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Ventilator Weaning Protocols: Influencing Outcomes and Promoting Success

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Ventilator Weaning Protocols: Influencing Outcomes and Promoting Success

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Ventilator Weaning Protocols: Influencing Clinical and Practice Outcomes

Ventilator management is a form of life-support that is often required for critically ill patients. It is estimated that more than 90% of critically ill adults will require mechanical ventilation while they are in the intensive care unit (Meade et al., 2001). Duration of mechanical ventilation varies and can depend on many factors such as diagnosis, comorbidities, or underlying infections. Physicians, nurses, and respiratory therapists play an important role in determining when these patients are ready to wean or come off of mechanical ventilation.

The American College of Chest Physicians Consensus Conference on Mechanical Ventilation has defined weaning as the gradual reduction of ventilator support and its replacement with spontaneous ventilation (Kollef et al., 1997). As soon as patients become stable, the practitioner's attention should change to promoting methods that ensure early ventilator liberation. The process of weaning patients from mechanical ventilation can account for almost 40% of the total duration of mechanical ventilation. The transition to ventilator liberation is often complex, requiring skilled assessment and planning by a multidisciplinary team. Unfortunately, the systems used in most ICUs are not conducive to collaborative care planning. (Henneman, et al., 2002).

Weaning patients from mechanical ventilation can be complicated. Each patient responds differently to the process and it becomes even more problematic when there is a lack of continuity among medical staff and no consensus on weaning technique (Crocker, 2002). Prolonged mechanical ventilation can increase ICU and hospital length of stay resulting in increased healthcare costs while exposing patients to unnecessary risks like mortality, ventilator-associated pneumonia (VAP), airway trauma, increased need for sedation, and decreased satisfaction among staff, patients, and patients' families (McLean, et al. 2006).

The value of removing the ventilator as soon as possible must be balanced against the risks of premature withdrawal, which include difficulty in reestablishing an airway, ventilator muscle fatigue, compromised gas exchange, and increased morbidity and mortality rates (MacIntyre, 2004). One of the most important aspects of ventilator care is assessing when the patient is ready to begin weaning and to liberate them from the ventilator as soon as possible.

Weaning patients from mechanical ventilation has typically been a responsibility of attending physicians or intensivists. Clinical judgment is not perfect and unfortunately, the systems used in most ICUs to communicate a patient's progress and plan of care are not conductive to collaborative care planning (Henneman et al., 2002). Doctors tend to underestimate the probability of successfully stopping mechanical ventilation and predictions, based on judgment alone, have low sensitivity and specificity (Blackwood et al., 2011). The duration of mechanical ventilation, and most notably of the weaning period, can be shortened by using a systematic approach for reducing the level of assistance and testing the possibility of resuming spontaneous breathing (Lellouche et al., 2006). Discontinuing mechanical ventilation in a safe and timely manner should lead to better outcomes for patients and clinicians alike, and any strategies that assist early discontinuation should be thoroughly evaluated (Blackwood et al., 2011).

Ventilator weaning protocols (VWPs) are a low-maintenance, inexpensive, and efficient method for hastening ventilator discontinuation but their success is highly influenced by the practice of the multidisciplinary team. The first section of this literature review will compare weaning methods using VWPs vs. non-standardized methods and identify what effect each has on clinical outcomes for adult patients in an ICU. Probably more important than the protocol is the means in which it is implemented. A lack of continuity amongst physicians, nursing, and

respiratory therapists can lead to the failure of event the best protocols. The last section of this review will examine methods that increase compliance and utilization of VWPs in an effort to decrease duration of mechanical ventilation.

An online search of keywords like “weaning protocols”, “standardized weaning protocols”, and “weaning from mechanical ventilation” produced a variety of trials and literature reviews. Nine of these studies were selected because they focused on promoting clinical outcomes by using a VWP vs. non-standardized approaches. This study population included adult patients in the ICU. Another nine studies were selected because they were dedicated to identifying practices that influenced or inhibited the success of VWPs. The population for these studies included members of the multidisciplinary team consisting of physicians, nurses, and respiratory therapists.

Outcomes not addressed in the following sections are available in the corresponding appendices at the end of the paper. The educational portion of this paper will discuss methods for implementing and maintaining a successful VWP and give examples of how a VWP can be implemented in an adult ICU.

Effect of Protocols of Clinical Outcomes

Duration of Mechanical Ventilation

The complications associated with mechanical ventilation seem to be directly related to the duration of mechanical ventilation. Duration of mechanical ventilation is defined as the time between the initiation of mechanical support to meeting ventilator discontinuation criteria (Marelich et al., 2000). Duration of mechanical ventilation is so closely tied to patient outcomes that all nine studies reviewed (Blackwood et al, 2011; Ely et al., 1999; Esteban et al., 1995; Gaafar et al., 2012; Grap et al., 2003; Kollef et al., 1997; McLean et al., 2006; & Smyrnios et al.,

2002) focused on it as a primary clinical outcome. The majority of these studies compared the effect of protocolized weaning vs. non-protocolized weaning on the duration of mechanical ventilation.

Four of the studies Gafaar et al. (2012); Grap et al. (2003); Kollef et al. (1997); Marelich et al. (2000) compared protocol-directed weaning with physician-directed weaning and found that protocol-directed weaning significantly reduced the duration of mechanical ventilation (24h, 33.6h, 32.6h, and 69h respectively). Smyrnios et al. (2002) compared the effects of protocolized weaning over a three-year period and found a significant improvement in mean ventilator days per patient (23.9 days in year one to 17.5 days in year three; $p = 0.004$). McLean et al. (2006) found that weaning via protocol reduced total duration of mechanical ventilation from 86.0 hours to 70.8 hours when compared to physician-directed weaning but the results were not significant ($p = 0.20$).

Blackwood et al., (2011) conducted a systematic review of ten trials and found that protocolized weaning, when compared with physician-directed weaning, significantly reduced duration of mechanical ventilation by 25% (mean log -0.29, 95% CI -0.5 to -0.09; $p = 0.006$). Ely et al. (1999) compared protocol-directed weaning managed by respiratory therapist to physician-directed weaning and found that protocolized weaning reduced total weaning time but did not significantly reduce duration of mechanical ventilation. In another unique study, Esteban et al. (1995) compared four methods of weaning patients using VWPs from mechanical ventilation were compared by Esteban et al. (1995) and found that a once daily spontaneous breathing trial (SBT), a method that assesses patients ability to breath on their own, via either C-PAP or T-tube ventilation led to ventilator liberation within 24 hours; three times more quickly

than intermittent mandatory ventilation, pressure-support ventilation, and intermittent SBTs (3d, 2d, & 2d respectively).

ICU Length of Stay

In the current climate of limited availability of intensive care beds, maximizing the use of limited intensive care resources is an important goal (Blackwood et al., 2001). In addition to decreasing rates of VAP, early liberation from mechanical ventilation can also shorten ICU and hospital length of stay (Shorr, 2003). Eight trials reviewed by Blackwood et al. focused on the effect of VWPs on ICU/hospital length of stay. None of the trials were able to show a significant correlation between VWPs and a reduction in overall hospital LOS. However, two of these trials (Krishnan et al., 2004; Simeone et al., 2002) found that using VWPs led to a reduction in ICU LOS. Although the remaining six trials by Ely et al., (1996); Namen et al., (2001); Navalesi et al., (2008); Rose et al, (2008); Piotto et al., (2010); & Stahl et al., (2009) did not show a significant reduction in ICU LOS, the pooled estimate was significant, corresponding to an average percentage difference in mean of -10% (-19% to -2%) (Blackwood et al., 2011).

Kollef et al. (1997) found that weaning via protocol reduced hospital length of stay from 14.2 days to 12.7 days but the findings were not significant ($p = 0.517$). Grap et al. (2003) also found a reduction in ICU length of stay (8.62 days to 7.93 days; $p = 0.29$).

Smyrnios et al. (2002) did show significant improvements in ICU and hospital length of stay with the use of a VWP. This study measured the effect of a VMP over time. Data was collected three times: before VWP implementation, one year after implementation, and two years after implementation of a VWP. When comparing year one to year three, it was found that VWPs decreased ICU and hospital length of stay (30.5 days to 20.3 days and 37.5 days to 20.6 days respectively; $p < 0.0005$). Although most of the trials reviewed did not show a significant effect

on ICU/hospital length of stay the research suggests that there were trends towards reduction in both settings and no negative effects on length of stay.

VAP

One of the most common complications of prolonged mechanical ventilation is VAP. VAP is a type of nosocomial or hospital-acquired pneumonia that can develop in a patient that has been on the ventilator for more than 48 hours. The incidence of VAP is 8-28% among patients that require mechanical ventilation and most experts agree that 20-30% of patients diagnosed with VAP will die as a result of the infection. Each case of VAP is associated with a direct cost of nearly $50,000. Adding to the pressure to eliminate cases of VAP, the Centers for Medicaid and Medicare Services (CMS) has announced that they may cease to reimburse hospitals for the costs associated with developing and treating VAP (Bird et al., 2010).

Patients who are ventilator dependent and contract VAP usually remain in the ICU requiring specialized care. Gaafar et al., (2000); Marelich et al., (2000) and McLean et al., (2006) identified VAP as the primary clinical outcome. In their study comparing protocolized weaning with physician-directed weaning, Gaafar, T., El-salam, A., Tawfeed, M., Gumae, E., & Mohammed, A. (2000) found that protocolized weaning significantly decreased the rate of ventilator-associated pneumonia ($p = 0.036$). Marelich et al. (2000) compared the effect of VWPs on adults in a trauma and MICU. Their study found that VWPs significantly reduced rates of VAP among trauma patients ($p = 0.061$, χ^2) while showing a positive effect on VAP among MICU patients although the results were not significant ($p = 0.100$, χ^2). Another study by McLean, S., Jensens, L., Schroder, D., Gibney, N., & Skjodt, N. (2006, May) showed that introducing a VWP reduced rates of VAP from 43% to 22%.

Mortality

In-hospital mortality rates among mechanically intubated patients are is nearly 44%. These numbers are much higher in populations with multiple comorbidities or that suffer from complications of mechanical ventilation like VAP or ventilator-associated lung injuries (Vasilyev, S., Schaap, R., & Mortensen, J. 1995). Ethical issues prohibit randomized controlled trials that directly influence mortality so there are very few trials related to ventilator protocols and their effect on mortality as a primary outcome. However, there are a few studies prospective studies that mention mortality as a secondary outcome. Gaafar et al. (2012) noticed a significant reduction in ICU mortality with the initiation of a VWP (57.5% before implementation and 28.6% after implementation; $p < 0.001$). Smyrnios et al. (2002) also noted a decline in mortality rates over a three-year period (32% to 28%, $p = 0.062$) after implementing a VWP but the results were not significant.

Cost

ICU patients cost nearly three times that of floor patients, with two thirds of the costs associated with the ICU portion of the stay alone, nearly $2,300 per ICU day; additionally, Medicare reimburses less for patients in the ICU (Cooper, 2004). This review has shown that VWPs can help reduce duration of mechanical ventilation and length of stay so it is no surprise that they can positively affect cost. Ely et al., (1999); Kollef et al., (1997); and Smyrnios et al., (2002) focused on hospital costs as a primary outcome. Ely et al. (1999) found that the positive effects of VWPs could lower cost of ICU care by nearly $5,000 per patient. Similarly, Kollef et al. (1997) showed that protocol-directed weaning created a hospital cost savings of nearly $129,000 per year when compared to physician-directed weaning. Smyrnios et al. (2002) also

found that weaning per protocol can generate a hospital cost savings of $3.4 million over a three-year period.

Practice Outcomes that Influence Protocol Success

Not only are VWPs superior to physician-directed weaning, they are also a highly effective means of improving care and controlling costs associated with critically ill patients. However, for VWPs to succeed, they must be managed properly. Design, education, implementation and evaluation are all very important steps in the formation of any protocol. Each step must be carried out appropriately for the protocol to succeed. The following section reviews literature that has identified practice outcomes that promote the success of VWPs.

The Multidisciplinary Team

Bruton, A., & McPherson, K. (2004) investigated the process of changing clinical practice with the implementation of a VWP in a regional general hospital. A multidisciplinary team was created to create the VWP and help facilitate practice change. The team used a hybrid of Proscha and Diclemente's Transtheoretical Model to introduce changes to weaning practices in the ICU. This model provides strategies to address barriers to change: precontemplation/contemplation, preparation/action and maintenance. The staff view's towards the weaning process was assessed before implementation. After implementation of the protocol, the team identified certain obstacles that created barriers to change and identified means to overcome these obstacles. The team evaluated the process in two ways. First, through questionnaires distributed to staff to determine if there had been any change in their view about the weaning process. Secondly, they collected data on patient outcomes. The results showed that the implementation of the VWP could be successful overtime through: performing a detailed assessment of the problem; the creation of a multi-disciplinary work team that is well educated

on the VWP and prepared to implement the change; and an ongoing education and evaluation process to maintain the change (Bruton, A., & McPherson, K. 2004).

Protocol Coordinator

Grap et al. (2003) and Crocker (2002) wanted to determine the effect of a protocol coordinator on the practice outcomes of the multidisciplinary team. The protocol coordinator or nurse consultant was responsible for overseeing every step of the implementation process. They were also in charge of educating and resourcing the rest of the staff. Grap et al. (2003) noted that continuing education, directed by the protocol, was necessary to ensure consistency. The study also suggested that the appointment of an outcome manger that is responsible for the education implementation and evaluation process could help ensure success of the VWP overtime. Crocker et al. (2002) also found that a nurse consultant, in charge of leading a nurse-led VWP, could add to the continued success of a VWP.

Assessing Readiness to Wean

McLean et al. (2006) investigated the effect of a Model for Accelerating Improvement used to guide healthcare teams in making procedural changes that help improve clinical outcomes for mechanically ventilated patients. Practice objectives were to increase staff's awareness and adherence to a VWP through the implementation of a four-step Model for Accelerating Improvement. Before implementation, data was collected regarding staff's awareness. Staff was educating through focus groups and learning sessions regarding the steps of the protocol and it's effects on patient outcomes. After the intervention, the staff's understanding of the VWP was reassessed. McLean suggests that continuing education helps increase staff's awareness of protocols. There was also evidence to suggest that adherence to VWP improved overtime (McLean et al., 2006).

Sheila Goodman (2006) also created a step-by-step approach to developing and implementing a VWP. She investigated the effect of this process on clinical and practice outcomes. The ten steps consisted of: selecting a protocol, setting up a team, agreeing on objectives, building awareness and commitment, gathering information, measuring data at baseline, producing the protocol, piloting the protocol, implementing the protocol, and reviewing the protocol. Questionnaires submitted by staff revealed that the presence of an extubation flow chart increased their autonomy and guided them in the decision-making process. Compliance also improved once the protocol was put into place because it helped nurses communicate with medical staff regarding the weaning process. Goodman also focused attention on patient's readiness to wean as evidence by assessing certain objective signs related to patient's respiratory, cardiovascular, neurological, and psychological status (Goodman, 2006).

Similarly, Burns et al. (1998) created a weaning assessment worksheet and scoring instrument to determine a patient's weaning potential. The Burns Wean Assessment Program (BWAP) assessed certain objective criteria related to respiratory, neurological, nutritional, and hemodynamic status in order to identify factors that impede the weaning process. It had previously been used as a systematic weaning assessment tool to manage mechanically ventilated patients. The calculated score of the BWAP helps determine an individual's readiness to wean. Patients with high BWAP scores (>90) were weaned successfully 96% of the time. As the BWAP scores decrease so does the likelihood of successful extubation. A systematic tracking of patients using scoring assessments like the BWAP can help clinicians determine a patients readiness to wean and lead to more successful extubations.

Enhancing Communication

Effective communication is important part of the implementation process. Henneman et al. (2002) suggested that an environment of ongoing communication between healthcare providers and the patient helped improve clinical outcomes, and investigated the effectiveness of a collaborative weaning plan in improving patient outcomes. This study paid special attention to a weaning board and flow sheet used to communicate and promote collaborative planning amongst the multidisciplinary team and the patient. These collaborative weaning plans were also successful at weaning patients that suffered from severe respiratory failure or those who had multiple comorbidities.

Ensuring Compliance

Compliance is another important aspect of the implementation process. Rice et al. (2012) wanted to determine how deviating from evidence-based guidelines affect patient outcomes. One of the dynamics that Rice (2012) investigated was how deviating from a VWP affected clinical outcomes. All data related to ventilator weaning was entered and measured for compliance. There were three types of deviation: no or minor deviations, moderate deviations, and major deviations. The study suggests that patients with major deviations from ventilator guidelines had more than twice the mortality at 30 and 90 days compared to those with no or minor deviations (all ORs > 2, all $p \leq 0.05$), as well as significantly fewer ventilator-free days (Rice et al., 2012).

Implications for Practice Change

VWPs have proven to be effective in reducing the duration of mechanical ventilator support without any adverse effects on patient outcomes (Marelich et al., 2000). Not only have these protocols shown that they can reduce the duration of mechanical ventilation for critically ill adults (Blackwood et al, 2011; Ely et al., 1999; Esteban et al., 1995; Gaafar et al., 2012; Grap et al., 2003; Kollef et al., 1997; McLean et al., 2006; & Smyrnios et al., 2002) and decrease ICU

LOS (Blackwood et al., 2001; Grap et al., 2003; Koleef et al., 1997; Shorr, 2003; & Smyrnios et al., 2002), they save money, and are associated with fewer complications than physician-directed weaning(Bird et al., 2010; Cooper, 2004; Ely et al.; 1999; Gaafar et al., 2012; Koleef et al., 1997; Marelich et al., 2000; McLean et al., 2006; & Smyrnios et al., 2002).

VWPs can be developed by multidisciplinary teams and initiated by attending physicians or intensivists. Once initiated, nurses and respiratory therapists can carry out these protocols, allowing physicians more time to care for additional, revenue-generating patients. Most of these protocols can be implemented without additional staff and with minimal training of nurse and respiratory therapists. The "weaning team" has the advantage of being able to focus exclusively on the weaning process. Protocol-directed care prevents delays in the initiation of weaning, reduces the number of potential decision points, and helps a group of caregivers develop expertise in a specific method of weaning (Smyrnios et al., 2002).

Implementing a VWP in an Adult ICU

Pre-Implementation Audit

The VWP will be piloted in a 15-bed CCU (critical care unit) over the course of three months. Prior to implementing a VWP, data will be collected over a three-month period (August to November 2014) to determine rates of VAP, duration of mechanical ventilation, and ICU length of stay. Since costs of care and mortality rates are directly influenced by the duration of mechanical ventilation (Ely et al., 1999; Kollef et al., 1997; Smyrnios et al., 2002), they will not be covered during the audit phase.

Creating the Ventilator-Weaning Protocol

This review of research will be presented to a multidisciplinary team of nurses, respiratory therapists, nurse managers, and intensivists at the bimonthly ICU council meetings.

The multidisciplinary team will use this information to update a VWP that unsuccessfully rolled out last year. The updated VWP will include criteria for weaning as well as reminders for reevaluating spontaneous breathing trials in patients that had previously failed (Figure 3). The VWP will be reviewed and amended over the course of several months to meet the needs of patients and the multidisciplinary team. Once finalized, the protocol will be voted on and implemented.

Ventilator-Weaning Protocol Coordinator

A member of the CCU council will be appointed as VWP coordinator and be responsible for oversee the implementation of the VWP. Their primary responsibilities will include reviewing data obtained during the audit phase, addressing issues found during audit phase, formulating an education plan for the multidisciplinary team, following up with multidisciplinary team during the piloting phase, and evaluating data gathered during the evaluation phase.

Education

To ensure its success, it is important that everyone is familiar with the VWP. Education of the multidisciplinary team will take place during the three-month audit phase in the form of a 15-minute presentation during CCU staff meetings in June and July. The staff meetings are mandatory for all nurses and respiratory therapists serving the CCU. Physicians and intensivists responsible for initiating the weaning process helped formulate the VWP and will be asked to attend.

All members of the multidisciplinary team will also be responsible for completing a one-hour online learning session regarding the VWP. The online learning session, developed by the VWP coordinator, will include a 50-minute tutorial introducing the protocol (significance, expected outcomes, staff's role in the protocol, expected documentation). The educational

module will be designed to improve the knowledge, skills, and practices of registered nurses and respiratory therapists. A pre-test/post-test (Figure 4) will be included in the module to evaluate learning objective and overall knowledge of VWP. Online learning sessions must be completed before the piloting phase begins. An application along with copies of the education material will be submitted to the Nursing Skills Competency Program division of the American Nurses Credentialing Center for evaluation and approval (American Nurses Credentialing Center, 2014). CEUs will be available as approved by the ANCC.

Piloting Phase

Piloting of the VWP protocol will begin on Monday November 3, 2014 in the CCU. At which point, all patients receiving mechanical ventilation in the CCU will be assessed and weaned according to the VWP. Patients receiving mechanical ventilation in the MICU and CVICU will be weaned according to standard practice. Any physician that is responsible for ordering ventilator weaning will be asked to comply with the protocol. Nurses that are taking care of patients meeting criteria for readiness to wean (Figure 3) will notify physicians and initiate the VWP. The protocol coordinator will be on the unit during the piloting to assist physicians, nurses, and respiratory therapists with any questions regarding the VWP.

Evaluation Phase

A major challenge in implementing any protocol is the ability to sustain the implementation process. For a protocol to succeed, it must be implemented in an environment of continuing education and thorough evaluation (Grap et al., 2003). The protocol coordinator will be responsible for collecting data regarding duration of mechanical ventilation, VAP rates, and ICU length of stay. This data will be compared the data collected in the audit phase to determine the effect of the VWP. The pretest/post test (Figure 4) will help assess the multidisciplinary

team's understanding of the VWP. The coordinator will also be present during implementation to serve as a resource while assessing compliance among nurses, respiratory therapists, and physicians. Chart and documentation reviews will be done at random to assess compliance. The VWP coordinator will compare data collected during the auditing phase to data collected during the piloting phase to judge the effect of the VWP on the following clinical outcomes: duration of mechanical ventilation, VAP rates, and ICU LOS.

Nurses, respiratory therapists, and physicians involved during the pilot will be asked to provide feedback regarding the VWP. Any relevant feedback will be presented at the following ICU council meetings. Changes to the VWP will be made as necessary. Upon successful piloting of the VWP, a hospital-wide implementation date will be set and ICU-wide education will begin. Once implemented, education regarding VWP will continue through new-hire training and annual online learning. VAP rates and ventilator days will be assessed quarterly during ICU council meetings to assess effect of VWP over time.

Conclusion

Patients receiving mechanical ventilation can have shorter durations of mechanical ventilation when standardized weaning protocols are used. These protocols decrease the duration of mechanical ventilation leading to shorter ICU stays, fewer complications like VAP, lower mortality rates, and reduced costs of care. These protocols seem to be most successful in settings where a multidisciplinary team is responsible for creating and implementing the VWP. A weaning coordinator can be useful to help educate staff on the VWP, serve as a resource during implementation, and evaluation effect of VWP on clinical outcomes. A thorough education program before and during implementation accompanied by an ongoing evaluation process is also influential for VWP's success.

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Table 1: Clinical Outcomes for Mechanically Ventilated Patients Before and After Implementation of Ventilator-Weaning Protocol

Reference	Objectives	Subjects	Intervention	Comparisons	Outcomes
Blackwood, B., Alderdice, F., Burns, K., Cardwell, C., Lavery, G., & O'Halloran, P. (2001, January 22). Use of mechanical weaning protocols for reducing duration of mechanical ventilation in critically ill adult patients: Cochrane systematic review and meta-analysis. *BMJ, 342*(c7237). Retrieved from: http://www.bmj.com/content/342/bmj.c7237	Cochran systematic review and meta-analysis comparing duration of mechanical ventilation, duration of weaning, and ICU length of stay before and after the implementation of a ventilator-weaning protocol.	N=1971 patients from eleven studies (sample size for studies ranged from 15 to 357 patients)	Protocol-directed weaning	Conventional weaning managed by physicians	Compared with usual care, the mean duration of mechanical ventilation in the weaning group was reduced by 25% (95% confidence interval 9% to 39%, P=0.006, ten trials); the duration of weaning was reduced by 78% (31% to 93%, P=0.009; six trials); and shortened ICU LOS by 10% (2% to 19%, P=0.02; eight trials).
Ely, W., Bennett, P., Bowton, D., Murphy, S., Florance, A., & Haponik, E. (1999, February). Large Scale Implementation of a Respiratory Therapist-driven Protocol for Ventilator Weaning. *American Journal of Respiratory and Critical Care Medicine, 159*(2), 439-446. Retrieved from http://www.atsjournals.org/doi/pdf/10.1164/ajrccm.159.2.9805120	Compare duration of mechanical ventilation, complications of mechanical ventilation, and cost of ICU care before and after the implementation of a respiratory-therapist-directed weaning protocol.	N=1067 patients	Protocol-directed weaning with a focus on daily weaning assessment and spontaneous breathing trial	Conventional weaning managed by physicians	Passing a daily weaning assessment and spontaneous breathing trial resulted in a shorter duration of mechanical ventilation by two days (P=0.27); Reduced overall complications by 50%, and lowered the cost of ICU care by more than $5,000 per patient.
Esteban, A., Frutos, F., Tobin, M., Alía, I., Solsona, J., Valverdú…..Blanco, J. (1995, February 9). A Comparison of Four Methods of Weaning Patients from Mechanical Ventilation. *The New England Journal of Medicine, 332*(6), 345-350. Retrieved from http://www.nejm.org/doi/pdf/10.1056	Compared four methods for weaning patients from mechanical ventilation and determine their effects on clinical outcomes. Weaning protocols were used for each approach.	N=130 patients* *Must have experienced respiratory distress during a two-hour trial of spontaneous breathing	Once-daily spontaneous breathing trials using either CPAP ventilation or T-tube oxygenation for up to two hours per day	Intermittent mandatory ventilation, pressure-support ventilation, or intermittent trials of spontaneous breathing	The adjusted rate of successful weaning was higher with a once-daily trial of spontaneous breathing than with intermittent mandatory ventilation (rate ratio, 2.83; 95% confidence interval, 1.36 to 5.89; P<0.006) or pressure-support ventilation (rate ration, 2.05; 95% confidence interval, 1.04 to 4.04; P<0.04)

Table 1: Clinical Outcomes for Mechanically Ventilated Patients Before and After Implementation of Ventilator-Weaning Protocol

Reference	Objectives	Subjects	Intervention	Comparisons	Outcomes
Gaafar, T., El-salam, A., Tawfeek, M., Gumaa, E., & Mohammed, A. (2012, November). Impact of Weaning Protocol on Outcome of Mechanical Ventilation in Adults. *Zagazig University Medical Journal, 18*(6) 1088-1085. Retrieved from http://www.zumedicaljournal.com/index.php?option	Compare duration of mechanical ventilation, duration of weaning hours, rates of VAP and mortality before and after the implementation of a ventilator-weaning protocol.	N=171 patients Before Protocol N=87 After Protocol N=84	Protocol-directed weaning	Conventional weaning managed by physicians	Intervention reduced the duration of mechanical ventilation by 30 hours (P=0.005); reduced the duration of weaning by 12 hours (P=0.019); decreased VAP rates by 13% (P=0.036); decreased rates of reintubations by 15% (P=0.026); and decreased mortality by 30% (P<0.001).
Grap, M., Strickland, D., Tormey, L, Keane, K., Lubin, S., Emerson, J…..Sessler, C. (2003, September). Collaborative Practice: Development, Implementation, and Evaluation of a Weaning Protocol for Patients Receiving Mechanical Ventilation. *American Journal of Critical Care, 12*(5), 454-460. Retrieved from http://ajcc.aacnjournals.org/content/12	Compare duration of mechanical ventilation and ICU length of stay before and after the implementation of a ventilator weaning protocol.	N=928 patients Before Protocol N=469 After Protocol N=459	Protocol-directed weaning led by nurses and respiratory therapists	Conventional weaning managed by physicians	Implementation of the protocol significantly reduced the duration of mechanical ventilation (7d to 5.6 d, P=0.02) and reduced ICU length of stay (8.6 d to 7.9 d, P=0.29).
Kollef, M., Shapiro, S., Silver, P., St. John, R., Prentice, D., Sauer, S…Baker-Clinkscale, D. (1997, April). A randomized, controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation. *Critical Care Medicine, 25*(4), 567-574. Retrieved from http://ezproxy.southern.edu:2146	Compare duration of mechanical ventilation, length of stay, and hospital costs savings before and after the implementation of a ventilator-weaning protocol.	N=357 patients Protocol-directed weaning group (n=179) Physician-directed weaning group (n=178)	Protocol-directed weaning led by nurses and respiratory therapists	Conventional weaning managed by physicians	Intervention decreased duration of mechanical ventilation by 9 days (44d for physician-directed weaning, 35 for protocol-directed weaning, P=0.029). Decreased length of stay by 1.5 days (14.2 to 12.7, P=0.517) and created a hospital cost savings of $129,000/year.

Table 1: Clinical Outcomes for Mechanically Ventilated Patients Before and After Implementation of Ventilator-Weaning Protocol

Reference	Objectives	Subjects	Intervention	Comparisons	Outcomes
McLean, S., Jensen, L., Schroeder, D., Gibney, N., & Skjodt, N. (2006, May). Improving Adherence to a Mechanical Ventilation Weaning Protocol for Critically Ill Adults: Outcomes After an Implementation Program. *American Journal of Critical Care, 15*(3), 299-309. Retrieved from http://ezproxy.southern.edu:2058	Compare rates of unsuccessful extubations, VAP, and duration of mechanical ventilation before and after the implementation of a ventilator-weaning protocol.	N=129 patients Before intervention: N=63 After intervention: N=66	Protocol-directed weaning	Conventional weaning managed by physicians	Intervention reduced the rate of unsuccessful extubations from 12.7% to 3.0% (P=0.05) decreased rates of VAP from 22 patients before the intervention to 13 patients after the intervention, (P=0.14), reduced average duration of mechanical ventilation from 86h to 70.8h (P=0.20) with no cases of unsuccessful extubations with adherence to protocol.
Smyrnios, N., Connolly, A., Wilson, M., Curly, F., French, C., Heard, S., & Irwin, R. (2002, June). Effects of a multifaceted, multidisciplinary, hospital-wide quality improvement program on weaning from mechanical ventilation. *Critical Care Medicine, 30*(6), 1224-1230. Retrieved from http://ezproxy.southern.edu:2146/sp	Compare mortality rates, hospital and ICU length of stay, number of ventilator days, amount of cased requiring tracheostomies, and hospital costs for ventilator dependent patients over a three-year period: year one (before intervention) and years two and three (after intervention).	N=738 patients over 3-year period Year One (Baseline): N=220 Year Two: N=247 Year Three: N=271	Protocol-directed weaning implemented in year two and three	Baseline year or year one (physician-directed weaning)	When comparing year one to year three, the intervention reduced mortality rates from 32% to 28% (p=0.062), decreased mean length of stay (hospital and ICU) from 37.5d to 24.7d, (p <0.0005), decreased the number of ventilator days by 6 (p=0.004), decreased percentage of cases requiring tracheostomies by 19% (p<0.0005), and produced a total cost savings of $3,440,787.

Table 2: Factors Influencing Practice Outcomes

Reference	Objective	Interventions	Results	Additional Results/Limitations
Bruton, A., & McPherson, K. (2004, September 1). Impact of the Introduction of a Multidisciplinary Weaning Team on a General Intensive Care Unit. *International Journal of Therapy and Rehabilitation, 11*(9), 435-440. Retrieved from http://ezproxy.southern.edu:2058	Identify techniques to successfully implement a ventilator weaning protocol after previous attempts to develop and maintain a protocol have failed.	Create a multidisciplinary weaning team that was responsible for all aspects of the weaning process (research, development, education, implementation, and evaluation).	The standardized approach developed by the weaning team improved continuity of care and staff's perception and awareness of the weaning protocol.	• Physician compliance was inconsistent • Nursing experience influenced the level of nurse comfort in managing protocol • Continuing education was vital to protocol's success
Burns, S., Marshall, M., Burns, J., Ryan, B., Wilmoth, D., Carpenter, R.....Aloi, A. (1998, January). Design, Testing, and Results of an Outcomes-Managed Approach to Patients Requiring Prolonged Mechanical Ventilation. *American Journal of Critical Care, 7*(1). 45-57. Retrieved from http://ezproxy.southern.edu:2171h	To determine the relationship with assessment scores, using the Burns Wean Assessment Program, and clinical outcomes of weaning trials for patients receiving mechanical ventilation.	A weaning assessment worksheet and scoring instrument (Burns Wean Assessment Program) was used to determine patient's weaning potential (Patients with higher BWAP scores are more likely to be weaned successfully).	Patients with BWAP scores >50 were weaned successfully 96% of the time while patients with BWAP scores <50 were weaned successfully 74% of the time.	• Systematic tracking and scoring of patients using models like the BWAP may be helpful in care planning and in determining weaning potential
Crocker, C. (2002, October 18). Nurse led Weaning from Ventilator and Respiratory Support. *Intensive and Critical Care Nursing, 18*(5), 272-279. Retrieved from http://ezproxy.southern.edu:2058	Determine the effects of nurse-led weaning protocols on clinical outcomes for mechanical ventilated patients.	A nurse consultant was placed in charge of the weaning protocol. Bedside nurses assessed for readiness to wean and managed the weaning process. Medical staff determined ventilator settings and mode.	Nurse led weaning can prevent delays when initiating weaning and may decrease average number of ventilator days (16.8 days before intervention, 8 days after intervention) and ICU mortality rates (35% before intervention, 28% after intervention).	• Nursing experience highly influenced clinical outcomes • Inappropriate sedation had a negative impact on outcomes • Delay in tracheostomy placement negatively affected patient outcomes • Nurse-led weaning positively influenced job satisfaction

Goodman, S. (2006, January 1). Implementing a Protocol for Weaning Patients off Mechanical Ventilation. *Nursing in Critical Care, 11*(1), 23-32. Retrieved from http://ezproxy.southern.edu:2058	Identify a "step by step" approach for successfully developing and implementing a ventilator weaning protocol and measure the protocols effect on clinical outcomes as discussed in the article.	A 10-step process for developing and implementing weaning protocols.	Weaning was commenced earlier (50% reduction in delay) and continuity of care improved as evidence by 75% of patients weaned per guidelines.	• Nurses developed more autonomy in the weaning process which positively influenced job satisfaction • Compliance improved once protocol was in place
Grap, M., Strickland, D., Tormey, L, Keane, K., Lubin, S., Emerson, J.….Sessler, C. (2003, September). Collaborative Practice: Development, Implementation, and Evaluation of a Weaning Protocol for Patients Receiving Mechanical Ventilation. *American Journal of Critical Care, 12*(5), 454-460. Retrieved from http://ajcc.aacnjournals.org/content/12	Identify methods that improve patient outcomes by increasing staff's compliance and understanding of a ventilator-weaning protocol.	An outcome manager was responsible for overseeing the implementation of the protocol, educating staff, and tracking compliance. Documentation was collected and reviewed to measure success of intervention.	Continued success of the ventilator-weaning protocol over time suggested that the improvement in clinical outcomes could be related to the change in practice.	• Continuing education was necessary to ensure consistency • Implementation can be more easily communicated and maintained if implemented in smaller groups
Henneman, E., Dracup, K., Ganz, T., Molayeme, O., & Cooper, C. (2002, March). Using a Collaborative Weaning Plan to Decrease Duration of Mechanical Ventilation and Length of Stay in the Intensive Care Unit for Patients Receiving Long-Term Ventilation. *American Journal of Critical Care, 11*(2), 132-140. Retrieved from http://ajcc.aacnjournals.org/content/11/2/132.	Evaluate the effectiveness of a collaborative weaning plan in improving outcomes for patients receiving long-term ventilation in the ICU	A collaborative weaning plan (weaning board and flow sheet) was used to facilitate communication and promote collaborative planning among the patient, the patient's family, and the healthcare team.	The intervention reduced the median duration of mechanical ventilation, average length of stay, and average cost of stay by 5 days, 4.5 days, and $13,000, respectively.	• Collaborative weaning plans were successful at weaning patients that were previously considered unweanable
McLean, S., Jensen, L., Schroeder, D., Gibney, N., & Skjodt, N. (2006, May). Improving Adherence to a Mechanical Ventilation Weaning Protocol for Critically Ill Adults: Outcomes After an Implementation Program. *American Journal of Critical Care, 15*(3), 299-309. Retrieved from http://ezproxy.southern.edu:2058	Improve staff's understanding of and adherence to a mechanical ventilator-weaning protocol.	Implement a Model for Accelerating Improvement (Plan-Do-Study-Act) to guide healthcare teams in making procedural changes that improve outcomes of mechanically ventilated patients.	Mean test scores (assessing knowledge of risks of reintubation and readiness to wean) increased from 9.8 before the intervention to 12.8 after the intervention.	• Staff adherence increased by 19% • Perceptions of safety climate did not change with protocol implementation

Rice, T., Morris, S., Tortella, B., Wheeler, A., & Christensen, M. (2012, March). Deviations from Evidence-Based Clinical Management Guidelines Increase Mortality in Critically Injured Trauma Patients. *Critical Care Medicine, 40*(3), 778-786. Retrieved from http://ezproxy.southern.edu:2146	Determine how deviation from evidence-based guidelines affects patient outcomes	All data relating to patient care was entered and then measured for compliance to evidence-based practice. Degrees of deviation included: No or only minor deviations, moderate deviations and major deviations.	Compliance was lowest (more major deviations) for mechanical ventilation and was associated with longer duration of mechanical ventilation.	• Trial was stopped early due to an overwhelming increase in mortality rates seen when deviating from evidence-based practice

Figure 3: Example of a Ventilator Weaning Protocol

Weight:
Height

DATE/TIME ORDERED

VENTILATOR WEANING PROTOCOL

1. **Initiate weaning protocol**

2. **Daily assessment of readiness to extubate:**
   Will be done by the Respiratory Therapist with the AM Assessment.

   Criteria for Weaning:
   Respiratory: FIO2 ≤ 50%, PEEP ≤+8; ABG values acceptable for this patient:
   PCO2_____ PO2_____ O2 Sat%_____
   Minimal Secretions
   CVS: **Stable**; Inotrope free/**low dose inotropes**; afebrile
   Neurological: **Sedation off or minimal; pain controlled; intact respiratory drive**
   Psychological: *Patient prepared and rested; no psychosis*
   Other: **Adequate nutrition and fluid status**

   (**Essential in bold,** *desirable in italic*)

3. **Sedation vacation:**
   Will occur immediately **if** the patient passed the assessment to extubate.
   Nursing will reduce the patient's sedation to a Ramsey of 2-3

4. Ramsey Sedation Scale:
   Level 1: Anxious, agitated, or restless
   Level 2: Cooperative, oriented, and tranquil
   Level 3: Responsive to command only
   Level 4: Briskly responsive to loud auditory stimulus or glabellar tap
   Level 5: Sluggishly responsive to loud auditory stimulus or glabellar tap
   Level 6: Not responsive to loud auditory stimulus or glabellar tap

5. **Spontaneous Breathing Trial begins:**
   RT to place ventilator settings at CPAP 5 cm H2O
   ATC is on for Drager ventilation of Flow-by for 7200 ventilators.

6. **Duration of SBT:**
   60 minutes. (Follow the criteria for failure of SBT).
   If the patient fails the weaning trial, they are returned to full ventilator support with the previous ventilator settings, rested overnight, and re-evaluated in AM.

7. **Extubation should be considered:**
   After 60 minutes of SBT with no failures and a RSBI (Rapid Shallow Breathing Index) of 100 or less

Figure 3 (cont.): Example of a Ventilator Weaning Protocol

Weight:
Height

DATE/TIME ORDERED

VENTILATOR WEANING PROTOCOL (CONT.)

Criteria for failure of SBT:

-Diaphoresis, agitation or other change in mental status.
-Signs of increased work of breathing or significant dyspnea for > 15 minutes.
-*Hypoxemia: PaO2 decreased to < 60% or SaO2 < 90%
-*Hypercapnia: Increased PaO2 > 10mmHg from pre-weaning level
-Increased respiratory rate to > 35 bpm for > 10 minutes
-Tachycardia (HR > 140) or bradycardia (HR < 50)
-Hypotension: Systolic blood pressure < 80mmHg, or drop by > 20%
-Hypertension: Increase in systolic blood pressure > 20%

1. Check ABG on all patients with primary hypercapnic respiratory failure.

See written order from Dr. _____ Date _____
_____RN

Physician Signature: _____ Date: _____ Time: _____

Figure 4: Pre-test/Post-test. *Learning objectives:* 1. Describe the role of VWPs in weaning patients from mechanical ventilation. 2. Describe the role of nurses and respiratory therapists in weaning patients from mechanical ventilation. 3. Identify advantages to VWP as compared to physician-directed weaning. 4. Identify elements of VWP being implemented.

1. **Before the establishment of VWPs, the standard means of weaning patients from mechanical ventilation was largely left to physician discretion (T/F):**
   a. True
   b. False
2. **It is estimated that more than _____ of critically ill adults will require mechanical ventilation while they are in the ICU.**
   a. 25%
   b. 50%
   c. 75%
   d. 90%
3. **The process of weaning patients from mechanical ventilation can account for almost _____ of the total duration of mechanical ventilation.**
   a. 20%
   b. 30%
   c. 40%
   d. 50%
4. **One of the most important aspects of ventilator care is assessing when a patient is ready to begin weaning and liberate them from the ventilator as soon as possible (T/F):**
   a. True
   b. False
5. **Ventilator weaning protocols (VWPs) can help improve which clinical outcomes: (Select all that apply):**
   a. Duration of mechanical ventilation
   b. Rates of ventilator-associated-pneumonia
   c. Costs of care
   d. Patient mortality
6. **VWPs save time, money, and are associated with fewer complications than physician-directed weaning (T/F):**
   a. True
   b. False
7. **Ventilator weaning protocols are highly influenced by the following practices:**
   a. Research and design
   b. Clinical education
   c. Evaluation
   d. All of the above
8. **The VWP has been developed by a multidisciplinary team of nurses, respiratory therapists, nurse managers, and physicians (T/F):**
   a. True
   b. False
9. **Once initiated, ventilator weaning protocols can be carried out by nurses and respiratory therapists (T/F):**
   a. True
   b. False
10. **I have reviewed and understand the elements of the ventilator weaning protocol for my facility. I also understand my role in weaning patients from mechanical ventilation, the documentation required, and my duty to comply within the protocol.**
    a. Yes, I understand
    b. No, I do not understand