PREDICTION OF SUCCESSFUL EXTUBATION FOR PATIENTS WEANED FROM MECHANICAL VENTILATION

Hashem T, MBBCH , Korraa E, MD and El Bouhy MS, MD, (2009): Thesis submitted for master degree in chest diseases Faculty of Medicine, Ain Shams University.

Abstract

Successful implementation **of weaning** protocols requires **criteria** that enable staff to identify patients who have a high probability **of** being successfully disconnected from mechanical ventilation so that the **weaning** protocol can be initiated. Ideally these **criteria** should be simple, easy to collect, have low or insignificant cost, and predict subsequent **weaning** and extubation success.

The aim of this study was to evaluate, and compare the sensitivity and specificity of two of the most popular tests in prediction of the weaning outcome and extubation: Rapid Shallow Breathing Index (RSBI), and Maximal Inspiratory Pressure (Pimax) in patients presented with respiratory failure and mechanically ventilated for 48 hours or less.

Thirty weanable patients were randomly and equally divided into two groups: group (1) and group (2) at which different predictor of successful extubation was applied on. (Pimax) in group 1 and rapid shallow breathing index (RSBI) in group 2, both was measured at 30 min from the beginning of SBT.

Patients who maintained accepted ABGs, conscious level, vital data (blood pressure, pulse and respiratory rate), efficient cough reflex

and most important matched with clinical evaluation, were finally extubated and considered successful outcome of the trial of extubation.

Any patient who showed any deterioration of the previous parameters at any time of SBT was reconnected again to the ventilator and considered failed trial of extubation.

The outcome of the study in group 1 was: successful extubation of 11 patients (73%), and failed trial of extubation in 4 patients (27%).

The outcome of the study in group 1 was: successful extubation of 11 patients (73%), and failed trial of extubation in 4 patients (27%) also.

Sensitivity of Pimax was 90 %, and specificity of Pimax was 100 %. But sensitivity of RSBI was 100 %, and the specificity of RSBI was 75 %.

INTRODUCTION

Discontinuing mechanical ventilation (MV) at the earliest opportunity will decrease the risk of developing ventilator-associated pneumonia and upper airway injury from prolonged intubation. However, premature extubation resulting in re-intubation is associated with an increased morbidity and mortality ***(Walsh et al., 2004).***

There are several parameters that are commonly used to predict the outcome of the weaning process for a patient's from mechanical ventilatory support. In the same time clinical judgment and experience play a large role in the physician's decision to withdraw mechanical ventilatory support. If a patient cannot be extubated and/or if the results of predicting tests are not satisfactory, the reason for the failure must be evaluated and treated ***(Maclntyre, 2005).***

Aim of the Work

The aim of this study is to evaluate and compare the sensitivity and specificity of Rapid Shallow Breathing Index (RSBI), and Maximal Inspiratory Pressure (Pi max) in prediction of successful extubation of patients presented with respiratory failure and mechanically ventilated.

Patients and Methods

Prospective randomized study was conducted at the Respiratory Intensive Care Unit (RICU) at Al-Abbassia Chest Diseases Hospital, at the period from July 2007 to February 2008. This study included 30 weanable patients presented with respiratory failure due to chest problem and necessitating mechanical ventilatory support, and all were mechanically ventilated for a period of 48 hours or less. These thirty weanable patients were randomly and equally divided into two groups: group (1) and group (2) at which different predictor of successfull extubation was applied on.

1. Prediction of successful extubation was done using measurement of: Maximum inspiratory pressure (Pi max) in group 1 and rapid shallow breathing index (RSBI) in group 2, both at 30 min from the beginning of SBT.

2. Patients that maintained accepted ABGs, conscious level, vital data (blood pressure, pulse and respiratory rate), efficient cough reflex (checked by passing a catheter through the endotracheal- tube to the trachea) and most important matched with clinical evaluation, were finally extubated and considered successful outcome of the trial of extubation.

3. Any patient who showed any deterioration of the previous parameters at any time of SBT was reconnected again to the ventilator and considered failed trial of extubation.

- ~~1.~~ RSBI is considered +ve if ≤105 and –ve if >105.
- Pimax is considered +ve if ≤ -20 and –ve if > -20cm H2O.

Formatted: List Paragraph, Justified, Bulleted + Level: 2 + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Statistical Analysis of Data

- **Analysis of data was done by IBM computer using SPSS (statistical program for social science) v15.0.**
- P value and correlation are significant at or below the 0.01 level (2-tailed).

RESULTS

- The achieved value of Pimax for the patients in group (1) varied from **(– 20) to (– 5**) cm H_2O with a mean value (**-15.6667**) cm H_2O, and SD ± **6.5**.
- The achieved value of RSBI for the patients in group 2 varied from **(33)** to (**112.5)** with a mean value (**60.7**), and SD ± **27.8**.
- In group (1) there was 11 patients extubated successfully and 4 patients failed in the trial. Pimax was +ve (≤ -20cmH2O) in 10 of the extubated patients, and –ve (≥ -20cmH2O) in one of them and in the four patients who failed in the trial.
- In group (2) there was also 11 patients extubated successfully and 4 patients failed in the trial. RSBI was +ve (<105) in all of the extubated patients and in one of the failed patients, and it was –ve (>105) in 3 of the failed patients.
- The outcome of this study in group 1was: successful extubation of 11 patients (73%), and failed trial of extubation in 4 patients (27%).
- The outcome of this study in group 2 was also: successful

extubation of 11 patients (73%), and failed trial of extubation in 4 patients (27%).

- ~~1.~~ Correlation between Pimax and successful extubation was negative. The lesser (more negative) Pimax was accompanied with higher possibility for successful extubation which was statistically significant, with a ***P value*** of 0.000.
- The successful extubation was negatively correlated to RSBI. The lower RSBI was accompanied with more possibility for successful extubation, which was statistically significant with *p value* of 0.000
- The results obtained in the present study showed that both tests had high sensitivity, but there was higher sensitivity for RSBI (100%) than Pimax (90%). Also there was higher specifity for Pimax (100%) than RSBI (75%), as all the weaned patients in group 2 had RSBI < 105, and all the failed patients in group 1 had Pimax > -20. However, there was one patient extubated with Pimax > -20 and one patient failed with RSBI < 105.

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Indent at: 0.5", Tab stops: Not at 0.5"

Discussion

In the present study, Pimax ≤ -20 was accompanied with high possibility for successful extubation, and Pimax ≥ -20 was accompanied with high possibility of failed trial of extubation (negative correlation).

That may be due to the ability of Pimax to identify an imbalance between respiratory capacity and load, which is the principal cause for weaning failure. The more negative Pimax, the more powerful respiratory muscles are ***(Gandia and Blanco, 1992).***

Similarly, the guidelines of determination of extubation readiness by ***American Association for Respiratory Care (AARC) (2007),*** included Pimax < -30 cm H_2O, and may accept Pimax < -20 cmH_2O in current clinical practice.

On the other hand, ***Leitch et al. (1996***) not only failed to confirm this importance of Pimax, but also they showed that Pimax was less accurate in predicting success than other indices**.**

This could be related to the difficulty of measuring Pimax in the mechanically ventilated patients who are more susceptible to fatigue, respiratory distress, and poor cooperation which is essential for this test, so the results of Pimax might not be applicable to these ICU patients ***(Caruso et al., 1999).***

In the current study, RSBI < 105 was accompanied with high possibility of successful extubation,1 and RSBI > 105 was accompanied with high possibility of failed trial of extubation (negative correlation).

This coincides with the guidelines of determination of extubation readiness by ***American Association for Respiratory Care (AARC) (2007),*** that included in adults, a rapid shallow breathing index of ≤ 105 breaths/min/L.

In contrast to these studies ***Meade et al. (2001)*** found that pooled results for RSBI showed that a positive result is minimally helpful in increasing the probability of successful weaning. They explained these results by that clinicians already have considered the results when they choose patients for trials of weaning. For instance, clinicians rarely test patients who had very high RR, or patients whose tidal volumes were very low for their ability to wean. Thus, the range of results was relatively narrow. The more narrow the range of results, the less likely that a test can discriminate between patients destined to fail a weaning trial and those destined to succeed.

The results obtained in the present study showed that both tests had high sensitivity, but there was higher sensitivity for RSBI (100%) than Pimax (90%). Also there was higher specifity for Pimax (100%) than RSBI (75%) .

This coincide with the observations of ***Macnaughton (2007),*** when he found that the Maximum inspiratory pressure (Pimax < –20 cm H2O) was of limited use because a number of patients failing this test may still wean satisfactorily. RSBI was the most sensitive and specific predictor of weaning failure in his study. This was assessed during a trial of spontaneous breathing or with a minimal level of pressure support ventilation (< 8 cm H_2O). A rapid shallow breathing index of more than 105 predicted weaning failure in 97% of patients.

The results obtained in the present study showed that both tests had high sensitivity, but there was higher sensitivity for RSBI (100%) than Pimax (90%). Also there was higher specifity for Pimax (100%) than RSBI (75%) .

CONCLUSION

- ~~1.~~ Using (RSBI <105) and Pimax < -20, during SBT is useful in predicting the outcome of the weaning process.

Formatted: Indent: Before: 0", Space After: 0 pt, Bulleted + Level: 1 + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5", Tab stops: 0.25", List tab + Not at 0.5"

- ~~2.~~ Because failed attempts at weaning have adverse effects on the mental and physical wellbeing of the patient, these simple bedside tests predicting success are desirable.

American Association for Respiratory Care (AARC) (2007): Removal of the endotracheal tube, revision & update**.** Respir Car Jan; 52(1):81-93.

Caruso P, Friedrich C, Denari S, et al. (1999): Unidirectional valve is the best method to determine maximal inspiratory pressure during weaning**,** American college of chest physicians.

Gandia F and Blanco J (1992): Evaluation of indexes predicting the outcome of ventilator weaning and value of adding supplemental inspiratory load. Intensive Care Med; 18: 327–33.

Leitch EA, Moran JL, Grealy B (1996): Weaning and extubation in the intensive care unit: clinical or index-driven approach? Intensive Care Med 22:752-759**.**

Macintyre NR (2005): Current issues in mechanical ventilation for respiratory failure**.** Chest; 128: 561s–567s.

Macnaughton Peter D (2007): Ventilatory support in the ICU. Intensive care anaesthesia and Intensive care Medicine 8:11 489.

Meade M,Guyatt G, Cook D, et al. (2001): Predicting Success in Weaning From Mechanical Ventilation, American College of Chest Physicians, Chest; 120:400S-424S.

Walsh TS, Dodds S and McArdle F (2004): Evaluation **of** simple criteria to predict successful weaning from mechanical ventilation in intensive care patients**.** The Board of Management and Trustees of the British Journal of Anaesthesia

INTRODUCTION

The requirement for ventilatory support using positive pressure ventilation to correct the blood gas abnormalities associated with acute respiratory failure is the most common indication for ICU admission ***(Tobin, 2001).***

The decision to commence ventilatory support depends on the clinical assessment of the patient rather than arbitrary blood gas value, which reflects both on the severity of the acute episode and the degree of chronic impairment of respiratory function. However, severe hypoxaemia (PaO_2 < 8 kPa) despite high-flow oxygen or a deteriorating respiratory acidosis (pH <7.3) is a common indication for instituting ventilatory support ***(Maclintyre, 2005).***

Discontinuing mechanical ventilation (MV) at the earliest opportunity will decrease the risk of developing ventilator-associated pneumonia and upper airway injury from prolonged intubation. However, premature extubation resulting in re-intubation is associated with an increased morbidity and mortality ***(Walsh et al., 2004).***

Choosing the right time for a successful discontinuation of MV, in the light of available physiologic and laboratory factors, remains a challenge ***(Manthous et al., 1998).***

The ability to sustain spontaneous ventilation depends on a normal central respiratory drive, the capacity of the respiratory muscles and the imposed load from the resistance and compliance of the respiratory system. The spontaneous breathing trial (SBT) is the most direct way to assess a patient's ability to breathe without mechanical ventilatory support; however, a failed SBT may not be predictive of ventilator dependence ***(Hanneman, 2004).***

Successful implementation of weaning protocols requires criteria that enable staff to identify patients who have a high probability of being successfully disconnected from mechanical ventilation so that the weaning protocol can be initiated. Ideally these criteria should be simple, easy to collect, have low or insignificant cost, and predict subsequent weaning and extubation success. Such criteria are likely to be specific to individual ICUs because of heterogeneity in case mix and organization between units **(*Macnaughton, 2007*).**

Aim of the Work

The aim of this study is to evaluate and compare the sensitivity and specificity of Rapid Shallow Breathing Index (RSBI), and Maximal Inspiratory Pressure (Pi max) in prediction of successful extubation of patients presented with respiratory failure and mechanically ventilated.

RESPIRATORY FAILURE

Definition:

Respiratory failure (R.F) it is a medical term for inadequate gas exchange by the respiratory system. It is indicated by observing a drop in blood oxygen level (hypoxemia) and/or a rise in arterial carbon dioxide (hypercapnia) which can be written as (PaO_2< 60 mmHg. (8.0 kPa),$PaCO_2$ > 45 mmHg (6.0 kPa) ***(Andrews et al., 2006).***

Classification:

RF may be classified as hypoxemic or hypercapnic and may be either acute or chronic. While acute respiratory failure is characterized by life-threatening derangements in arterial blood gases and acid-base status, the manifestations of chronic respiratory failure are less dramatic and may not be as readily apparent ***(Spearman et al., 1982).***

Type I:

- Type 1 RF is defined as hypoxia without hypercapnia, indeed the CO_2 level may be normal or low. It is typically caused by a ventilation/perfusion mismatch; the air flowing in and out of the lungs is not matched with the flow of blood to the lungs ***(Hall et al., 2000).***

Type II:

- Type 2 RF is defined as build up of carbon dioxide that has been generated by the body. The underlying causes are: reduced breathing effort (in the fatigued patient), increased resistance to breathing (such as in asthma) or an increase in the area of the lung that is not available for gas exchange (such as in emphysema) ***(Roussos, 1985).***

Other types of RF:

Type III, Perioperative respiratory failure:

The physician frequently encounters patients in the perioperative period who are unusually susceptible to atelectasis as a primary mechanism causing type III or perioperative respiratory failure. In general, abnormal abdominal mechanics reduce the end-expired lung volume (↓FRC) below the increased closing volume (↑CV) in these patients, leading to progressive collapse of dependent lung units. The end result can be type I, or type II RF, or both ***(Raju and Manthous, 2000).***

Type IV, Hypoperfusion states cause RF:

A significant number of ventilated patients fall outside the categories of type I, II, or III respiratory failure. These are the patients who have been intubated and stabilized with ventilator support during resuscitation from a hypoperfusion state, so type IV RF is most commonly due to cardiogenic, hypovolemic, or septic shock without associated pulmonary problems ***(Roussos et al., 1992).***

The appropriate rationale for ventilator therapy in these patients who are frequently tachypneic with erratic respiratory patterns is to stabilize gas exchange and minimize the steal of a limited cardiac output by the working respiratory muscles until the mechanism for the hypoperfusion state is identified and corrected. Note that liberation from the ventilator of the patient with type IV RF is simple: when shock is corrected, the patient resumes spontaneous breathing and is extubated ***(Ward et al., 1992).***

Distinctions between acute and chronic RF:

Acute hypercapnic RF develops over minutes to hours; therefore, pH is less than 7.3. Chronic respiratory failure develops over several days or longer, allowing time for renal compensation and an increase in bicarbonate concentration. Therefore, the pH usually is only slightly decreased. The distinction between acute and chronic hypoxemic RF cannot readily be made on the basis of arterial blood gases. The clinical markers of chronic hypoxemia, such as polycythemia or cor pulmonale, suggest a long-standing disorder ***(Elliott, 2003).***

Causes of RF:

These diseases can be grouped according to the primary abnormality and the individual components of the respiratory system, as follows:

1. Central nervous system (CNS) disorders:

A variety of pharmacological, structural, and metabolic disorders of the CNS are characterized by depression of the neural drive to breathe.This may lead to acute or chronic hypoventilation and hypercapnia.Examples include tumors or vascular abnormalities involving the brain stem, an overdose of a narcotic or sedative and metabolic disorders such as myxedema or chronic metabolic alkalosis. ***(Roussos, 1992).***

2. Disorders of the peripheral nervous system, respiratory muscles, and chest wall:

These disorders lead to an inability to maintain a level of minute ventilation appropriate for the rate of carbon dioxide production which lead toconcomitant hypoxemia and hypercapnia. Examples include Guillain-Barré syndrome, muscular dystrophy, myasthenia gravis, severe kyphoscoliosis, and morbid obesity ***(Hall et al., 1992).***