Manovacuometry as a predictor of extubation success

https://doi.org/10.56238/sevened2024.001-059

Armando Jarib Gonçalves Tavares[1], Blenda Alves Santana[2], Maisa Adriele Nalves da Silva[3], Paulla Romyna de Oliveira Souto[4], Elizângela Sofia Ribeiro Rodrigues[5], Agrinazio Geraldo Nascimento Neto[6], Geovane Rossone Reis[7] and Thais Bezerra de Almeida[8]

ABSTRACT

INTRODUCTION: In the Intensive Care Unit (ICU), patients in serious or risk condition, potentially recoverable, who require uninterrupted care, are submitted. Invasive mechanical ventilation (MV) is one of the therapeutic pillars for the treatment of critically ill patients, especially those with respiratory failure. The measurement of respiratory muscle strength is performed with the use of a manometer, this equipment is appropriate for measuring positive pressures (manometer) and negative pressures (vacuometer), consequently measuring inspiratory (MIP) and expiratory (MEP) muscle strength. In general, MIP above 60 cmH2O can be considered normal, values between 40 and 60 cmH2O may indicate normality unless there is visible weakness of other muscles, and values below 40 cmH2O indicate fatigue or respiratory muscle weakness. METHODOLOGY: This is a systematic literature review, carried out through a bibliographic survey related to the theme Novacuometry as a Predictor of Extubation Success. The inclusion criteria were: articles published from 2010 onwards, theses, dissertations in Portuguese and foreign languages. RESULTS: To start the research, we searched the databases for articles with the descriptors, totaling 72 scientific publications, of which 29 remained from the reading of the title, and they were used only once in the database that first referenced the article as a criterion for selection. After reading the abstracts, 18 remained, which make up this integrative review. DISCUSSIONS: Weaning indices from mechanical ventilation can be used in homogeneous populations, although the accuracy may be lower in these populations than in heterogeneous populations. The evaluation of MIP and MEP as a predictor of success in weaning from mechanical ventilation is a routine procedure. FINAL CONSIDERATIONS: In this study, it was possible to observe that the use of manovacuometry is effective to evaluate the strength of the respiratory muscles through MIP and MEP of each patient, thus promoting an increase in the success rates of extubations. The extubation process without an effective evaluation can lead to an increase in: retubation, length of stay on mechanical ventilation, mortality rate, days of hospitalization and, consequently, an increase in hospital costs.

Keywords: Extubation, Respiratory Muscles, Artificial Respiration.

[1] Physical Therapy Student, University of Gurupi (UNIRG)
E-mail: armandoj43038@gmail.com
[2] Physical Therapy Student, University of Gurupi (UNIRG)
E-mail: ablendasantana@gmail.com
[3] Physical Therapy Student, University of Gurupi (UNIRG)
E-mail: maisaadriele1998@gmail.com
[4] Physical Therapy Student, University of Gurupi (UNIRG)
E-mail: paullaromyna@outlook.com
[5] MSc in Physiotherapy, University of Gurupi (UNIRG)
E-mail: elizangelasrrodrigues@gmail.com
[6] Specialist in Physiotherapy, University of Gurupi (UNIRG)
E-mail: agrinaziogeraldo@gmail.com
[7] PhD in Physical Therapy, University of Gurupi (UNIRG)
E-mail: geovanerossone@unirg.edu.br
[8] Specialist in Physiotherapy, University of Gurupi (UNIRG)
E-mail: thais-tba@hotmail.com

INTRODUCTION

In the Intensive Care Unit (ICU), patients in serious or risk condition, potentially recoverable, who require uninterrupted care are submitted (Oliveira et al, 2010). Invasive mechanical ventilation (MV) is one of the therapeutic pillars for the treatment of critically ill patients, especially those with respiratory failure (Sabetzk and Cicotoste, 2009).

Mechanical ventilation may be used when patients are unable to maintain spontaneous breathing or require sedation to induce coma. Ventilatory support aims to maintain appropriate oxygenation and ventilation to provide respiratory comfort for the patient (Lopes et al, 2009; Davis et al, 2012; Fernández et al, 2013).

According to Lopes (2009), mechanical ventilation can subject the patient to some complications, such as: infections, barotrauma, cardiovascular injuries, tracheal injuries, oxygen toxicity, ventilator-induced lung injury, and diaphragmatic atrophy. It is common for patients to remain bedridden, leading to inactivity and immobility, predisposing factors for polyneuropathy and myopathy of critically ill patients (Dantas et al, 2012).

It is called prolonged mechanical ventilation after 48 hours of intubation. The process of ventilatory weaning begins, which refers to the process of transition from artificial ventilation to spontaneous ventilation in patients who remain on invasive mechanical ventilation. Ventilatory weaning is usually successful for most patients, at the beginning of the process it is necessary that the disease that contributed or caused the respiratory decompensation is stable or already resolved. (Epstein, 2009; Eskandar et al, 2007; Levine et al, 2008; Boles et al, 2007).

According to Epstein (2002), weaning from mechanical ventilation can be defined as a process of abrupt or gradual withdrawal of ventilatory support. Discontinuation of ventilatory support should be performed as soon as the patient is able to keep his/her airway protected and adequate spontaneous ventilation, but if the patient is a patient with acute respiratory failure and in severe conditions, this ventilatory weaning process should be more prolonged (Gehner, 2007).

Extubation is defined as the removal of the artificial airway. To this end, the Spontaneous Breathing Test (SBT) is previously performed to assess tolerance to spontaneous breathing prior to extubation (Boles, 2007).

The extubation process can lead to important consequences, as both delayed extubation and extubation failure have serious consequences, and thus there is a longer duration of mechanical ventilation and increased mortality. Premature discontinuation exerts strong stress on the respiratory and cardiovascular systems, unnecessary delays can lead to diaphragmatic hypotrophy (Epstein, 2002; Girard, 2008; Levine et al, 2008).

According to Epstein (2002), there is an incidence of unplanned extubation ranging from 0.3% to 16%, which can be performed by the patient himself, while 17% are accidental. Almost half

of the patients with self-extubation do not require reintubation, since many patients are kept on mechanical ventilation longer than necessary (Boles et al, 2007; Epstein 2000).

Respiratory muscle training (RMT) has been shown to be effective in alleviating respiratory complications, improving or redistributing ventilation, improving strength, fatigue resistance and respiratory muscle coordination, increasing cough effectiveness and promoting airway clearance, correcting inefficient breathing patterns and reducing respiratory work, thus improving general functional capacity and reducing complications caused by MV. (Doebber et al, 2015; Godoy et al, 2015).

Inspiratory muscle training (IMT) is a therapeutic resource used to promote the increase of strength and endurance of inspiratory muscles, which can contribute to successful weaning in a shorter time, based on three pillars: the overload imposed on the muscle; the specificity of training and the reversibility of muscle atrophy. (Nascimento et al, 2015)

According to Giustina, Montenezzo (2003) and Aguiar et al (2009), manovacuometry is a truly useful method for the evaluation of respiratory muscle pressures, emphasizing that Inspiratory Pressure (MIP) measurements are of greater clinical relevance due to the fact that inspiratory muscles support greater ventilatory workloads. Expiratory pressure (MEP) measurements are useful for differentiating between neuromuscular weakness of abdominal muscles and specific weakness of the diaphragm or other inspiratory muscles.

The measurement of respiratory muscle strength is performed with the use of a manometer, this equipment is appropriate to measure positive pressures (manometer) and negative pressures (vacuometer), consequently measuring inspiratory (MIP) and expiratory (MEP) muscle strength, with nostril occlusion and coupling to the mouthpiece. By the conventional method, the manometer will be coupled to a "T" unit, with one outlet closed and the other coupled to the patient's endotracheal tube. By the one-way valve method, one of the outlets of the "T" tube was attached to the endotracheal tube and the other to a low-resistance one-way valve that allowed only selective expiration. In general, MIP above 60 cmH2O can be considered normal, values between 40 and 60 cmH2O may indicate normality unless there is visible weakness of other muscles, and values below 40 cmH2O indicate fatigue or respiratory muscle weakness. (Junior & Gomes 2016).

Therefore, this research project aims to evaluate the relationship between the results obtained in the tests of muscle strength measurement through manovacuometry and the success in extubation of patients who remained under mechanical ventilation in the ICU.

METHODOLOGY

This is a systematic literature review, carried out through a bibliographic survey related to the theme Novacuometry as a Predictor of Extubation Success.

The inclusion criteria were: articles published from 2010 onwards, theses, dissertations in Portuguese and foreign languages.

On the other hand, the exclusion criteria adopted: publications smaller than the year 2010, which are not in Portuguese and foreign language and of a paid nature.

The searches were carried out in the following online databases: Medline (Online System for Search and Analysis of Medical Literature), Bvs (Virtual Health Library), Lilacs (Latin American and Caribbean Health Sciences Literature), Scielo (Online Electronic Scientific Library) and Google Scholar. The search strategy consisted of searching for the descriptors "Mechanical Ventilation"; "Manochorometer"; "MIP"; "PEmax"; "Extubation".

The data collection period was from June to November 2023 and the selection of articles was initially carried out by abstracts and according to the inclusion and exclusion criteria mentioned.

Since this is not a study with human beings or animals, the present study did not need to be submitted to the Research Ethics Committee, according to resolution 466/1.

RESULTS

To start the research, we searched for articles in the databases with the aforementioned descriptors, totaling 72 scientific publications, which, from the reading of the title, 29 remained, being used only once in the database that first referenced the article as a criterion for selection. After reading the abstracts, 18 remained, which make up this integrative review.

Table 1: Studies on manovacuometry as a predictor of extubation success, year of publication, title, authors, and main results.

Year of publication	Title	Authors	Main results
2010	Influence of different types of nozzles and tracheal diameters on manovacuometry	Onaga, Fabiane Inoue et al.	The results of our study show that the more anatomical shape of the rectangular mouthpiece favors less air escape, generating higher MEP values compared to the circular mouthpiece, however, for the MIP measurement there was no influence of the type of mouthpiece used, regardless of the volunteer's gender. Regarding the different tracheal diameters, no similar studies were found in the indexed literature that would allow further discussion. In this study, there was no interference in the MEP and MIP values, considering the internal diameters of 1.0 and 1.5 cm and the same tracheal length (80 cm).
2011	Assessment of inspiratory muscle strength (MIP) during weaning from mechanical ventilation in neurological patients admitted to the intensive care unit	Passarelli, Rita de Cássia Vianna et al.	The evaluation of MIP as a predictor of success in weaning from mechanical ventilation is a routine procedure. The usefulness of MIP measurement in patients requiring ventilatory support has been demonstrated by values obtained to predict the success of weaning from mechanical ventilation.

2011	Rapid and shallow breathing index as a predictor of extubation success for invasive mechanical ventilation: evaluation in a general population of critically ill patients and subdivided into different comorbidities	Hahn, Cássia Elisa Barth.	The results of this study demonstrate that the variables related to the Rapid Shallow Breathing Index, RSRI 1, RSRI 2, and RSRI Delta were always smaller and statistically significant in patients who were successful in extubation, demonstrating that such variables are related to success or failure in the invasive mechanical ventilation extubation test.
2011	Efficacy of the FerrariTadini ventilatory weaning rate in an intensive care unit of a public hospital in Fortaleza/CE	Bastos, Vasco Pinheiro Diógenes	In the present study, only two patients returned to mechanical ventilation, i.e., they were unsuccessful after extubation, which represents 90.91% (n = 6) of effectiveness in the extubation process. This finding is similar to the study 192 Fisioterapia Brasil - Volume 12 - Number 3 - May/June 2011 by Ferrari-Tadini [4], which reports that for this same population studied, the effectiveness of mechanical ventilation withdrawal was 66.7% of the cases.
2011	Predictive parameters for weaning from mechanical ventilation	Nemer, Sérgio Nogueira; Barbas, Carmen Sílvia Valente.	Among the numerous parameters, the most well-known and used is the rapid and shallow breathing index, or RR/VT ratio. (25,26) The RR/VT ratio has been evaluated in more than 22 studies,(26) and has been mentioned and frequently recommended in major reviews of weaned.
2011	Impact of the use of a digital vacuum gauge and one-way valve on respiratory indices predictors of ventilatory weaning	Souza, Leonardo Cordeiro et al.	In the present study, we sought to re-evaluate the predictive performance of MIP in comparison with P0.1 and P0.1/MIP in a new scenario. The measurements were made using a digital vacuum gauge, which allows measurements every 100 ms with an accuracy of 1 cmH2O, under a one-way valve in contrast to previous studies.
2012	Criteria associated with success and failure weaning from mechanical ventilation	De Barros, Juliana El-Hage Meyer et al	Regarding success and failure in weaning from mechanical ventilation, failure in weaning from mechanical ventilation usually occurs due to an imbalance between respiratory muscle pump and respiratory muscle load. In most cases, weaning failure is multifactorial. Some causes of failure are: alteration of respiratory mechanics, due to high resistance or low compliance, pulmonary congestion, increased oxygen demand, muscle atrophy due to inactivity, polyneuromyopathy of the critically ill patient, hydroelectrolyte disorders, among others.
2014	Evaluation of Respiratory Muscle Strength in Patients Undergoing Prolonged Mechanical Ventilation Before and Post Extubation in a Hospital in Fortaleza/CE	Moreira, Priscila Mesquita et al	The sample consisted of 12 patients who were on prolonged mechanical ventilation and in the extubation phase. When the values of maximal pressures before extubation were analyzed, a mean of -38.3 ± 3.01 cmH2 O was found for maximal inspiratory pressure and + 47.5 ± 3.36 cmH2 O for maximal expiratory pressure. The values after 24 hours of extubation were -47 ± 3.36 cmH2 O for maximal inspiratory pressure and + 50 ± 6.25 cmH2 O for maximal expiratory pressure.
2014	Evaluation of respiratory functionality in patients with prolonged hospital stay	Silva, Bruna Camila Araujo et al.	The assessment of respiratory muscle strength, lung volumes, and lung capacities by manovacuometry and ventilometry, respectively, are practical and non-invasive tools of respiratory physiotherapy that can allow the estimation of respiratory capacity and the risks of pulmonary complications.

2015	Maximal inspiratory pressure and rapid and shallow breathing index as predictors of successful ventilatory weaning	Dos Santos Bien, Umilson et al.	Logistic regression analysis showed that both MIP and RSBI contributed significantly to explain the success of ventilatory weaning, with a higher odds ratio found for MIP. Another important finding of the present study was the non-difference in the PaO2/FiO2 ratio between the success and failure groups. This suggests little importance of the variation in oxygen levels in predicting the success of ventilatory weaning in the present sample. It is probable that, since the ERT, the patients have always had a PaO2/FiO2 ratio greater than 150, which characterizes the absence of gas exchange disorder
2016	Predictors of extubation failure in an intensive care unit	Lopes, Juralice de Sousa Campos et al	In the Hayashi et al study, the following were considered as clinical predictors of extubation failure at the time of SBT, the lowering of the level of consciousness, sweating and agitation, significant worsening of arterial pH or partial pressure of carbon dioxide gas in the arterial blood (PaCO2); decrease in gas exchange with partial pressure of oxygen in arterial blood (PaO2) lower than 60mmHg, with the need for oxygen fractions greater than 0.5, maintaining SaO2 below 90%, increased work of breathing (tachypnea, use of accessory muscles and change in respiratory muscle pattern), body temperature > 38ºC, 20% increase or decrease in systolic blood pressure and the need to use vasoactive drugs in doses greater than 5mg/kg by weight bodily.
2018	Weaning from mechanical ventilation of critically ill adult patients: a review of the use of protocols	Marinho, Robson Inácio et al.	Most of the studies (60%) performed the SBT of patients undergoing MV through the T-tube associated with oxygen therapy, while the others were performed through the PSV mode, showing slight differences in the levels of pressure support (PS) used (PS between 5 and 7 cmH2O; PEEP between 5 and 10 cmH2O). The absolute frequency of use of predictors of MV weaning is shown in Figure 2, in which a preference for the use of the Rapid and Shallow Breathing Index (RSBI) and Maximal Inspiratory Pressure (MIP) can be observed.
2019	Behavior of maximal inspiratory pressure and rapid shallow breathing index values during the spontaneous breathing test	De França, Eduardo Eriko Tenório et al	In the present study, the influence of SBT performed for 30 min was evidenced, both in the PSV group and in the T-tube group, on the values of MIP and SRBI. However, the MIP behavior varied when comparing the modes of performing the ERT, where greater variations were observed in the "T-tube" group
2019	Weaning strategies from mechanical ventilation in an intensive care unit	De Azevedo Muniz, Yasmin et al..	The Brazilian MV Guidelines advise classifying weaning as easy (success in the first SBT) and difficult (when the patient fails the first SBT and requires up to three ERTs or up to seven days after the first SBT). Studies have observed that patients with difficult weaning were unable to perform or maintain spontaneous breathing, resulting in failure.
2019	Clinical profile and predictive rates of weaning of extubated patients in an intensive care unit in Fortaleza, CE	De Medeiros, Ana Irene Carlos; Da Silva, Lailane Saturnino; Bastos, Vasco Pinheiro Diógenes..	The mean age in the sample was 54.8±12.3 years, similar to other Brazilian studies16–18, and, although age > 65 years was identified as a risk factor for extubation failure18, in the present study, there was no difference in age in the comparison between patients who successfully or unsuccessfully extubated patients. The MV time in the study was 8.7±4.2 days, lower than in the study by Santos et al.19, in which the time was 11.35 ± 7.99 days, and longer than in the study by Silva et al.18, which was 4.7 ± 3.7 days. Teixeira et al.14 and Ribeiro et al.20 reported that the longer the MV time, the lower the chances of successful weaning.

2020	Risk factors for extubation failure and their clinical implications in an intensive care unit	Kavaturo, Juliana Harumi Hattori Sakuragi et al.	Causes of respiratory failure and comorbidities were not significantly correlated with extubation failure in the present study. However, some authors have observed that pneumonia as a cause of the initiation of invasive ventilatory support and comorbidities such as heart failure, chronic respiratory diseases, and neurological diseases were factors significantly associated with the occurrence of extubation failure, which may not have been identified in this study due to the small sample included or the clinical profile of the individuals studied.
2020	Predictive capacity of ventilatory weaning rates in the extubation outcome of mechanically ventilated adult patients: a systematic review	Costa, Francineide Fernandes; Perazzo, Renata Cavalcanti Farias; Nóbrega, Júlia Cristina Leite.	Several predictors of extubation outcome were identified, including respiratory rate (RR), respiratory rate variability (RSV), left ventricular ejection fraction (LVEF), inspiratory flow signal power index (Pi), evaluation of cough efficacy, ICU Acquired Muscle Weakness (ICU-FM), respiratory muscle weakness, Rapid and Shallow Breathing Index (SSRI), ERT, analysis of pulmonary aeration and diaphragmatic thickness by USG.
2020	The effects of inspiratory muscle training in patients on invasive mechanical ventilation in the weaning process: a literature review	EpaminondaS, Lorena Cristine Soares; Dias, Williane Sarmento; Dos Santos, Renato Caldas.	Inspiratory muscle training (IMT) is an intervention that has been adopted to improve the strength and resistance to fatigue of the inspiratory muscles in patients with respiratory function alterations, and can be performed by means of counter-resistance breathing, through a linear Threshold device, the most widely used method for specific training of the inspiratory muscles. The use of this device favors the increase of the strength and endurance of the respiratory muscles, with the purpose of facilitating the weaning of MV.

Source: Own authorship (2023).

DISCUSSIONS

Weaning indices from mechanical ventilation can be used in homogeneous populations, although the accuracy may be lower in these than in heterogeneous populations. The evaluation of MVD indices in neurological patients seems to be the least indicated among those referring to homogeneous populations. Integrative indices are generally more accurate, although they may also have limited accuracy in predicting extubation. MVD indices are useful in identifying patients who are likely to be unable to tolerate MVD due to a high risk of failure. And they will also be useful for the possible identification of reversible causes of MVD failure, serving as a focus in the approach of a new trial (Sérgio and Carmem, 2011).

Inspiratory muscle training (IMT) is an intervention that has been adopted to improve the strength and fatigue resistance of inspiratory muscles in patients with respiratory function alterations, and can be performed through counter-resistance breathing, through a linear Threshold device, the most widely used method for specific inspiratory muscle training. The use of this device favors the increase of the strength and endurance of the respiratory muscles, with the purpose of facilitating weaning from mechanical ventilation.

According to Moreira 2014, an improvement in respiratory muscle strength is observed after 24 hours of extubation, suggesting that prolonged MV can cause respiratory muscle weakness and hypotrophy and consequently hinder the process of weaning from MV and extubation.

According to (Onaga *et al*, 2010) there was no interference in the values obtained from MIP and MEP regarding tracheal diameters, however, the types of mouthpieces used in analog manometers may interfere with the values obtained from MEP. It is proposed that, in the clinical routine, MEP measurements should be performed with a rectangular mouthpiece, which offers a more anatomical shape, with less air escape. According to (Souza *et al*, 2011), MIP obtained by digital technology with the use of a one-way valve showed a better performance as a predictor of ventilatory weaning when compared to P0.1, also exhibiting a tendency to be higher than P0.1/MIP.

According to (Passarelli *et al*, 2011), the evaluation of MIP as a predictor of success in weaning from mechanical ventilation is a routine procedure. Most of the related studies demonstrate 80% sensitivity, but with 25% specificity, i.e., it is possible that patients who fail to be weaned do not necessarily have a reduced MIP. In addition, its reproducibility is questionable, due to the diversity of methods and difficulty in standardizing the technique, and yet most studies do not include homogeneous populations.

According to (Juliana, 2012), after analyzing the results, it can be observed that only the clinical criteria did not meet satisfactory conditions for weaning, especially for the group of patients with failure with regard to the reversal of the cause that led them to mechanical ventilation, improvement of the neurological level and positive fluid balance. However, in general, the data found in this study were within acceptable conditions for weaning for both the success and failure groups, showing that despite the fulfillment of clinical, physiological and predictive criteria, patients may evolve with weaning failure and require reintubation, i.e., the criteria to predict weaning are relevant points to be considered before extubation. However, the patient's bedside clinical evaluation should also be analyzed, and a decision should be made according to the sum of the evaluations. Finally, in order to optimize this process, it is necessary to implement weaning protocols that could contribute to post-extubation success and the institution of early noninvasive mechanical ventilation, as recommended by the current literature.

FINAL THOUGHTS

In this study, it was possible to observe that the use of manovacuometry is effective to assess the strength of the respiratory muscles through MIP and MEP of each patient, thus promoting an increase in the success rates of extubations. The extubation process without an effective evaluation can lead to an increase in: retubation, length of stay on mechanical ventilation, mortality rate, days of hospitalization and, consequently, an increase in hospital costs.

New randomized studies with robust statistical methodologies should be conducted in order to seek objective guidelines that reduce the probability of extubation failure.

REFERENCES

1. Aguiar, A. C. S., Morais, F. D., Correia, D. R., Barbosa, H. C. F., Gléria, P. D. M., & Fernandes, V. C. C. (2009). Análise da atuação fisioterapêutica em relação à força muscular respiratória em pacientes submetidos à cirurgia bariátrica. *Revista Movimenta*, 2(2), 54-58.

2. Araújo, B. (2014). Avaliação da funcionalidade respiratória em pacientes com tempo prolongado de internação hospitalar. Disponível em: file:///C:/Users/Laura%20Fisnack/Downloads/V32_n4_2014_p433a438%20(1).pdf

3. ATS/ERS Statement on respiratory muscle testing. (2002). *American Journal of Respiratory and Critical Care Medicine*, 166, 518-624.

4. Boles, J. M., Bion, J., Cormors, A., Herridge, M., Marsh, B., Melot, C., et al. (2007). Weaning from mechanical ventilation. *European Respiratory Journal*, 29(5), 1033-1056.

5. Dantas, C. M., Silva, P. F., Siqueira, F. H., Pinto, R. M., Matias, S., Maciel, C., et al. (2012). Influência da mobilização precoce na força muscular periférica e respiratória em pacientes críticos. *Revista Brasileira de Terapia Intensiva*, 24(2), 173-178.

6. Davis, R. T., Bruells, C. S., Stabley, J. N., McCullough, D. J., Powers, S. K., & Behnke, B. J. (2012). Mechanical ventilation reduces rat diaphragm blood flow and impairs oxygen delivery and uptake. *Critical Care Medicine*, 40(10), 2858-2866.

7. Doebber, L. G., Argett, S. P., Silva, T. P., & Callegaro, C. C. (2015). Efeitos clínicos do treinamento muscular inspiratório em pacientes sob ventilação mecânica invasiva: uma revisão integrativa. XX Seminário Interinstitucional de Ensino, Pesquisa e Extensão.

8. Epstein, S. K. (2009). Weaning from mechanical support. *Current Opinion in Critical Care*, 15, 36-43.

9. Epstein, S. K. (2002). Decision to extubate. *Intensive Care Medicine*, 28, 535–546.

10. Eskandar, N., & Apostolakos, M. J. (2007). Weaning from mechanical ventilation. *Critical Care Clinics*, 23(2), 263-274.

11. Epstein, S. K., Nevins, M. L., & Chung, J. (2000). Effect of unplanned extubation on outcome of mechanical ventilation. *American Journal of Respiratory and Critical Care Medicine*, 161, 1912–1916.

12. Ely, E. W. (2000). The utility of weaning protocols to expedite liberation from mechanical ventilation. *Respiratory Care Clinics of North America*, 6, 303-319.

13. Esteban, A., Alia, I., Ibanez, J., Benito, S., & Tobin, M. J. (1994). Modes of mechanical ventilation and weaning. A national survey of Spanish hospitals. The Spanish Lung Failure Collaborative Group. *Chest*, 106, 1188–1193.

14. Fernandez, J., Migueena, D., Mulett, H., Godoy, J., & Martinón-Torres, F. (2013). Adaptive support ventilation: State of the art review. *Indian Journal of Critical Care Medicine*, 17(1), 16-22.

15. Gehner, C. (2007). Parâmetros preditivos para o sucesso do desmame da ventilação mecânica em pacientes com acidente vascular cerebral e traumatismo crânio-encefálico. Dissertação de mestrado, Universidade Federal do Rio Grande do Sul.

16. Girard, T. D., & Ely, W. E. (2008). Protocol-driven ventilator weaning: Reviewing the evidence. *Clinics in Chest Medicine*, 29, 241-252.

17. Godoy, M. D., Costa, H. L., Neto, A. E., Serejo, A. L., Souza, L. C., Kalil, M. R., Kalil, R. F., Monteiro, L. F., Souza, O. G., Freitas, M. R., & Bastos, V. H. (2015). Fraqueza muscular adquirida na UTI (ICU-AW): efeitos sistêmicos da eletroestimulação neuromuscular. *Revista Brasileira de Neurologia*, 51(4), 110-113.

18. Giustina, A. P. D., & Montemezzo, D. (2003). Análise das pressões musculares respiratórias em indivíduos portadores da Síndrome de Down. Santa Catarina.

19. Inoue, F. (n.d.). Influência de diferentes tipos de bocais e diâmetros de traqueias na manovacuometria. Disponível em: file:///C:/Users/Laura%20Fisnack/Downloads/download%20aeee.pdf

20. Junior, B. R., & Gomes-Neto, M. (2016). Treinamento Muscular Inspiratório no Ambiente Hospitalar: Protocolo para um Ensaio Clínico Randomizado. *Revista Pesquisa em Fisioterapia*, 6(2).

21. Levine, S., Nguyen, T., Taylor, N., Friscia, M. E., Budak, M. T., Rothenberg, P., et al. (2008). Rapide disuse atrophy of diaphragm fibers in mechanically ventilated humans. *New England Journal of Medicine*, 358(13), 1327-1335.

22. Lopes, C. R., Sales, A. L. M., Simões, M. D. J., Angelis, M. A., & Oliveira, N. M. L. (2009). Efeitos agudos da ventilação mecânica com hiperoxia na morfometria do diafragma de ratos. *Revista Brasileira de Fisioterapia*, 13(6), 487-492.

23. Meade, A. (n.d.). Prevendo o sucesso no desmame da ventilação mecânica. Disponível em: https://pubmed.ncbi.nlm.nih.gov/11742961/

24. Nascimento, L. P., Andrade, A. L., Faria, T. C., Souza, L., Rocha, C. B., Carvalho, S. M., & Borges, J. B. (2015). Treinamento muscular respiratório em Distrofia Muscular de Duchenne. *Revista Neurociências*, 23(1), 9-15.

25. Oliveira, A. B. F., Dias, O. M., Mello, M. M., Araujo, S., Dragosavac, D., Nucci, et al. (2010). Fatores associados à maior mortalidade e tempo de internação prolongado em uma unidade de terapia intensiva de adultos. *Revista Brasileira de Terapia Intensiva*, 22(3), 250-256.

26. Sabetzk, S. M., & Cicotoste, C. L. (2015). Desmame Ventilatório de pacientes cardíacos, internados na unidade coronariana: comparação entre SIMV, PSV e TUBO-T [resumo]. *Anais do 3º Seminário de Fisioterapia 38 | ASSOBRAFIR Ciência*, 6(1), 31-39 da Uniamérica.

27. Sackett, D., Straus, S. E., Richardson, W. S., Rosenberg, W., & Haynes, R. B. (2003). *Medicina baseada em evidências* (2ª ed.). ArtMed.

28. Santos, R. M. G., et al. (2017). Manovacuometria realizada por meio de traqueias de diferentes comprimentos. *Fisioterapia e Pesquisa*, 24, 9-14.

29. Nogueira, S. (n.d.). Avaliação da forma muscular respiratória (PiMAX). Disponível em: file:///C:/Users/Laura%20Fisnack/Downloads/sergionnemer.pdf