The Role of Diaphragmatic Rapid Shallow Breathing Index and Maximum Inspiratory Pressure in Predicting Outcome of Weaning From Mechanical Ventilation

Thesis

Submitted to the Faculty of Medicine
Ain Shams University In partial fulfillment of the
Requirements of the degree of
Master in Intensive Care

By

Ahmed Fathy Ahmed Abd-Allah
(M.B.B.CH.) Alexandria University 2013

SUPERVISORS

Prof. Dr. Galal Adel Mohamed Abd Al Rahem Al Kadi
Professor of Anesthesiology,
Intensive Care and Pain Management.
Faculty of Medicine, Ain Shams University.

Dr. Raham Hasan Mostafa
Assistant Professor of Anesthesiology,
Intensive Care and Pain Management.
Faculty of Medicine, Ain Shams University.

Dr. Omnia Mohamed Mostafa Helwa
Lecturer of Anesthesiology,
Intensive Care and Pain Management.
Faculty of Medicine, Ain Shams University.

Faculty of Medicine
Ain Shams University
2020

Acknowledgement

Praise to "Allah", the Most Gracious and the Most Merciful Who Guides Us to the Right Way

I would like also to express my deep gratitude to ***Prof. Dr. Galal Adel Mohamed Abd Al Rahem Al Kadi*** *Professor of Anesthesiology, Intensive Care and Pain Management, Faculty of Medicine, Ain Shams University. who had made a great effort with me in this thesis. For his precious guidance, wise instructions, meticulous supervision, valuable experience and time, endless cooperation and true concern to accomplish this work in the best possible image. for the time he gave to me, his support and sincere help.*

It is a great honor to express my deep gratitude and cordial appreciation to ***Dr. Raham Hasan Mostafa,*** *Assistant Professor of Anesthesiology, Intensive Care and Pain Management. Faculty of Medicine, Ain Shams University. who gave me much of her effort, experience and close supervision throughout the work. She provided me continuous encouragement and support. She generous assistance and meticulous guidance had a pivotal role in the completion of this study. for providing me the experience, cooperation and close supervision throughout the work. she provided me continuous encouragement and support.*

I would like to express my deep gratitude to ***Dr. Omnia Mohamed Mostafa Helwa,*** *Lecturer of Anesthesiology, Intensive Care and Pain Management. Faculty of Medicine, Ain Shams University. for her great encouragement, constant support. Without she continuous help this work would never have been accomplished. She patience and willingness to provide continuous guidance have been instrumental in bringing the study to completion.*

Last but not least I would like to express my deepest thanks to my Family for their continuous guidance and constant encouragement.

My great appreciation is extended to
all those who shared either practically.
or morally in the accomplishment of this work.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBRIVATIONS

AECOPD	**:**	Acute Exacerbation of COPD
APACHE	**:**	Acute Physiologic Assessment and Chronic Health Evaluation
ARDS	**:**	Acute Respiratory Distress Syndrome
AUC	**:**	Area under the curve
CBC	**:**	Complete Blood Count
CI	**:**	Confidence intervals
CPAP	**:**	Continuous positive airway pre ssure
Cs, rs	**:**	Static respiratory system compliance
DBP	**:**	Diastolic blood pressure
DD	**:**	Diaphragmatic displacement
DE	**:**	Diaphragmatic excursion
DHF	**:**	Decompensated Heart Failure
DRSBI	**:**	Diaphragmatic rapid shallow breathing index
F	**:**	Respiratory frequency
FIO_2	**:**	Fraction of inspired oxygen
HR	**:**	Heart rate
ICU	**:**	Intensive care unit
MIP -PImax	**:**	Maximum inspiratory pressure
MV	**:**	Mechanical ventilation
NIV	**:**	Non Invasive ventilation
NPV	**:**	Negative predictive value
$P_{0.1}$	**:**	Airway occlusion pressure

PaO_2	**:**	Partial pressure of arterial oxygen
PEEP	**:**	Positive end expiratory pressure
PPV	**:**	Positive predictive value
PSV	**:**	Pressure support ventilation
ROC	**:**	Receiver operating characteristic curve
RR	**:**	Respiratory rate
RSBI	**:**	Rapid shallow breathing index
RV	**:**	Residual Volume
SaO_2	**:**	arterial oxygen saturation
SBP	**:**	Systolic blood pressure
SBT	**:**	Spontaneous breathing trial
TV	**:**	Tidal Volume
US	**:**	Ultrasound

INTRODUCTION

Mechanical ventilation is the defining event of intensive care unit (ICU) management. It is a lifesaving intervention in patients with acute respiratory failure and whose spontaneous ventilation is inadequate for subsequent development of life threatening hypoxiaand/or respiratory acidosis. **(Colice et al., 2013)**

On the other hand prolonged unnecessary mechanical ventilation hasmultitude of complications such as laryngeal trauma, pharyngeal trauma, trachealor bronchial rupture, esophageal intubation, pulmonary aspiration of gastric contents, ventilator induced lung injury and ventilator associated pneumonia.

Therefore, a major goal of ICU physicians is to liberate patients from mechanical ventilation as early as possible to avoid such complications that may increase mortality and length of ICU stay. **(Keyt et al., 2014)**

Weaning from mechanical ventilation is the process of reducing ventilator support, ultimately resulting in a patient breathing spontaneously and being extubated. It is wise to push the patient to face the situation of spontaneous breathing by a test mimicking the real spontaneous breathing. This process can be achieved rapidly in majority of patients when the original cause of the respiratory failure has improved. The remaining cases require a more gradual method of withdrawing ventilation. **(Perren et al., 2013)**

Accurate prediction of weaning outcome helps the intensivists in decision making regarding weaning the patients from mechanical ventilation, so thatthe intensivists will proceed in the process of weaning and extubation onlyfor the patients who are expected to be weaned successfully. However, patients with high possibility of weaning failure should be further evaluated cautiously to avoid premature weaning and extubation with their hazardous results such as muscle fatigue, reintubation and aspiration. Numerous numerical indices have been used to predict the outcome of weaning. The sensitivities and specificities of each vary depending upon the cut-off used. Many of the indices have good sensitivities but most have low specificities. **(Ayman et al., 2014)**

One of the major determinants of weaning failure is the imbalance between the mechanical load imposed on the diaphragm and its ability to cope with it.Hence, evaluating diaphragmatic function before any weaning attempt could be of importance. However, despite growing evidence that diaphragmatic dysfunction plays a fundamental role in ventilator dependency diaphragmatic function is still poorly monitored in intensive care units (ICUs). **(Heunks et al., 2010)**

Direct evaluation of diaphragmatic strength is based on the measurement of the maximal trans-diaphragmatic pressure generated by the diaphragm during phrenic nerve stimulation (twitch-occlusion technique) or of the diaphragmatic tension-time index. Both of which -though useful in research are invasive, technically demanding, and require considerable expertise. **(Doorduin et al., 2013)**

Ultrasound is a safe, painless and non-invasive imaging modality that produces pictures of the inside of the body using sound waves. Because ultrasound images are captured in real-time, they can show the structure and movement of the body's internal organs, as well as blood flowing through blood vessels.

Diaphragmatic ultrasonography has been recently proposed as a simple, non-invasive, and bedside method to determine diaphragmatic displacement (DD) during spontaneous or assisted breathing.DD reflects the diaphragm’s ability to generate force and hence tidal volume (TV) during the inspiratory phase. Diaphragmatic dysfunction (defined as DD <10 mm) has been found to be a predictor of weaning failure among patients in medical ICUs. **(Ferrari et al., 2014)**

Measurement of DD is of value in evaluating the diaphragmatic function. However, measurement of force generated by inspiratory muscles (among which the diaphragm is the main component) by evaluating the maximum pressure generated during most forceful inspiration was found to be useful in predicting weaning outcome as well. Therefore the maximum inspiratory pressure (MIP) has been used as an important parameter in predicting weaning from mechanical ventilation. **(DiNino et al., 2014)**.

Many physicians simply look at the patient's ability to tolerate a spontaneous breathing trial (SBT) without distress through the respiratory rate (RR) and TV during the SBT. The RR/TV ratio, i.e., the rapid shallow breathing index (RSBI), one of the most used clinical indices to predict weaning outcome, reflects the balance between mechanical load posed on the inspiratory muscles and the inspiratory muscles ability to face it during the weaning attempt. **(Spadaro et al., 2016)**

However, RSBI was found to have both variable sensitivity and specificity for predicting weaning outcome. Although the diaphragm plays a fundamental role in generating TV in healthy subjects, if the diaphragmatic efficiency is impaired the accessory inspiratory muscles mild contribute to the ventilation for a limited period of time, for example during a SBT. However, since they are by far less efficient and more fatigable than the diaphragm, their exhaustion was likely lead to weaning failure in subsequent hours. Hence, the contribution of the accessory muscles to TV could compromise the diagnostic accuracy of the RSBI by masking the underlying diaphragmatic dysfunction.. (**Huang et al., 2013)**

Accordingly, substituting TV with DD (ultrasonographic evaluation of diaphragmatic displacement)in the RSBI, i.e., calculating diaphragmatic RSBI (D-RSBI, RR/DD), can result in a more accurate predictive index than the traditional RSBI.As the weaning parametersincluding those evaluating the diaphragmatic function may show variable accuracy in predicting weaning outcome. Combination of different weaning parameters may improve the accuracy than of each parameter alone. **(Kim et al., 2011)**

AIM OF THE WORK

To assess the accuracy of Diaphragmatic Rapid shallow breathing index and Maximum inspiratory pressure in predicting the outcome of weaning from mechanical ventilation.

Chapter 1

Challenge of mechanical ventilation

Mechanical ventilation (MV) is one of the most important events of intensive care unit (ICU) management. It is a lifesaving intervention in critical patients suffering from acute respiratory failure and whose spontaneous ventilation is no longer adequate to sustain life due suffering from life threatening hypoxia and/or respiratory acidosis. **(Colice et al., 2013)**

The mechanical ventilation choice should be based on a clinical judgment that requires consideration of the entire clinical scenario. Breathing effort can increase owing to changed lung mechanics (e.g. increased airways resistance, decreased compliance) or increased respiratory demand (e.g. metabolic academia). MV can replace some or all of the elevated breathing work, allowing the ventilatory muscles to recover from their fatigue. **(Bourke et al., 2014)**

On the other side prolonged unnecessary MV has many complications such as tracheoesophagealfistula, diaphragmatic dysfunction, oxygen toxicity, aspiration, ventilator induced lung injury and ventilator associated pneumonia.