The care of the patient undergoing weaning from mechanical ventilation in Critical Care.

Abstract

The aim of this article is to discuss the care of the mechanically ventilated patient, who is undergoing extended weaning from mechanical ventilation. Areas discussed within this article include ventilation and weaning, a holistic multidisciplinary approach to care, nursing considerations and the use of weaning protocols.

Introduction

A Critical Care Nurse requires a vast knowledge and understanding of physiology and pathophysiology and must be knowledgeable, skilled, competent and compassionate (Adam, Osborne and Welch, 2017). This article seeks to provide an understanding of caring for a patient who is being weaned from mechanical ventilation. There are many reasons why mechanical ventilation is initiated for patients, such as to allow for general anaesthesia for patients who are undergoing surgery, or those who have a compromised airway or respiratory failure. However, as soon as a patient is commenced on mechanical ventilation, it is recommended that the weaning process should commence as soon as possible (Boles et al, 2007). The term “weaning” describes the entire process of liberating the patient from mechanical ventilatory support (Boles et al, 2007). The United Kingdom Intensive Care Society (ICS) define weaning “as the gradual reduction of ventilatory support and its replacement with spontaneous ventilation” (ICS, 2007, p1). Whilst this definition is widely accepted, there are many other accepted worldwide definitions. Successful weaning is

dependent on a strong respiratory effort, appropriate level of consciousness to sustain spontaneous breathing, sufficient respiratory muscle strength and a stable cardiovascular system (Cutler and Cutler, 2010). The incidence of weaning failure is significant, with 20%-30% of patients being deemed difficult to wean from mechanical ventilation (Heunks and van der Hoeven, 2010). Several patient groups, such as those with COPD, cardiac diseases, spinal injuries and the elderly, are at a higher risk of failing to wean (Jeganathan, Kaplan and Balk, 2015).

Prolonged delays in the discontinuation from mechanical ventilation can increase complication rates, including airway trauma and ventilator acquired pneumonia (VAP) (White, 2012; MacIntyre et al, 2001). Patients who have failed to respond to discontinuation attempts, or need to be mechanically ventilated beyond 24 hours, may be determined as ventilator dependant. It is important to identify the cause of ventilator dependence, as reversible conditions could be treated. There are several reasons why patients may become ventilator dependant which include; neurological, respiratory, cardiovascular and psychological issues (White, 2012; MacIntyre et al, 2001).

Areas discussed within this article include ventilation and weaning, holistic multidisciplinary approach to care, nursing considerations and the use of weaning protocols.

Weaning and Ventilation

The ICS (2007) describe weaning as the gradual decrease of ventilatory support and its replacement with a patient's own spontaneous ventilation. This can be a rapid, uneventful procedure or it can be prolonged for days or weeks in some patients (ICS, 2007). The ICS (2007) highlight that prolonged weaning from mechanical ventilation

is a problem in every Critical Care Unit and not only increases mortality and morbidity of the patient; it also has implications on resources and cost of healthcare.

The ICS (2007) states that mechanical ventilation can only be discontinued when the patient can spontaneously breathe. The most important factor in the weaning process is to treat the underlying condition that may prevent weaning, as the patient will not wean if they are not capable of breathing independently (ICS, 2007). There are many factors than can prevent weaning including, for example; sedation, pain, abdominal distention, pleural effusion or pneumothorax, plus many more (ICS, 2007). Therefore, any factor that prevents the patient from weaning effectively should be identified and treated or minimised.

Davidson et al (2016) recommends that mechanically ventilated patients should have a documented weaning plan, and spontaneous breathing should be established as soon as possible. A daily assessment of readiness for weaning should be undertaken and a switch from controlled ventilation to assisted ventilation, such as Pressure Support Ventilation (PSV), should be made as soon as the patient recovery allows (Davidson et al, 2016). The patient must meet the following criteria to be assessed as ready to wean. The patient should have a normal Inspiration: Expiration ratio, a reducing FiO2 (less than 50%), appropriate underlying respiratory rate, no requirement for high Positive End Expiratory Pressure (PEEP) and appropriate tidal volumes with moderate airway pressures (ICS, 2007).

Davidson et al (2016) state that daily spontaneous breathing trials (SBT) and progressive reduction of PSV are satisfactory methods of weaning. A SBT is when a patient is placed on a T-piece or Continuous Positive Airway Pressure (CPAP) of 5cmH20 and monitored closely for 30 to 120 minutes. The trial is considered to have failed if the patent has a respiratory rate above 35, increased heart rate by 20% and /

or oxygen saturations less than 90% for a period of more than 5 minutes. Also if the patient has increased anxiety and agitation for longer than 5 minutes or the patient's systolic blood pressure is maintained above 180mmHg or below 90mmHg for longer than one minute (Adam, Osborne and Welch, 2017). If a patient successfully completes a SBT and is able to protect their own airway, mechanical ventilation can be discontinued and the patient can be extubated (ICS, 2007).

If a patient fails a SBT, they should be placed back on mechanical ventilation and reassessed on a daily basis (ICS, 2007). If a patient fails three consecutive SBTs or has been mechanically ventilated for longer than a week, a more staged reduction on a mechanical ventilator may be required (Adam, Osborne and Welch, 2017). Boles et al (2007) state that PSV or assist-control ventilation modes should be favoured over other modes of ventilation in weaning patients. PSV is used to support a patient's own respiratory effort. It allows the opportunity to gradually reduce the level of support to facilitate weaning (Adam, Osborne and Welch, 2017). With PSV the PEEP, inspiratory pressure level, and sensitivity are pre-set. When a patient initiates a breath, a breath is delivered at the pre-set pressure and maintained throughout inspiration. The weaning patient determines the tidal volume, inspiratory time and respiratory rate (Cutler and Cutler, 2010). The degree of PSV support should be gradually weaned so that the patient contributes increasingly to the work of breathing. This can be achieved by reducing PSV with increasingly prolonged periods of CPAP (ICS, 2007).

A patient's respiratory support should be gradually decreased until full discontinuation of mechanical ventilation can be achieved and the patient can be extubated. If ventilatory support is still required post extubation, a non-invasive positive pressure ventilation system may be used during the weaning phase (ICS, 2007). The ICS are currently conducting a large randomised control trial investigating the clinical benefits

and cost effectiveness of using non-invasive weaning strategies as an intermediate step to wean patients off mechanical ventilation, compared to other weaning strategies (Warwick Clinical Trials Unit, 2016).

Sedation

Sedation may be required for a patient to tolerate an endotracheal tube and mechanical ventilation but the adverse effects of prolonged sedation are often underestimated (ICS, 2014a). Increased sedation has shown to increase mortality, length of time for mechanical ventilation, further critical illness and post-traumatic stress disorder (PTSD) (ICS, 2104a).

Tracheostomies

The ICS (2007) recommend that in patients failing to wean rapidly (+/- 5 to 21 days), a percutaneous tracheostomy should be considered as this can facilitate weaning from mechanical ventilation. Tracheostomies halve the dead space, therefore make weaning easier as it reduces the work of breathing (Woodrow, 2012). The ICS (2014b) state that key factors that have increased the use of temporary tracheostomies in the general critical care population is the belief that it promotes earlier weaning, patient mobilisation and reduced sedation requirements.

However, recent studies have found that early insertion of tracheostomy has been found to not reduce mortality, VAP or the duration of invasive mechanical ventilation (Davidson et al, 2016). Additionally, tracheostomies have the disadvantages of preventing an adequate cough and can impair a patient's swallow (ICS, 2007).

Extubation Failure

Failed extubation is defined as the need for re-intubation within 48 -72 hours following a planned extubation and can occur in up to 33.8% of patients (Krinsley, Reddy and Iqbal, 2012). Therefore, it is essential that a patient is assessed appropriately throughout weaning and extubation, as failed extubations are associated with a significant increase of morbidity and mortality (Krinsley, Reddy, and Iqbal, 2012).

Risk factors for extubation failure include; Rapid, shallow breathing during SBTs, increased age, prolonged duration of mechanical ventilation, increased severity of illness; and pneumonia or pulmonary disease as the cause for mechanical ventilation (Davison et al, 2016). Additional support should be provided if risk factors for extubation failure are identified (Davidson et al, 2016).

Multidisciplinary Team Approach

For effective weaning from mechanical ventilation, each member of the multidisciplinary team (MDT) is required to contribute his or her expertise through collaborative practice. The aim of collaboration is to optimise patient outcome by allowing the MDT to utilise all available resources for the patient (Cutler and Cutler, 2010). Cutler and Cutler (2010) highlight that a Critical Care Nurse's role is key in the co-ordination and effective communication flow through the MDT.

A patient weaning from mechanical ventilation requires input from all members of the multi- and inter-disciplinary team within critical care. As part of the 'Core Standards in Intensive Care Units' (Danbury et al, 2013) the roles of each member of the MDT is outlined, and their contribution is pertinent to caring for the weaning patient.

Consultant-led medical teams must make decisions on the management of the critically unwell patient, and treatments plan and goals must be effectively communicated within the MDT (Danbury et al, 2013).

The presence and contribution of a physiotherapist is outlined as a core standard for critical care units in the contribution and construction of a weaning plan (Danbury et al, 2013). Physiotherapy involvement is important to effectively manage the patient's chest physiotherapy and to commence appropriate physical rehabilitation for patients with a tracheostomy. Danbury et al (2013) recommend that physiotherapists are essential in constructing weaning and rehabilitation strategies that work in conjunction to optimise a patient's capacity and reserve. The implementation of rehabilitation and early mobilisation in mechanically ventilated patients has shown physical and psychological function benefits (Ntoumenopoulos, 2015), decreases the risk of polyneuropathy and shortens the duration of weaning (Blot, Afonso and Labeau, 2014). Physical rehabilitation is crucial, as muscle weakness after mechanical ventilation is associated with mortality (Medrinal et al, 2016). However, despite physiotherapists often being consulted and actively contributing to weaning protocols, the majority of physiotherapists contribute to weaning through early prescription of exercise rather than the adjustment of respiratory support (Morer and Aswegen, 2016). Morer and Aswegen (2016) also advocate further methods of inspiratory muscle training to ensure successful weaning. Inspiratory muscle training can have significant benefits for patients weaning from mechanical ventilation, including improved breathing pattern, more successful weaning and potential reductions in length of stay (Elkins and Dentice, 2015).

Danbury et al (2013) also recommend that a dietician must be part of the Critical Care MDT. The aim of nutritional support is to reduce or treat malnutrition (Ros, McNeill and

Bennet, 2009). Adequate nutrition must be established in weaning patients, as they have increased metabolic requirements and rely on administration of nutritional support to meet their increased demands (Marshall et al, 2012). Critical Care Nurses play an important role in ensuring that set nutritional goals are met for patients (Marshall et al, 2012), as during the acute phase of illness, inconsistent delivery of nutrition can advance malnutrition further (Ros, McNeill and Bennet, 2009).

With patients who have a tracheostomy, Speech and Language Therapists (SALT) must assess communication and swallowing needs of the patient, when the decision has been made to wean the patient and the sedation hold has started (Danbury et al, 2013).

Critical Care Nurses play a crucial role in the collaboration of the MDT, as they have the knowledge of the patient's response to weaning. Therefore, nurses can drive the process forward using a patient centred approach, by individualised planning and assessing patient's physical and emotional resources (Cederwall et al, 2014).

Nursing Considerations

Critical Care Nurses have a key role in continuously assessing and monitoring the patient weaning from mechanical ventilation, using a thorough 'Airway, Breathing and Circulation' approach. Signs of airway problems, respiratory distress and cardiovascular instability must be recognised and acted upon promptly. Higgins (2011) argues that Critical Care Nurses remain best placed to facilitate effective weaning. Additionally, adjusting weaning parameters requires a high level of skill and training, and a sound knowledge of cardiorespiratory physiology and pathophysiology (Higgins, 2011). Tingsvick, Johansson and Martensson (2015) found that the main factor that influenced the decision making process was the overall assessment of the patient,

and that successful weaning required a skilled competent nurse. Kydonaki et al (2016) further supported these findings and added that novice Critical Care Nurses required more encounters of cues to attain the concept of successful weaning with certainty, compared to experienced nurses. Kydonaki et al (2016) discovered that one sample group in this study demonstrated advanced clinical reasoning in the weaning process. Kydonaki et al (2016) attributed this to the continuous development programme on mechanical ventilation and weaning that was provided by the medical team on that unit. Therefore, greater nurse education could be a crucial influencing factor in effectively assessing and managing a patient weaning from mechanical ventilation.

Assessment

Airway

The safety of a patient weaning from mechanical ventilation is paramount. It is essential that a Critical Care Nurse has the necessary knowledge and skills to care for patients with an artificial airway. An artificial airway should be secured so that it is immobile (Cutler and Cutler, 2010). The security of an artificial airway must be checked regularly. The size and position of the artificial airway should be clearly documented and checked (Woodrow, 2012). Nurses must ensure tapes are changed every 24 hours or when indicated (ICS, 2014b). Securing an endotracheal tube or tracheostomy requires two people and tapes should be regularly examined to ensure they have not become too loose or tight, and ensure there is no pressure damage (Cutler and Cutler, 2010). It is recommended that the pressure within airway tube cuff is checked with a cuff monometer, and documented routinely. The pressure should not exceed 30cm H2O as excessive pressures can result in tissue damage and complications such as tracheal stenosis, ulceration and necrosis (Adam, Osborne and Welch, 2017).

It is essential that respiratory gases delivered to patients are humidified as inadequate humidification could lead to life threatening complications such as; blockage of the airway with tenacious sputum, secondary infection and impaired gas exchange (ICS, 2104). Tracheal suctioning is an essential component of secretion control and maintenance of tube patency (ICS, 2014b). However, tracheal suctioning poses its own risks such as hypoxia, bradycardia, tracheal mucosal damage and bleeding. Consequently, suctioning requirements should be based on a patient's individual need and patients should be encouraged to expectorate their own secretions (ICS, 2014b). Closed circuit suction systems are advocated as suction-induced hypoxemia can be reduced as the patient can maintain the oxygen concentration, tidal volume and PEEP delivered by the ventilator whilst being suctioned (Cutler and Cutler, 2010).

Patients with a blocked or displaced airway will die quickly if not appropriately managed. Therefore, nurses must have appropriate airway management skills (Higginson, Jones and Davies, 2010). If a patient weaning from mechanical ventilation shows signs of a blocked or displaced airway, such as sudden hypoxia or ventilator pressure alarms, endotracheal suctioning should be performed to check airway patency (Cutler and Cutler, 2010). An anaesthetist should be called immediately to reposition or reintubate the patient if clinically necessary.

To enhance safety of caring for patients with a tracheostomy the 'National Tracheostomy Safety Project' was developed (McGrath et al, 2012). This project has produced emergency algorithms to improve the management of tracheostomy critical incidents by first responders.

Breathing

When caring for the patient weaning from mechanical ventilation the patient must be continuously observed for respiratory distress, hypoxaemia and fatigue (Cutler and Cutler, 2010). Patients weaning from mechanical ventilation should be continuously monitored through pulse oximetry (SP02) and capnography (ETC02). Although these methods are not as reliable as obtaining an Arterial Blood Gas (ABG) reading of PO2 and PCO2, they can be used as a guide to assess the efficiency of ventilation (Adam and Osbourne, 2009). Regular ABG measurement samples should be obtained to ensure the patient is ventilating adequately and ventilator support is adjusted accordingly to normalise blood pH, PO2 and PCO2 levels.

There are four steps for conducting a clinical respiratory system examination; inspection, palpation, percussion and auscultation. The critical care nurse should examine the patients breathing to ensure equal air entry and detect any abnormalities that may prevent weaning (Cutler and Cuter, 2010).

The nurse should monitor the patient's respiratory rate and tidal volume on PSV, as it may be necessary to adjust the pressure support to avoid tachypnoea or large tidal volumes. Newmarch (2006a) argues that critical care nurses are in an ideal position to detect signs of fatigue as early as possible as they have a high level of contact with patients. Patients weaning from mechanical ventilation should be continuously monitored for signs of respiratory distress. The most common signs are rapid, shallow breathing, reduced tidal volumes, the use of accessory muscles, tachycardia, reduced arterial oxygenation saturations and increased carbon dioxide levels (Newmarch, 2006a).

A patient's position when weaning from mechanical ventilation should also be considered. A patient should be positioned in in a 30-45 degree semi recumbent

position to increase the depth of breathing, reduce resistance of inspiration and reduce the incidence of VAP, thought to be due to aspiration of stomach contents (Adam, Osborne and Welch, 2017).

Circulation

In order to successfully wean a patient from mechanical ventilation, the patient must be haemodynamically stable at each phase of weaning. Positive pressure ventilation can decrease cardiac output and respiratory muscle fatigue, which can induce significant cardiopulmonary distress (Newmarch, 2006b, Newmarch, 2006a). Weaning should be discontinued immediately in this instance. Therefore, patients weaning from mechanical ventilators should be attached to a cardiac monitor to monitor for arrhythmias and blood pressure changes.

Fluid balance must also be maintained, as adequate hydration is essential in effective recovery from critical illness and in secretion management, but fluid overload may delay weaning and contribute to its failure (Davidson et al, 2016)

Other Considerations

Patients who are mechanically ventilated are at increased risk of preventable complications. ‘Care bundles’ have been developed to reduce ventilator acquired complications significantly in ventilated patients (Cutler and Cutler, 2010). Common standards of care include, DVT prophylaxis as the patients mobility is impaired, Gastric ulcer prophylaxis from increased risk in critical illness, oral hygiene to prevent VAP,

Haemoglobin (Hb) trigger to transfuse blood if Hb falls below 7g/dl, daily sedation holding to reduce duration of mechanical ventilation and VAP and ventilator tube management to prevent airway management (Cutler and Cutler, 2010).

Communication

It is crucial to continue to provide holistic care to critically ill patients even when their physical needs appear more significant. A Critical Care Nurses must consider all dimensions of a patients needs including physical, emotional, social and spiritual (Cutler and Cutler, 2010). A Critical Care admission is a stressful and strenuous event for patients and their families (Blot, Afonso and Labeau, 2014). MacIntyre et al (2001) highlight that psychological factors are among the most prevalent factors leading to ventilator dependence as well social, familial and economic issues. Critical Care Nurses are ideally placed to offer patients and families support, to reduce anxiety during the weaning process (Newmarch, 2006b). The fear of losing or reducing the support of an apparent life-support system can lead to increased anxiety which could impact upon the patents ability to wean effectively (White, 2012; MacIntyre et al, 2001). Boles (2007) believes that there is uncertainty surrounding the best methods of conducting effective weaning, but highlights that successful weaning requires the cooperation of the patient during this phase of recovery. The ICS (2007) add that lack of patient motivation could be a factor that prevents weaning. Nurses are most often the healthcare professional who offers constant feedback to the patient and their family of progress (Newmarch, 2006b). It is therefore essential that nurses are effective and compassionate communicators. Constant explanations of nursing interventions, treatment plans and alarms can alleviate patient anxiety and increase patient

compliance (Newmarch, 2006b). Newmarch (2006a) further adds that the patients understanding of the weaning process needs to be evaluated regularly and repeat explanations of treatment plans should be offered. This will ensure that any inconsistencies in understanding can be identified and addressed accordingly.

Effective communication is crucial when caring for the patient weaning from mechanical ventilation as this can educate and empower patients to enhance their own weaning process. The ICS (2014b) adds that communication aids, including picture cards are vital to reduce anxiety and prevent the patient from feeling isolated. Khalafi, Elahi and Ahmadi (2016) found that loss of communication skills, lack of professional knowledge and poor continuity of care can hinder the weaning process. It was found that a patient's confidence towards the nurse caring for them could be enhanced when the nurse provides constant communication, involving long-term face-to-face contact. Khalafi, Elahi and Ahmadi (2016) found that spending more time with the patient also had positive results for the nurse, as it gave the nurse more confidence in their clinical judgment, which lead to more effective decision-making and successful weaning.

Weaning protocols

Despite recommendations for Critical Care Units to develop and implement weaning protocols from as early as 2001 (MacIntyre et al, 2001), many Critical Care Units do not have a weaning protocol. Blackwood et al's (2011) Cochrane review, which is based upon Randomised Controlled Trials (RCT) and quasi RCT's, found that weaning protocols were associated with significant reductions in mechanical ventilation including; a 25% reduction in total duration of MV, a 78% reduction for the weaning duration and a 10% reduction in the length of stay. White, Currey and Botti (2011),

found that weaning protocols support the reduction in the duration of mechanical ventilation, improve patient outcomes, limit resource use and contain costs. Furthermore, Zhu et al (2015) found that the introduction of an evidenced based weaning protocol contributed to the quality improvement in the clinical outcome of mechanically ventilated patients. When Goodman (2006) developed, and implemented a weaning protocol in a district general hospital, the biggest improvement found was increased nurse autonomy and decision making. It also provided a tool to discuss a patient's weaning with medical staff.

Despite this, research has found that weaning protocols have been rarely used by nurses, with the rationale of it being considered as a guideline for decision making (Kydonaki, Huby and Tocher, 2013). Additionally, senior nurses advocated that they based decision making on clinical judgment and experience alone. Overall, despite there being significant evidence to support the development and implementation of weaning protocols on improving patient care, the issues highlighted suggest that clinical judgement and experience may be the biggest influencing factor in providing the most effective individualised weaning plan for a patient. Developing, trialling and implementing a weaning protocol within Critical Care Units are recommended to evaluate whether patient outcomes improve or nursing autonomy is increased. However, a strong evidence base could be difficult to find due to the number of influencing factors on weaning.

Conclusion

To conclude, weaning a patient from mechanical ventilation remains a complex process with many influencing factors. All members of the MDT must contribute accordingly to successfully wean a patient from mechanical ventilation. The critical

care nurses role is key in the management and care of the weaning patient, from continuously monitoring the patient, co-ordinating the MDT to providing holistic care. There is strong evidence that weaning protocols have displayed large reductions in the duration of mechanical ventilation. However, it is suggested that education, clinical judgement and experience may be the biggest influencing factor in providing the most effective weaning plan for the patient. Therefore, it is recommended that collaborative weaning protocols are developed and implemented in critical care units to evaluate if patient outcomes improve, or nursing autonomy is increased.

References

Adam, S.; Osborne, S. and Welch, J. (2017) *Critical Care Nursing* Science and Practice. 3rd. Oxford, Oxford University Press.

Blackwood, B., Alderdice, F., Burns, K., Cardwell, C., Lavery, G., O'Halloran, P. (2011) Use of weaning protocols for reducing duration of mechanical ventilation in critically ill adult patients: Cochrane systematic review and meta-analysis. *British Medical Journal.*[online] Vol. 342, c7237, pp:1-14. DOI:http://dx.doi.org/10.1136/bmj.c7237 [Accessed 4th Dec 2016].

Blot, S., Afonso, E and Labeau, S. (2014) Insights and advances in multidisciplinary critical care: a review of recent research. *American Journal of Critical Care*. 23, 1, 70-79.

Boles, J.M., Bion, J., Connors, A., Herridge, M., Marsh, B., Melot, C., Pearl, R., Silverman, H., Stanchina, M., Vieillard-Baron, A. and Welte, E. (2007) Weaning from mechanical ventilation. *European Respiratory Journal*. 29, 5, 1033-1056.

Cederwall, C-J., Plos, K., Rose, L., Dubeck, A. and Ringdal, M. (2014) Critical care nurses management of prolonged weaning: and interview study. *British Association of Critical Care Nurses*. 19, 5, 236-242.

Cutler, L.R. and Cutler, J.M. (2010) *Critical Care Nursing; made Incredibly Easy*. London, Lippincott Williams& Wilkins.

Danbury, D., Gould, T., Baudouin, S., Berry. A., Bolton, S., Borthwick, M., Brown, C., Himsworth, A., Khan, Z., Masterson G., Mcauslan-Crine, S., McFetridge, B., McGowan, S., Richardson. A., Segaran, E. and Steen, S. (2013) *Core Standards for*

Intensive Care Units. London, The Faculty of Intensive Care Medicine/The Intensive Care Society.

Davidson, C., Banham, S., Elliott, M., Kennedy, D., Gelder, C., Glossop, A., Church, C., Creagh-Brown, B., Dodd, J., Felton, T., Foëx, B., Mansfield, L., McDonnell, L., Parker, R., Patterson, C., Sovani, M. and Thomas, L. (2016) BTS/ICS Guidelines for the Ventilatory Management of Acute Hypercapnic Respiratory Failure in Adults. *Thorax*. 71, Supplement 2, 1-35.

Elkins, M. and Dentice, R. (2015) Inspiratory muscle training facilitates weaning from mechanical ventilation among patients in the intensive care unit: a systematic review. *Journal of Physiotherapy*. 61, 3, 125-134.

Goodman, S. (2006) Implementing a protocol for weaning patients off mechanical ventilation. *British Association of Critical Care Nurses.* 11, 1, 23-32.

Heunks, L. and van der Hoeven, J. (2010) Clinical review: the ABC of weaning failure- a structured approach. *Critical Care*. 14, 6, 245

Higginson, R., Jones, B. and Davies, K. (2010) Airway management for nurses: emergency assessment and care. *British Journal of Nursing*. 19, 16, 1006-1014.

Intensive Care Society (ICS) (2007) *Intensive care society guidelines – when and how to wean.* London, Intensive Care Society.

Intensive Care Society (ICS) (2014a) *Intensive care society review of best practice for analgesia and sedation in the critical care*. London, Intensive Care Society.

Intensive Care Society (ICS) (2014b) *Standards for the care of adult patients with a temporary tracheostomy; standards and guidelines*. London, Intensive Care Society.

Jeganathan, N.; Kaplan, C; and Balk, R. (2015) Ventilator liberation for high risk patients. *Respiratory Care*. 60, 2, 290-296

Khalafi, A., Elahi, N. and Ahmadi, F. (2016) Continuous care and patients' basic needs during weaning from mechanical ventilation: A qualitative study. *Intensive and Critical Care Nursing.* 37, 37-45.

Krinsley, J.S., Reddy, P.K., and Iqbal, A. (2012) What is the optimal rate of failed extubation? *Critical Care.* 16:111 DOI: 10.1186/cc11185 [Accessed 24 April 2017]

Kydonaki, K., Huby, G. and Tocher, J. (2013) Difficult to wean patients: cultural factors and their impact on weaning decision-making. *Journal of Clinical Nursing*. 23, 683-693.

Kydonaki, K., Huby, G., Tocher, J. and Aitken, L. (2016) Understanding nurses' decision making when managing weaning from mechanical ventilation: a study of novice and experienced critical care nurses in Scotland and Greece. *Journal of Clinical Nursing.* 3-4, 25, 434-444.

MacIntyre, N., Cook, D., Ely, W., Epstein, S., Fink, J., Heffner, J., Hess, D., Hubmayer, R. and Scheinhorn, D. (2001) Evidence-Based Guidelines for Weaning and Discontinuing Ventilatory Support. *Chest.* 120, 6, 375-395. Supplement.

Marshall, A., Cahill, N., Gramlich, L., MacDonald. G., Alberda, C. and Heyland, D. (2012) Optimising nutrition in intensive care units: empowering critical care nurses to be effective agents of change. *American Journal of Critical Care*. 21, 3, 186-194.

McGrath, B., Bates, L., Atkinson, D. and Moore, J. (2012) Multidisciplinary guidelines for the management of tracheostomy and laryngectomy airway emergencies. *Anaesthesia.* 67, 9, 1025–1041.

Medrinal, C., Prieur, G., Frenoy, E., Combret, Y., Gravier, F., Bonnevie, T., Poncet, A., Quesada, A., Lamia, B. and Contal, O. (2016) Is overlap of respiratory and limb muscle weakness at weaning from mechanical ventilation associated with poorer outcomes? *Intensive Care Medicine.* [online] http://dx.doi.org/10.1007/s00134-016-4626-7 [accessed 3rd Dec 2016]

Newmarch, C. (2006a) Caring for the mechanically ventilated patient: part one. *Nursing Standard.* 20, 17, 55-64.

Newmarch, C. (2006b) Caring for the mechanically ventilated patient: part two. *Nursing Standard.* 20, 18, 55-64.

Ntoumenopoulos, G. (2015) Rehabilitation during mechanical ventilation: Review of the recent literature. *Intensive and Critical Care Nursing*. 31, 3,125-132.

Ros, C., McNeill, L. and Bennet, P. (2009) Review: nurses can improve patient nutrition in intensive care. *Journal of Clinical Nursing*. 18, 17, 2406-2415.

Tingsvick, C., Johansson, K. and Martensson, J. (2015) Weaning from mechanical ventilation: factors that influence intensive care nurse's decision-making. British *Association of Critical Care Nurses*. 20, 1, 16-24

Warwick Clinical Trials Unit (2016) *Breathe*. [online], Last updated 5th Sep 2016, Available at: http://www2.warwick.ac.uk/fac/med/research/hscience/ctu/trials/critical/breathe [Accessed: 29th Dec 2016].

White, A. (2012) Long term mechanical ventilation: management strategies. *Respiratory Care*. 57, 6, 889-899.

White, V., Currey, J. and Botti, M. (2011) Multidisciplinary team developed and implemented protocols to assist mechanical ventilation weaning: A systematic review of literature. Worldviews on Evidence-Based Nursing. 8,1, 51-59.

Woodrow, P. (2102) Intensive Care Nursing; A framework for Practice. 3rd Edition. Oxon, Routledge.

Zhu, B., Zhiqiang, L., Jiang, L., Du, B., Jiang, Q., Wang, M., Lou, R. and Xi, X. (2015) Effect of a quality improvement program on weaning from mechanical ventilation: a cluster randomised trial. *Intensive Care Medicine*. 41, 10,1781-1790.