**Ain Shams University**
**Faculty of Medicine**
**Department of Anesthesiology, Intensive care and Pain Management**

# Evaluation of Diaphragmatic Ultrasonography as one of the Criteria of Discontinuation of Mechanical Ventilation

Thesis submitted for partial fulfillment of MD degree in anesthesiology , intensive care and pain management

By
**Hatem El-Sayed Mohammed El-Sayed**
M.B.B.CH., M.Sc., Anesthesia – Ain Shams University

Supervised by

**Prof. Dr. Bahaa El-Din Ewaiss Hassan**
**Professor of Anesthesiology, Intensive Care & Pain Management**
**Faculty of Medicine, Ain Shams University**

**Prof. Dr Ahmed Nagah Elshaer**
**Professor of Anesthesiology, Intensive Care & Pain Management**
**Faculty of Medicine, Ain Shams University**

**Dr. Mohamed Saleh Ahmed**
**Lecturer of Anesthesiology, Intensive Care & Pain Management**
**Faculty of Medicine, Ain Shams University**

**Dr. Sondos Ahmed Ibrahem**
**Lecturer of Anesthesiology, Intensive Care & Pain Management**
**Faculty of Medicine, Ain Shams University**

**Faculty of medicine**
**Ain shams university**
**2019**

*Acknowledgement*

*In the first all thanks to **Allah**, the most gracious and the most merciful, who gave me the power to perform and complete this study.*

*I would like to express my deepest gratitude and appreciation to **Prof. Dr. Bahaa El-Din Ewaiss Hassan,** Professor of Anesthesiology, Intensive Care & Pain Management, Faculty of Medicine, Ain Shams University, for his continuous encouragement and valuable supervision and guidance throughout this work, and For giving me much of his effort & time and his continuous guidance, correction and explanation to finish this work.*

*Also, I would like to express deep gratitude and deepest thanks to **Prof. Dr Ahmed Nagah Elshaer,** Professor of Anesthesiology, Intensive Care & Pain Management, Faculty of Medicine, Ain Shams University, For his continuous guidance, advises and supervision. And For giving me much of his effort & time throughout this work.*

*Also, I would like to express deep gratitude and deepest thanks to **Dr. Mohamed Saleh Ahmed,** Lecturer of Anesthesiology, Intensive Care & Pain Management, Faculty of Medicine, Ain Shams University, For his continuous guidance, advises and supervision. And For giving me much of his effort & time throughout this work.*

*Also, I would like to express deep gratitude and deepest thanks to **Dr. Sondos Ahmed Ibrahem,** Lecturer of Anesthesiology, Intensive Care & Pain Management, Faculty of Medicine, Ain Shams University, For her continuous guidance, advises and supervision. And For giving me much of her effort & time throughout this work.*

*Hatem El-Sayed Mohammed*

بسم الله الرحمن الرحيم

# قالوا

## سبحانك لا علم لنا
## إلا ما علمتنا إنك أنت
## العليم الحكيم

صدق الله العظيم

سورة البقرة الآية: ٣٢

جامعة عين شمس
كلية الطب
قسم التخدير والرعاية المركزة وعلاج الألم

# تقييم استخدام الموجات فوق الصوتية على الحجاب الحاجز كإحدي معايير الفطام من جهاز التنفس الصناعي

رسالة
توطئة للحصول على درجة الدكتوراه فى التخدير و الرعاية المركزة و علاج الألم

مقدمة من:-
**الطبيب/ حاتم السيد محمد السيد**
**بكالوريوس الطب والجراحة العامة-ماجستير التخدير**

تحت إشراف
**أ.د/ بهاء الدين عويس حسن**
أستاذ التخدير والرعاية المركزة وعلاج الألم
كلية الطب- جامعة عين شمس

**أ.د/ أحمد نجاح الشاعر**
أستاذ التخدير والرعاية المركزة وعلاج الألم
كلية الطب- جامعة عين شمس

**د/محمد صالح أحمد**
مدرس التخدير والرعاية المركزة وعلاج الألم
كلية الطب- جامعة عين شمس

**د/سندس أحمد إبراهيم**
مدرس التخدير والرعاية المركزة وعلاج الألم
كلية الطب- جامعة عين شمس

**كلية الطب**
**جامعة عين شمس**
**٢٠١٩**

# Table of Contents

# List of Abbreviations

| | |
|---|---|
| **B mode** | Brightness Mode |
| **BMI** | Body Mass Index |
| **BP** | Blood Pressure |
| **CBC** | Complete Blood Count |
| **$CO_2$** | Carbon Dioxide |
| **COPD** | Chronic Obstructive Lung Disease |
| **CPAP** | Continuous Positive Airway Pressure |
| **CROP index** | Dynamic Compliance, Respiratory Rate, Oxygenation, Maximal Inspiratory Pressure |
| **CT** | Computed Tomography |
| **dB** | Decibel |
| **DM** | Diabetes Mellitus |
| **ERV** | Expiratory Reserve Volume |
| **f** | Frequency |
| **FDA** | Food And Drug Administration |
| **$FiO_2$** | Fraction Of Inspired Oxygen |
| **FRC** | Functional Residual Capacity |
| **Hz** | Hertz |
| **ICU** | Intensive Care Units |
| **IEQ** | Inspiratory Effort Quotient |
| **IRV** | Inspiratory Reserve Volume |
| **K** | Potassium |
| **M mode** | Motion Mode |
| **MHz** | Mega Hertz |
| **MIP = $PI_{max}$** | Maximum Inspiratory Pressure |
| **MV** | Minute Ventilation |
| **MVV** | Maximum Voluntary Ventilation |
| **Na** | Sodium |
| **NPV** | Negative Predictive Value |
| **P0.1** | Airway Occlusion Pressure |
| **$PaO_2$** | Arterial Oxygen Partial Pressure |
| **$pCO_2$** | Partial Pressure Of Carbon Dioxide |
| **PEEP** | Positive End-Expiratory Pressure |
| **pHi** | Gastric Intraluminal Ph |

# List of Abbreviations (Cont…)

| | |
|---|---|
| **PPV** | Positive Predictive Value |
| **PSV** | Preesure Support Ventilation |
| **RR** | Respiratory Rate |
| **RSBI= f/$V_t$** | Rapid Shallow Breathing Index |
| **RV** | Residual Volume |
| **SBP** | Systolic Blood Pressure |
| **SBT** | Spontaneous Breathing Trial |
| **SPL** | Spatial Pulse Length |
| $SP_{O2}$ | Arterial Oxygen Saturation |
| **tdi** | Diaphragmatic Thickness |
| **tdi%** | Diaphragmatic Thickness Fraction |
| **Ti** | Inspiratory Time In Seconds |
| $T_i/T_{tot}$ | Inspiratory Time Fraction (Ti/Ttot) |
| **TLC** | Total Lung Capacity |
| $T_{tot}$ | Total Time Of Respiratory Cycle In Seconds |
| **US** | Ultrasound |
| **VC** | Vital Capacity |
| $V_t$ | Tidal Volume |
| $V_t$**/Ti** | Mean Inspiratory Flow |
| **ZOA** | Zone Of Apposition |

# List of Tables

# List of Figures

# List of Figures *(Cont…)*

# Introduction

The optimal time to discontinue patients from mechanical ventilation is critical, as premature discontinuation may be followed by reinstitution of ventilator support in up to 25% of patients. On the other side, delayed weaning may be associated with ventilator-induced diaphragm atrophy ***(Funk et al., 2010).***

In addition, unnecessary delays in weaning from mechanical ventilation can lead to deleterious Complications such as ventilator-associated pneumonia and ventilator-induced diaphragm atrophy even with short periods of mechanical ventilation ***(Matamis et al., 2013).***

The respiratory muscle load-capacity imbalance (the common pathophysiology of weaning failure) can also contribute to extubation failure ***(Levine et al., 2008).***

As spontaneous breathing trial (SBT) monitoring is insensitive to detect early signs of load-capacity imbalance. several indices have been developed to assess the patient’s ability to breathe spontaneously. Variables such as{minute ventilation, maximum inspiratory pressure, respiratory rate, rapid shallow breathing index (respiratory frequency/tidal volume), airway occlusion pressure 0.1 s, and a combined index named CROP (compliance, rate, O2, pressure index) have been used in common clinical practice, however these indices have done little to improve the timing of successful extubation ***(El-Khatib and Bou-Khalil, 2008).***

The diaphragm is considered the main muscle of respiration as it contributes approximately to 70% to tidal volume during inspiration in normal people. Thus it is not uncommon to report diaphragmatic dysfunction in patients with difficult weaning. Recently, diaphragmatic ultrasonography has been considered as a simple, non-invasive method for evaluation of diaphragmatic contractile activity either by assessment of diaphragm excursion or diaphragmatic thickness ***(Thille et al., 2013).***

Since diaphragmatic motion plays a prominent role in spontaneous respiration, observation of the diaphragm kinetics seems essential. The use of tools previously available for this purpose is limited due to the associated risks of ionizing radiation (fluoroscopy, computed tomography) or due to their complex and/or highly specialized nature, requiring a skilled operator (transdiaphragmatic pressure measurment, diaphragmatic electromyography, phrenic nerve stimulation, magnetic resonance imaging) ***(Vivier et al., 2012).***

Bedside ultrasonography is a valuable tool in the intensive care unit. This is especially true where an adequate imaging technique is frequently limited by a variety of factors, including difficulty of patient transportation to the radiology department due to illness severity. Ultrasonography is a noninvasive technique, which has proved to be an accurate, safe, easy to use bedside modality, overcoming many of the standard limitations of imaging techniques ***(Matamis et al., 2013).***

# Aim of the Study

The aim of the study was to evaluate the diaphragmatic thickness fraction as a new parameter to assess the patient readiness for extubation.

# Anatomy and Physiology of the Diaphragm

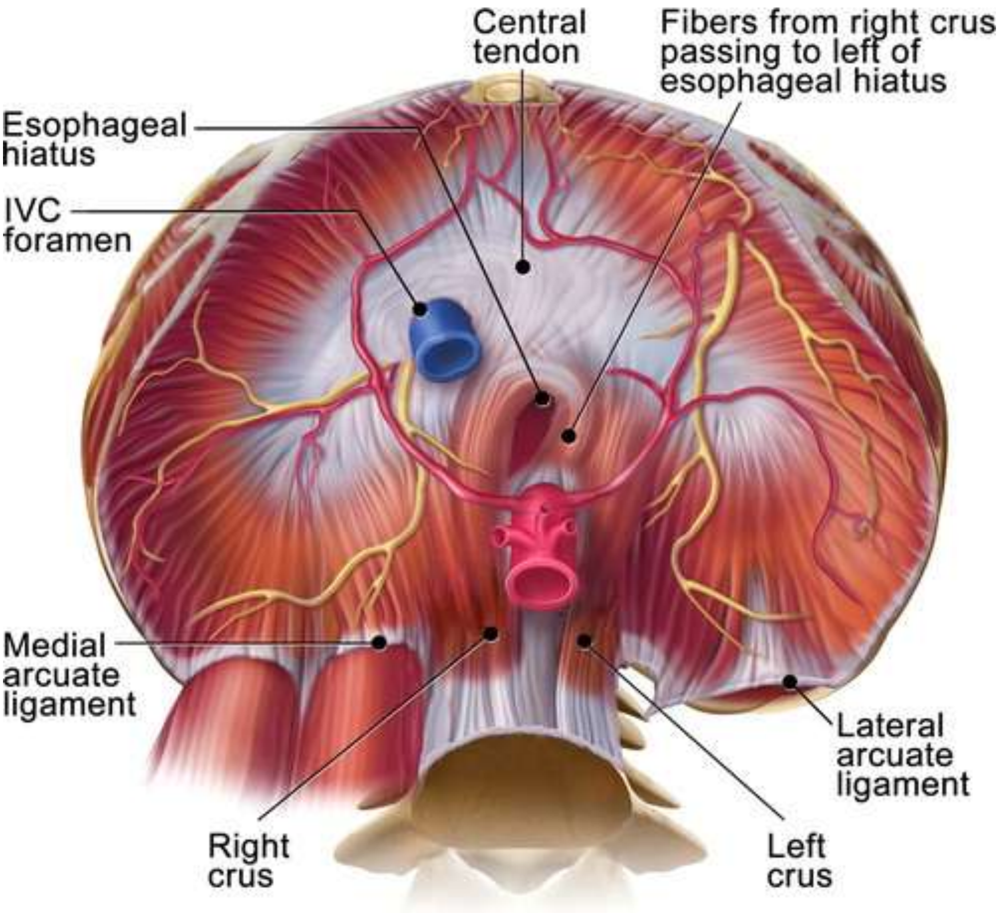


**Figure (1):** Showing the Human diaphragm, frontal view from below ***(Netter, 2014)***.

The diaphragm is the physical barrier that separates the thorax from the abdomen and the main muscle of ventilation ***(Nason et al., 2012).***