns Wean Assessment Protocol on a small scale as a retrospective evaluation to determine if the protocol could be established as a consistent practice to aid in extubation decision-making.

Plan

This QI project evaluated pre-extubation m-BWAP scores of patients who have been extubated. The purpose of assessing the m-BWAP is to determine if it would be an effective tool to evaluate the eligibility of medically complex ICU patients for liberation from mechanical ventilation. To measure if this protocol has the potential for successful outcomes, patients who have already been extubated were scored using the m-BWAP during the pre-extubation period. Scores were evaluated in the context of whether or not the patient had to be reintubated during the 24 hours after extubation.

Do

This part of the project involved data collection on each of the patients. Patients from three hospitals, intubated during a two-month period, were selected. They were identified as having had a non-surgical airway added to their airway category on the electronic medical record. Their charts were reviewed for data required by the m-BWAP and those data were collected. Additionally, the following 24 hours post-extubation period were assessed to determine if the patient required reintubation during this time and that data was recorded.

Study

The "study" section of the cycle involves assessing the collected data and evaluating the results (IHI, 2022). For this project, the m-BWAP scores were compared to the success or failure of the extubation. The values were statistically analyzed using a t-test, a ROC analysis, and logistic regression to determine if higher or lower scores on the assessment are associated with weaning success or failure.

Act

In the "act" section of the cycle, conclusions from the "study" portion of the cycle were evaluated to determine if there are recommended changes that are appropriate to establish an effective and useful protocol for the units (IHI, 2022). In this project, data to assess specific elements of the protocol were not able to be extracted from the patient's chart. Thus, if the protocol were adopted in the future, additional charting elements would need to be added to aid in scoring these patients.

Setting and Stakeholders

HonorHealth's three Level 1 trauma centers include Osborn, John C Lincoln, and Deer Valley Medical Centers comprise the setting and stakeholders. Combined, they designate 131 ICU beds. The setting of this project was in these three ICUs. These ICUs have a mixed patient population including trauma, surgical, neurology, neurosurgical, and medical critically ill patients. Many patients required intubation in these ICUs and the decision for extubation was made by the critical care provider and executed by the respiratory therapist.

The Network Director of Critical Care Services provided authorization to implement this project in the ICU at HonorHealth Osborn (Appendix A). The key stakeholder included the network director and her permission for implementation was vital for the project's success.

Planning the Intervention

This QI project's focus was to retrospectively collect and evaluate data from patients who had been extubated in the three ICUs. The project investigator reviewed charts of eligible patients who had been intubated during the period from May 1 through June 30, 2022. Data retrieved included the required elements to calculate the m-BWAP (Appendix B) and the patient's extubation outcome in the 24 hours following the extubation. Other data outside of the parameters of the m-BWAP that were recorded for each patient included sex, length of time on mechanical ventilation, admitting diagnosis, the reason for intubation, the facility the patient was in, and the medical group of the provider who ordered extubation.

Participants and Recruitment

To be included in this project, patients in HonorHealth Osborn, JCL, and Deer Valley's ICUs must have been extubated from the period between May 1 through June 30, 2022, and have had a non-surgical airway added to the electronic health record (EHR). Patients who were intubated, but not extubated by June 29 (24 hours before the end of the project period) were not included. These were adult ICUs and only data from patients 18 and older were included. Patients with any diagnosis were included, except for current COVID-19 infection, self-extubations, terminal extubations, patients who died while on mechanical ventilation, or patients who were transferred to an outside facility before extubation. Patients were not recruited to participate as only their charts were reviewed retrospectively, and their care was not impacted by any part of this project.

Consent and Ethical Considerations

Safety and ethical considerations are essential to evaluate in any project that involves human participants. This project involved no patient intervention and only preexisting, blinded clinical data were used. All data were collected retrospectively, and patient care was not impacted. Before implementing this project, several steps were taken to ensure that patients were not negatively affected by this project. Both The University of Arizona and HonorHealth Institutional Review Boards (IRB) reviewed the project proposal to ensure ethical principles would be maintained prior to project implementation. This was a retrospective chart review and no consent was obtained. All patient identifiers were removed after the data collection was completed.

Data Collection

Data were collected by manual chart review from patient charts. Included patients were extubated during the specified two-month period of the project timeline. Data from 18 patients were included from each hospital. Of patients not eliminated due to exclusion criteria, those remaining were stratified into extubation failures and extubation successes from each hospital. All extubation failures identified were included from each hospital and the remaining 18 patients for each hospital were randomly selected using a random number generator. Data included were based on the m-BWAP (Appendix B) and dates of intubation, extubation, and possible re-intubation up to 24 hours post-extubation. Each question of the 20-element protocol was answered “yes” if the patient met the specified criteria, “no” if the patient did not meet the criteria, or “not assessed” if the information was not available. Patients were scored a “yes” or “no” if the information is available in the chart or “not assessed” if the information had not been charted. The data were gathered from the 24 hours preceding extubation, or the most recently available information as appropriate based on the m-BWAP protocol. The following 24 hours after extubation was evaluated to determine if the patient was reintubated (unplanned) or remained successfully extubated.

Data Analysis

Modified BWAP scores were tabulated following the scale scoring instructions. A score of “5” was assigned to all “yes” values and a score of “0” to all “no” values. If the information was not available in the chart, the item was not scored and was marked as “not assessed” unless otherwise specified on the m-BWAP protocol. The scores from each item were combined and the total calculated score was used in the analysis. These values were analyzed to determine if they predicted extubation outcomes. Five elements of the m-BWAP that were not charted at any of the facilities included general body strength and endurance condition, the ability of airway clearance, dynamic lung compliance, dynamic airway resistance, and maximal inspiratory pressure. Due to this missing information in the charting, no patient scored higher than the original 60-point extubation cutoff and the extubation cutoff value was not analyzed in the context of extubation decision-making. The probability of extubation success was associated with a continuous score. A receiver operating characteristic (ROC) analysis was performed to assess how the m-BWAP discriminates between successful and unsuccessful extubations. Logistic regression was used to test whether other variables including sex and age, in addition to m-BWAP score, were related to intubation success or failure. Demographic statistics for several variables, including sex, time on mechanical ventilation, the reason for intubation, and facility were collected and presented. Tables and graphs were used as necessary to display results. All statistical analysis was performed with IBM SPSS Statistics (Version 28).

RESULTS

There were 248 records provided for patients who were extubated during the time period between May 1, 2022, and June 30, 2022. Of the total records, those not excluded in the exclusion criteria included 18 patients from Deer Valley, 50 patients from John C. Lincoln, and 53 patients from Osborn. All extubation failures were included in the analysis. Of the remaining patients, all patients from Deer Valley were included and the remaining patients from John C. Lincoln and Osborn were randomly selected using a number generator to select a total of 18 patients from each hospital.

Sample Size and Demographics

A total of 54 patients were included in the analysis. Age, sex, duration of intubation, the reason for intubation, and the number of failed extubations for each hospital are displayed in Table 1.

Outcomes

There were three failed extubations and 51 successful extubations observed among all three hospitals during the study period. A t-test was used to assess the relationship between the m-BWAP and the extubation outcome groups. The difference between the mean m-BWAP scores was not significant at the 0.05 level ($t(52)=1.413$, $p=0.164$). The mean (standard deviation) m-BWAP score for extubation successes was 34.14 (9.859) and 26.00 (3.606) for the extubation failures. However, the t-test for unequal variances was significant, with p=0.03.

Table 1

Demographic Data

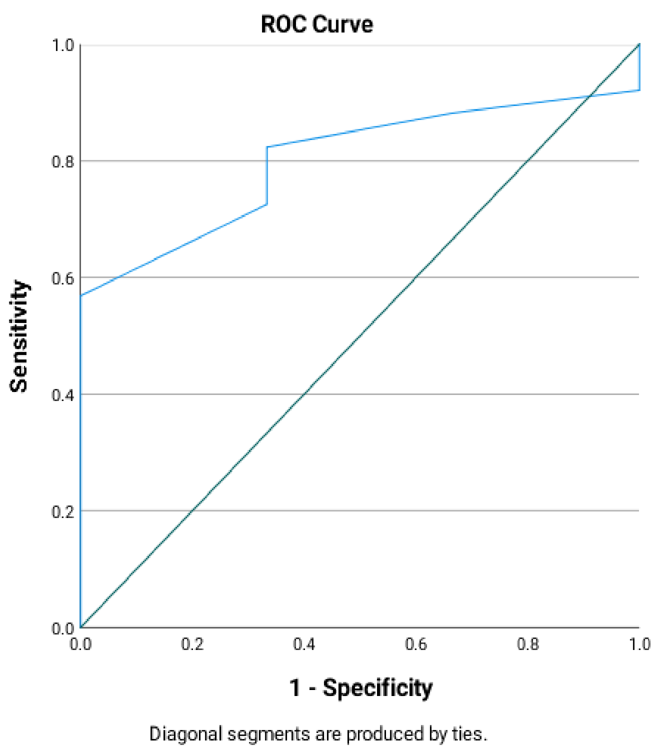
	Extubation Failure	**Extubation Success**	**Total**	**p**
N	3	51	54	
Age (years)[a]	68.67 (14.572)	52.43 (20.121)	53.33 (20.101)	0.176
Females (%)	66.7	33.3	35.2	0.240
Duration of Intubation (hours)[a]	57.53 (56.564)	57.35 (49.257)	57.36 (49.089)	0.995
Reason for Intubation:				0.989
Airway protection	1	16	17	
Cardiac arrest	0	1	1	
Respiratory distress	1	14	15	
Social	0	6	6	
Status epilepticus	0	1	1	
Surgery	1	13	14	
Facility:				0.347
Deer Valley	0	18	18	
John C. Lincoln	1	17	18	
Osborn	2	16	18	

[a] Mean value with standard deviation in parentheses

A ROC analysis was conducted to determine if m-BWAP would discriminate between the two outcome groups. The ROC curve appears in Figure 1. The ROC curve is a visual depiction of the discrimination between two groups on the basis of one or more variables. It plots the relationship between sensitivity (proportion of true positives) and 1 – specificity (proportion of false positives), therefore, both of these quantities are captured in a single measure. In this case, the two groups were the success or failure of extubation and the variable discriminating between the groups was the m-BWAP score. The diagonal line in the figure represents chance performance. The area under the ROC curve was 0.801 with a standard error of 0.081 and a 95% confidence interval of 0.642 and 0.960. The area under the curve was not significantly different from chance, p=0.081. However, the chance probability (0.5) is not contained in the 95% confidence interval.

Figure 1

ROC Analysis



Logistic regression using age, sex, and m-BWAP score as independent variables and intubation outcome (extubation success and extubation failure) as the dependent variable was conducted. None of these variables were significantly related to intubation outcome (Age p=0.454, sex p=0.219, and m-BWAP score p=0.220). Due to only three extubation failures during the project period, this project is not powered to detect statistically significant differences.

DISCUSSION

Summary

Extubation failures have serious negative repercussions including increased ICU length of stay and higher mortality rates (Maggiore et al., 2018). Clinical decision tools have been developed to decrease the rate of extubation failures in the ICU including the m-BWAP. Higher scores with this tool and its predecessor (BWAP) have been associated with extubation success and shorter times on mechanical ventilation. The use of the m-BWAP empowers clinicians in extubation decision-making (Abdelaleem et al., 2020; Dehghani et al., 2016; Jeong & Lee, 2018; Sepahyar et al., 2021).

The objective of this project was to determine if the m-BWAP would be a useful scale to employ in three of HonorHealth's ICUs by applying the scale to patients who had already been extubated and calculating whether higher scores were associated with extubation success and lower scores were associated with extubation failure. Overall, the results did not support using or not using the m-BWAP scoring due to the lack of statistical significance from the small size of the extubation failure group.

Interpretation

To analyze if scores from the m-BWAP were associated with extubation successes or failures, a t-test, ROC analysis, and logistic regression were performed. For the t-test, the association between the m-BWAP scores and the extubation outcome was not significant, but likely this was related to the small sample size of the extubation failure group. Perhaps, with a larger sample size, the difference between the groups would be significant as suggested by the significant test with unequal variances. The ROC analysis also demonstrated that the discrimination between the two outcome groups was not significantly different from chance; however, this also could be due to the small sample size as demonstrated by the even odds value (chance) not being contained in the 95% confidence interval. The logistic regression was also not significant when analyzing the multivariate relationship between age, sex, and m-BWAP scores to extubation outcome. The above analyses demonstrated that there was no statistical significance in any of these tests but would likely have significance if there were more observations in the extubation failure group.

Having a low extubation failure rate in this hospital system, although impressive, leads one to question if perhaps patients are remaining intubated for longer than needed for the treatment of their disease process. It is important to consider the repercussion of extended use of mechanical ventilation, including ventilator-induced lung injury, increased mortality, diaphragmatic injury, and ventilator-acquired pneumonia (Abdelaleem et al., 2020; Schepens et al., 2019). To get a full picture, future work should also include the number of self-extubation. Results from this study could be used for future studies at these facilities that would investigate the timing of spontaneous breathing trials with the intention of earlier liberation from mechanical ventilation.

Implications

Practice

Although the results of this project were not statistically significant, future research may demonstrate statistical significance for identifying patients with a higher risk of extubation failure using this protocol. In that event, an evidence-based case for integrating the m-BWAP into everyday practice in HonorHealth's ICUs could be supported. Nursing staff could use this protocol to advocate for their patients regarding their potential to be extubated or their need to remain intubated, as well as identify potential weaknesses in their care. With such a low rate of reintubations, it is possible that patients could have been extubated earlier thereby avoiding potential challenges resulting from longer than necessary intubation times. It may be useful to consider evaluating if this tool may be used to identify if patients could be safely extubated earlier.

Education

If this protocol were eventually found to be useful and effective in this care setting, staff from various disciplines would need to be educated on specific areas of charting that are needed to use the m-BWAP. There were inconsistencies in charting among clinicians, which made it more difficult to identify certain data points and resulted in omissions of data including the absence of measured blood gasses and chest x-rays, inaccurate measures of urinary output, discrepancies in target and measured caloric goals, and varying practices on reporting respiratory weaning parameters. If the m-BWAP were to be implemented, an educational program would need to be developed for nurses, respiratory therapists, healthcare providers, physical therapists, and dieticians to standardize target data entry so that data can more easily and accurately be extracted from the chart.

Research

Perhaps the greatest implication of this study is for additional research. This project provides a guide for future research to be performed using the project protocol. To procure sufficient data to yield statistical significance, increasing the length of the study period or adding data from other hospitals in the system should be considered.

Policy

Currently, there is no policy at HonorHealth regarding extubation protocols. If further research yielding statistically significant results determined that the m-BWAP could differentiate candidates for successful extubation from expected extubation failures, then it would be prudent to consider establishing a new policy that included this protocol.

Limitations

There were several limitations in this study that impacted the data collection process. The greatest limitation was the small number of extubation failures present during the designated study period. A longer study period may have increased the number of extubation failures that could have been evaluated, however, this would have taken additional time beyond initially proposed. Another limitation was the varying charting practices of the nurses, respiratory therapists, and other members of the healthcare team. The introduction of this protocol into the hospital would require education on necessary charting measures that should be added to the record needed by the protocol. Missing elements of the charting included specific activity milestones, the ability to cough sputum outside the airway, dynamic lung compliance, dynamic airway resistance, and maximal inspiratory pressure.

DNP Essentials Addressed

The eight DNP Essentials outline core competencies for doctoral nursing education (American Association of Colleges of Nursing [AACN], 2006). These Essentials provide a foundation for preparing DNP students to work in the advanced practice role. This DNP project addressed three of the eight DNP Essentials including Essential I, Essential II, and Essential III.

DNP Essential I: Scientific Underpinnings for Practice

DNP Essential I was demonstrated in this DNP project by evaluating a new extubation decision-making practice through the utilization of Kurt Lewin's Change Theory. The project coordinator was able to challenge the current extubation decision-making practice and evaluate if a new protocol would be effective to implement.

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

DNP Essential II was demonstrated by evaluating the current practice policy and using strategies to endorse change through quality improvement (AACN, 2006). Additionally, the project coordinator focused on improving the health outcomes of the target population.

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

DNP Essential III was demonstrated by transforming research into practice and expanding the body of knowledge surrounding the research topic (AACN, 2006). Furthermore, the research was evaluated for significance, and opportunities for further research were identified.

Conclusions

The m-BWAP is an extubation decision-making tool that has been successful in helping clinicians determine if patients are suitable for extubation. This project reviewed if this protocol would be an effective tool to use in the ICUs at HonorHealth Deer Valley, John C. Lincoln, and Osborn hospitals. A total of 54 patient charts were reviewed within the context of the m-BWAP protocol inclusive of measures such as hemodynamics, consciousness, respiratory parameters, and various lab values. Although only three extubation failures were available to analyze in the study period and results were not found to be statistically significant, the project did provide a framework for further research and future study of this protocol.

Plan for Sustainability

The PDSA cycle could be used to continue this project to achieve statistically significant results (IHI, 2022). In the "Act" portion of this project, it was found that the results were not statistically significant so no change to practice was recommended. To expand upon this project, it would be possible to continue to the "Plan" portion of the cycle and potentially increase the number of observations of extubation failures by expanding the study period to include more months of patient data.

Plan for Dissemination

The results of this project will be presented to HonorHealth ICU leadership and the HonorHealth Nursing Research Council. As the results of the project were not statistically significant at this time, the protocol is not recommended to be disseminated to the HonorHealth ICUs.

APPENDIX A

HONORHEALTH SITE APPROVAL LETTER/HONORHEALTH INSTITUTIONAL REVIEW BOARD APPROVAL LETTER/THE UNIVERSITY OF ARIZONA INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

HonorHealth Scottsdale Osborn Medical Center
7400 E. Osborn Rd.
Scottsdale, AZ 85251

June 16th, 2022

University of Arizona Institutional Review Board
c/o Office of Human Subjects
1618 E Helen St
Tucson, AZ 85721

Please note that Ms. Valerie Borgstrom, UA Doctor of Nursing Practice student, has permission of the HonorHealth Scottsdale Osborn Medical Center to conduct a quality improvement project at our facility for her project, "A Comprehensive Extubation Protocol to Prevent Extubation Failure."

Ms. Borgstrom will retrospectively review electronic medical records of patients who have been extubated after mechanical ventilation at HonorHealth Scottsdale Osborn Medical Center. Ms. Borgstrom's activities will be completed by November 2022.

Ms. Borgstrom has agreed to provide to my office a copy of the University of Arizona Determination before she reviews patients' electronic medical records. She will also present aggregate results to the unit director.

If there are any questions, please contact my office.

Signed,

Mary C. Poquette, DNP, RN, NEA-BC
Network Director
Critical Care Services
Nursing

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HONORHEALTH™

DATE:	11/07/2022
TO:	Valerie Borgstrom
FROM:	HonorHealth IRB (HIRB)
PROJECT TITLE:	A Comprehensive Extubation Protocol to Prevent Extubation Failure
STUDY #:	IRB-22-0061
SUBMISSION TYPE:	Initial Application
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	11/07/2022
REVIEW CATEGORY:	Exemption category 45 CFR 46.104(d) (4) Secondary research for which consent is not required: Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met: (i) The identifiable private information or identifiable biospecimens are publicly available; (ii) Information, which may include information about biospecimens, is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained directly or through identifiers linked to the subjects, the investigator does not contact the subjects, and the investigator will not re-identify subjects; (iii) The research involves only information collection and analysis involving the investigator's use of identifiable health information when that use is regulated under 45 CFR parts 160 and 164, subparts A and E, for the purposes of 'health care operations' or 'research' as those terms are defined at 45 CFR 164.501 or for 'public health activities and purposes' as described under 45 CFR 164.512(b); or (iv) The research is conducted by, or on behalf of, a Federal department or agency using government-generated or government-collected information obtained for nonresearch activities, if the research generates identifiable private information that is or will be maintained on information technology that is subject to and in compliance with section 208(b) of the E-Government Act of 2002, 44 U.S.C. 3501 note, if all of the identifiable private information collected, used, or generated as part of the activity will be maintained in systems of records subject to the Privacy Act of 1974, 5 U.S.C. 552a, and, if applicable, the information used in the research was collected subject to the Paperwork Reduction Act of 1995, 44 U.S.C. 3501 et seq.

Thank you for your submission of NEW PROJECT materials for this project. The HonorHealth Institutional Review Board has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

The following items were included in the review of this submission:

Type	**Description**	**Version #**	**Date**
Document	Borgstrom Data Collection Sheet.pdf	1	09/30/2022
Protocol	Borgstrom DNP Project	1	09/30/2022

We will retain a copy of this correspondence within our records.

If you have any questions, please contact Julie Washington at 480-323-3071 or jwashington@honorhealth.com. Please include your project title and study number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within HonorHealth IRB (HIRB)'s records.

University of Arizona IRB
845 N Park Ave., Suite 537A
Tucson, AZ 85719
Fax: 520-621-9810
VPR-IRB@arizona.edu

ACKNOWLEDGEMENT OF AN EXTERNAL IRB UPDATE

January 31, 2023

Dear Valerie Borgstrom:

On 1/31/2023, the IRB Office reviewed the updated information for the following study that is relying on an external IRB as the IRB of record:

Site Information	
Type of Review:	IRB Site
Site Name:	Comprehensive Extubation Protocol
IRB Submission ID:	STUDY00002152
Site Investigator:	Valerie Borgstrom
Additional Site Funding:	None
Site Documents Reviewed:	• Advisor Attestation, Category: Institutional Approval; • Attestation for Scientific Review and Department Review, Category: Institutional Approval; • Data Collection Sheet, Category: Other; • HonorHealth IRB Approval.pdf, Category: Other; • PI CV, Category: CV; • Protocol, Category: Other; • Revised 12.14.22 Borgstrom IRB Protocol for Projects Using External IRBs.docx, Category: IRB Protocol;
Study Information	
Study Title:	A Comprehensive Extubation Protocol to Prevent Extubation Failure
IRB Parent Protocol ID:	STUDY00002152
Study Sponsor:	None
Study Prime Sponsor:	None
IND, IDE or HDE:	None

This notification serves to acknowledge the updates you provided for the above listed study. If not already submitted, you may be required to also submit these updates to HonorHealth.

THE UNIVERSITY OF ARIZONA
Research
Innovation & Impact

University of Arizona IRB
845 N Park Ave., Suite 537A
Tucson, AZ 85719
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VPR-IRB@arizona.edu

The University of Arizona maintains a Federalwide Assurance (FWA) with the Office for Human Research Protections (OHRP) (FWA #00004218). All research procedures should be conducted according to the approved protocol and policies and guidance of the IRB of record. Please refer to Guidance *Investigators Responsibility after IRB Approval, Reporting New Information,* and *Single IRB Review*.

As a reminder, please promptly notify the local IRB Office upon:

1. Modification in cases of:
   a. Key personnel changes
   b. Alteration of Banner required consent language
2. Report any **local** unanticipated problems involving risks to participants or others
3. Notification that HonorHealth has renewed its approval at continuing review
4. Closure of the study

We value your feedback and would appreciate you taking the time to complete our survey about your experience with the IRB staff: https://uarizona.co1.qualtrics.com/jfe/form/SV_ehQ04WxNA06b42i.

If questions arise at any time during your study, please email the general IRB inbox at VPR-IRB@arizona.edu.

APPENDIX B

EVALUATION INSTRUMENTS (MODIFIED BWAP SCORING)

	Item	Description	Definitions
1	Age	<65 years old	5 points if the age is less than 65 years
2	Cardiac function	Without heart failure	0 points if the patient has a clinical diagnosis of heart failure with LVEF less than 35%, otherwise 5 points
3	Haemodynamic status	Stable heart rhythm	5 points if the heart rate is less than 120/min, variation is less than 20% and without history of VT/Vf or type II second degree or third degree AV block in the last one week
4		Stable blood pressure	5 points if systolic blood pressure is between 90 and 180 mm Hg, variation is less than 20% and without use of inotropic agents or vasopressors
5	Metabolic rate	Free from factors that will increase or decrease metabolic rate	5 points if body temperature is between 35.5 to 38.0°C, without active infection (without antibiotic use or infection improving after antibiotic used for more than 5 days), seizure activity in the last one week or uncontrolled hypo- or hyper-thyroidism
6	pH	Stable arterial blood gases pH	5 points if the patient has no acidaemia or alkalaemia (pH is between 7.30 and 7.45)
7	PaO_2 and $PaCO_2$	Stable PaO_2 and $PaCO_2$	5 points if the patient's PaO_2 is more than 60 mm Hg under low-level positive end-expiratory pressure (≤5 cm H_2O) and low fraction of inspired oxygen (≤40%) used and $PaCO_2$ is less than 55 mmHg
8	CXR appearance	Stable pulmonary infiltration and pleural effusion	5 points if the patient has improving pulmonary infiltrates and/or pleural effusion with a total area ≤25%
9	Consciousness	Well consciousness (1, 3 or 5 points)	Glasgow Coma Scale: 1 point if less than 6, 3 points if between 6 and 10, 5 points if more than 10
10	Electrolyte imbalance	Stable sodium, potassium, calcium and phosphate concentration	5 points if serum sodium, potassium, calcium and phosphate are all within normal range (sodium: 135–146 mmol/L, potassium: 3.5–5 mmol/L, total calcium: 8.6–10.2 mg/dL, phosphate: 2.7-4.5 mg/dL)
11	Hydration	Stable fluid status	5 points if urine output is more than 1500 mL per day or cumulative fluid is not more than 1500 mL in the past 3 days (after excluding insensible loss)
12	Nutrition	Well nutrition status	5 points if enteral feeding amount is more than 25 kcal/kg/day or serum albumin level is more than 3 g/dL
13	Activity	General body strength and endurance condition	5 points if the patient can make antigravity movements of the upper and lower limbs 10 times successively
14	Airway clearance	Ability of airway clearance	5 points if the patient has the ability to cough sputum outside the artificial airway
15	Secretion	Amount and consistency of secretion	5 points if the secretion is thin and scant (defined as need of sputum suction not more than once within 2 hours)
16	Weaning index	Well LCs	5 points if dynamic lung compliance is ≥25 mL/cm H_2O
17		Low Raw	5 points if dynamic airway resistance is ≤15 cm H_2O/L/S
18		Well P_{Imax}	5 points if maximal inspiratory pressure is ≤20 cm H_2O
19		Low RSBI	5 points if rapid-shallow breathing index is ≤105/L
20		Appropriate MV	5 points if minute ventilation is between 2 and 10 L/min

The score in each of the 20 items ranges from 0 to 5 points (0 points if the patients' conditions do not completely meet the description) except for the item of consciousness (1, 3 or 5 points according to the description in the Table).

AV, atrioventricular; CXR, chest X-ray; LCs, lung compliance; LVEF, left ventricle ejection fraction; MV, minute ventilation; $PaCO_2$, partial pressure of arterial carbon dioxide; PaO_2, partial pressure of arterial oxygen; P_{Imax}, maximal inspiratory pressure; Raw, airway resistance; RSBI, rapid shallow breathing index; Vf, ventricular fibrillation; VT, ventricular tachycardia.

APPENDIX C

CHART AUDIT FORMS

Item	Variable Name	Description	Score
Patient Number	Patient#	Assigned patient number	1, 2, 3…
Hospital	HospName	Name of hospital	O = Osborn JCL = John C Lincoln DV = Deer Valley
Medical Service	MedServ	Extubation ordering physician group	CC = Critical Care T = Trauma
Admitting Diagnosis	AdmDiag	Admitting Diagnosis	Free text
Reason for Intubation	ReasonIntubation	Reason for Intubation	Free text
Time on Mechanical Ventilation	VentTime	Number of hours on mechanical ventilation	0+
Number Intubation	NumInt	How many times intubated during study period	1+
Sex	Sex	Sex	M = Male F = Female O = Other
m-BWAP: Age	MBWAP1	<65 years old	0 = greater than or equal to 65 years 5 = less than 65 years
m-BWAP: Cardiac function	MBWAP2	Cardiac function: without heart failure	0 = clinical diagnosis of heart failure with LVEF less than 35% 5 = otherwise
m-BWAP: Hemodynamic status – stable heart rhythm	MBWAP3	Hemodynamic status: stable heart rhythm	0 = otherwise 5 = heart rate is less than 120/min, variation is less than 20% and without history of VT/Vf or type II second degree or third-degree AV block in the last one week
m-BWAP: Hemodynamic status – stable blood pressure	MBWAP4	Hemodynamic status: stable blood pressure	0 = otherwise 5 = systolic BP 90 and 180 mm Hg, variation is less than 20% and without use of inotropic agents or vasopressors
m-BWAP: Metabolic rate	MBWAP5	Free from factors that will increase or decrease metabolic rate	0 = otherwise 5 = body temperature is between 35.5 to 38.0°C, without active infection (without antibiotic use or infection improving after antibiotic used for more than 5 days), seizure activity in the last one week or uncontrolled hypo- or hyper-thyroidism

Item	Variable Name	Description	Score
m-BWAP: pH	MBWAP6	Stable arterial blood gases pH	0 = otherwise 5 = no acidemia or alkalemia (pH is between 7.30 and 7.45)
m-BWAP: PaO_2 and $PaCO_2$	MBWAP7	Stable PaO_2 and $PaCO_2$	0 = otherwise 5 = PaO_2 is more than 60 mm Hg under low-level positive end-expiratory pressure (≤5 cm H_2O) and low fraction of inspired oxygen (≤40%) used and $PaCO_2$ is less than 55 mmHg
m-BWAP: CXR appearance	MBWAP8	Stable pulmonary infiltration and pleural effusion	0 = otherwise 5 = improving pulmonary infiltrates and/or pleural effusion with a total area ≤25%
m-BWAP: Consciousness	MBWAP9	Well consciousness (GCS)	1 = GCS less than 6 3 = GCS between 6 and 10 5 = GCS more than 10
m-BWAP: Electrolyte imbalance	MBWAP10	Stable sodium, potassium, calcium, and phosphate concentration	0 = otherwise 5 = serum sodium between 135-146 mmol/L, potassium between 3.5-5 mmol/L, total calcium between 8.6-10.2 mg/dL, and phosphate between 2.7-4.5 mg/dL
m-BWAP: Hydration	MBWAP11	Stable fluid status	0 = otherwise 5 = urine output is more than 1500 mL per day or cumulative fluid is not more than 1500 mL in the past 3 days (after excluding insensible loss)
m-BWAP: Nutrition	MBWAP12	Well nutrition status	0 = enteral feeding amount is less than 25 kcal/kg/day or serum albumin level is less than 3 g/dL 5 = enteral feeding amount is more than 25 kcal/kg/day or serum albumin level is more than 3 g/dL
m-BWAP: Activity	*item not included due to lack of charting	General body strength and endurance condition	0 = patient cannot make antigravity movements of upper and lower limbs 10 time successively 5 = patient can make antigravity movements of the upper and lower limbs 10 times successively
m-BWAP: Airway clearance	*item not included due to lack of charting	Ability of airway clearance	0 = patient cannot cough sputum outside the artificial airway 5 = patient has the ability to cough sputum outside the artificial airway

Item	Variable Name	Description	Score
m-BWAP: Secretion	MBWAP13	Amount and consistency of secretion	0 = otherwise 5 = the secretion is thin and scant (defined as need of sputum suction not more than once within 2 hours)
m-BWAP: Weaning index – well LCs	*item not included due to lack of charting	Well LCs	0 = dynamic lung compliance < 25 mL/cm H_2O 5 = dynamic lung compliance is ≥25 mL/cm H_2O
m-BWAP: Weaning index – low Raw	*item not included due to lack of charting	Low Raw	0 = dynamic airway resistance is >15 cm H_2O/L/S 5 = dynamic airway resistance is ≤15 cm H_2O/L/S
m-BWAP: Weaning index – Well P_{Imax}	*item not included due to lack of charting	Well PImax	0 = maximal inspiratory pressure is >20 cm H_2O 5 = maximal inspiratory pressure is ≤20 cm H_2O
m-BWAP: Weaning index – Low RSBI	MBWAP14	Low RSBI	0 = rapid-shallow breathing index is > 105/L 5 = rapid-shallow breathing index is ≤105/L
m-BWAP: Weaning index – Appropriate MV	MBWAP15	Appropriate MV	0 = minute ventilation is less than 2 or greater than 10 L/min 5 = minute ventilation is between 2 and 10 L/min

Adapted from Jiang et al., 2014

APPENDIX D

PROJECT TIMELINE

Completion Date	Planning	Pre-implementation	Implementation	Evaluation
June 10, 2022	Submit proposal to project chair			
June 15-20, 2022		Make changes to proposal		
June 21, 2022		Proposal approval from chair		
June 30, 2022		Proposal Defense Presentation		
July 1-22, 2022	Revision to proposal per committee recommendations			
September 28, 2022		HonorHealth Nursing Research Council Presentation		
September 30, 2022		Submit HonorHealth IRB documents		
November 7, 2022		Obtain HonorHealth IRB approval		
November 11, 2022		Submit University of Arizona IRB documents		
January 31, 2023		Obtain University of Arizona IRB approval		
February 8-March 11, 2023			Intervention: Chart review	
March 14-16, 2023				Analyze Data
April 12, 2023				Final Defense Presentation of project results

APPENDIX E

LITERATURE REVIEW GRID

Project Question: Is the retrospective application of an extubation protocol associated with patients who have had successful or failed extubations in the medical ICU?

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
Abdelaleem et al., 2020	Value of modified Burns Wean Assessment Program scores in the respiratory intensive care unit: An Egyptian study.	Observational study	In patients with respiratory diseases, m-BWAP scores were higher in patients who had successful ventilator weaning compared to those patients with unsuccessful weaning.	The findings from this study support the use of the m-BWAP scoring system to assess the potential for successful extubations.
Baptistella et al., 2018	Predictive factors of weaning from mechanical ventilation and extubation outcome: A systematic review	Systematic review	There are many parameters and scores that can predict extubation outcomes. Rapid spontaneous breathing index (RSBI) is the most studied and relied upon parameter. Measures not related to respiratory function can predict extubation outcome.	This systematic review gives guidance on what parameters can be predictive to ventilatory weaning success and may provide guidance for extubation parameters in this project.
Bobbs et al., 2019	Decreasing failed extubation with the implementation of an extubation checklist	Retrospective study	Implementation of an extubation checklist decreases rates of failed extubation. However, this checklist did show an increase in ICU length of stay, but no difference in ventilator days or hospital length of stay.	Having an extubation checklist or list of parameters is associated with decreased rates of failed extubation which is part of the purpose of the project.
Burns et al., 1991	Weaning for mechanical ventilation: A method for assessment and planning	Literature review/protocol development	This article describes the development of the Burns Weaning Assessment Protocol and the multitude of factors that are associated with successful ventilator weaning.	This is the weaning assessment that the m-BWAP was based on.
Chan et al., 2018	A multidisciplinary protocol-driven approach to improve	Retrospective study	A bedside provider-led protocol reduced overall intubation times and increased rate of early	A protocolized extubation protocol can improve extubation rates without increasing reintubation rates.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
	extubation times after cardiac surgery		extubation without an increase in reintubation of mortality.	
Cove et al., 2016	Multidisciplinary extubation protocol in cardiac surgical patients reduces ventilation time and length of stay in the intensive care unit	Retrospective before and after observation study	The addition of an extubation protocol lead to a 35% decrease in time to extubation and decreased ICU length of stay by one day.	A protocolized weaning can decrease time spent on mechanical ventilation and time in the ICU. This supports the use of an extubation protocol.
Dehghani et al., 2016	An overview of the predictor standard tools for patient weaning from mechanical ventilation	Review study	This paper reviews several different studies that utilize a variety of extubation weaning protocols. The use of these tools reduces ICU length of stay, time on the ventilator, failed extubation, and associated costs.	This article supports the use an extubation protocol and reviews several scoring systems and weaning tools and their impact on weaning times.
Duan et al., 2021	Predictive power of extubation failure diagnosed by cough strength: A systematic review and meta-analysis	Systematic review and meta-analysis	Cough peak flow has moderate diagnostic power to predict extubation failure.	This article explores one of many important weaning parameters that could potentially be used in a greater ventilator weaning protocol.
Fan et al., 2017	Liberation from mechanical ventilation in critically ill adults. An official ATS/ACCP Clinical Practice Guideline	Practice Guideline	Duration of mechanical ventilation was reduced for patients when extubation readiness was assessed with a ventilator liberation protocol	Although there are many guidelines offered in this clinical practice guideline, the suggestion that an extubation protocol can limit the duration of mechanical ventilation is supportive of the project.
Ghanbari et al., 2020	Comparison between a nurse-led weaning protocol and a weaning protocol based on physician's clinical judgment in ICU patients	Quasi-experimental study	A nursing-led weaning protocol reduced the amount of time on mechanical ventilation compared to physician-led weaning.	Having a protocolized extubation led by nursing could lead to shorter mechanical ventilation time when compared to standard practice of having physicians be solely responsible for this decision.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
Jeong & Lee, 2018	Clinical application of modified Burn Wean Assessment Program scores at first spontaneous breathing trial in weaning patients from mechanical ventilation.	Prospective observational study	Modified BWAP scores can be used to predict extubation success.	This study demonstrated the clinical efficacy of the m-BWAP score in predicting successful extubations, showing the utility of this type of scoring system.
Jiang et al., 2014	Predicting weaning and extubation outcomes in long-term mechanically ventilated patients using the modified Burns Wean Assessment program scores	Retrospective cohort study	Modified BWAP scores can be used to predict extubation outcome in long term mechanically ventilated patients	This is the protocol that will be used for this project and that many of the other studies listed are based on.
Kuriyama et al., 2020	Performance of the cuff leak test in adults in predicting post-extubation airway complications: A systematic review and meta-analysis	Systematic review and meta-analysis	Testing the cuff leak on intubated patients before extubation has excellent specificity but moderate sensitivity for post-extubation airway obstruction.	Testing a cuff leak is an important part of an extubation protocol and should be included as part of the project protocol.
Nitta et al., 2019	A comprehensive protocol for ventilator weaning and extubation: A prospective observational study	Prospective observational cohort study	Use of a specific extubation protocol (developed for this study) reduced post-extubation respiratory failure, reintubation rates, and hospital mortality.	The protocol developed in this study will act as a guideline for the protocol in the project.
Quintard et al., 2017	Intubation and extubation of the ICU patient	Practice guideline	Spontaneous breathing trial decrease risk of extubation failure (but inadequate as the only test). Cuff leak test should be performed before extubation.	The guidelines offer elements that should be considered in the protocol for the project.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
Sepahyar et al., 2021	The effect of nursing interventions based on Burns Wean Assessment Program on successful weaning from mechanical ventilation: A randomized controlled trial	Randomized controlled trial	Successful ventilator weaning was associated with higher BWAP scores. The use of BWAP score reduced number of re-intubations	The BWAP is a tool that may have success in the intended ICU setting in regard to reducing re-intubation rates and having increased successful extubations.

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