



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 Ibrahim
Lecturer of Anesthesiology, Intensive Care & Pain Management
Faculty of Medicine, Ain Shams University

Faculty of medicine
Ain shams university
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Hatem El-Sayed Mohammed

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قالوا

لسببائك لا تعلم لنا
إلا ما علمتنا إنك أنت
العليم العظيم

صدق الله العظيم

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

رسالة

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

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

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List of Abbreviations

B mode	Brightness Mode
BMI	Body Mass Index
BP	Blood Pressure
CBC	Complete Blood Count
CO₂	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
FiO₂	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
PaO₂	Arterial Oxygen Partial Pressure
pCO₂	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

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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 measurement, 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

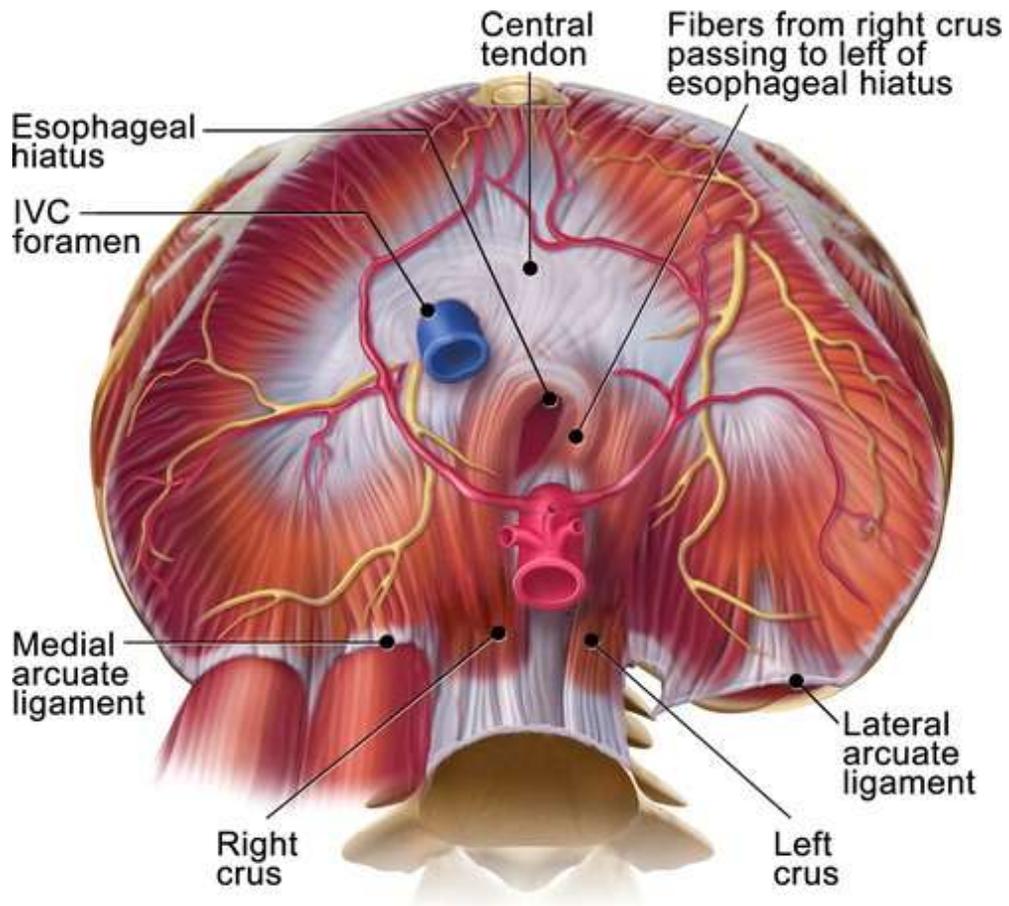


Figure (1): Showing the Human diaphragm, frontal view from below (*Netter, 2014*).

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