

**ASSESSMENT OF DIAPHRAGMATIC  
MOBILITY BY CHEST ULTRASOUND IN  
COPD PATIENTS ON DIFFERENT MODES  
OF MECHANICAL VENTILATION**

Thesis  
Submitted For partial fulfillment of  
**MD Degree in chest diseases**

By  
***Ahmed Mohamed Abd Elsamad***  
*M.B.B.Ch, M.Sc*

Supervised By  
***PROF. ADEL MOHAMED SAEED***  
*Prof. of chest diseases*  
*Faculty of Medicine, Ain Shams University*

***DR. ASHRAF ABBAS ELMARAGHY***  
*Assist. Prof of chest diseases*  
*Faculty of Medicine, Ain Shams University*

***DR. RIHAM HAZEM RAAFAT***  
*Lecturer of chest diseases*  
*Faculty of Medicine, Ain Shams University*

**FACULTY OF MEDICINE  
AIN SHAMS UNIVERSITY**

**2019**

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

وَقُلْ أَعْمَلُوا فَسِيرَ اللَّهِ  
عَمَلَكُمْ وَرَسُولَهُ وَالْمُؤْمِنُونَ

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ  
الْعَظِيمِ



# Acknowledgment

- ✍ First and foremost, thanks to **ALLAH**, the most merciful and the greatest beneficent.
- ✍ I would like to express my great appreciation to **Prof. Adel Mohamed Saeed**, Professor of Chest Diseases, Faculty of Medicine, Ain Shams University; for his sincere effort, valuable advice and great confidence that he gave me throughout the whole work.
- ✍ I am deeply grateful to **Assist. Prof. Ashraf Abbas Elmaraghy**, assistant Professor of Chest Diseases, Faculty of Medicine Ain Shams University; for his great directions & continuous advice all through the work. His time and effort are clear in every part of this work.
- ✍ I would like to express my great appreciation to **DR.Riham Hazem Raafat** ,lecturer of chest Diseases, Faculty of Medicine, Ain Shams University; for her sincere effort, valuable advice and great confidence that she gave me throughout the whole work.Many thanks & gratitude for her.

# Contents

<b>Subjects</b>	<b>Page</b>
• List of Abbreviations .....	5
• List of Tables .....	7
• List of Figures .....	9
• Introduction .....	11
• Aim of the work .....	13
• Review of Literature	
- Chapter one: COPD .....	15
- Chapter two: US and diaphragm.....	48
- Chapter three: Overview of MV.....	66
• Patients & Methods .....	105
• Results .....	113
• Discussion .....	129
• Summary.....	139
• Conclusion.....	145
• Recommendations .....	146
• References .....	147
• Arabic summary	

## List of Abbreviations

<b>ARDS</b>	<b>: Acute respiratory distress syndrome</b>
<b>BIPAP</b>	<b>: Bi-level positive airway pressure</b>
<b>DD</b>	<b>: Diaphragmatic dysfunction</b>
<b>DE</b>	<b>: Diaphragmatic excursion</b>
<b>DVT</b>	<b>: Deep venous thrombosis</b>
<b>EF</b>	<b>: Ejection fraction</b>
<b>ER</b>	<b>: Emergency room</b>
<b>GOLD</b>	<b>: Global initiative for chronic obstructive lung disease</b>
<b>ICU</b>	<b>: Intensive care unit</b>
<b>MV</b>	<b>: Mechanical ventilation</b>
<b>NIV</b>	<b>: Non invasive</b>
<b>OSA</b>	<b>: Obstructive sleep apnea</b>
<b>PDI</b>	<b>: trans-diaphragmatic pressure</b>
<b>PIMAX</b>	<b>: maximum inspiratory pressure</b>

**PS : Pressure support**

**RSBI : Rapid shallow breathing index**

**SBT : Spontaneous breath trial**

**TV : Tidal volume**

**VC : Volume control**

**VIDD : Ventilator induced diaphragmatic dysfunction**

## List of Tables

<b>Table No.</b>	<b>Title</b>	<b>Page</b>
<b>Table (1)</b>	<b>Indications and Goals for mechanical ventilation</b>	<b>68</b>
<b>Table (2)</b>	<b>Modes of Non-invasive Positive-Pressure Ventilation</b>	<b>100</b>
<b>Table (3)</b>	<b>Indications and contraindications for NIV</b>	<b>102</b>
<b>Table (4)</b>	<b>Descriptive analysis for the studied parameters:</b>	<b>113</b>
<b>Table (5)</b>	<b>Correlation between the studied modes of mechanical ventilation:</b>	<b>115</b>
<b>Table (6)</b>	<b>Correlation between diaphragmatic excursions in every mode of mechanical ventilation with other parameters</b>	<b>116</b>
<b>Table (7)</b>	<b>Comparison between success cases and failure cases regarding age and gender</b>	<b>120</b>
<b>Table (8)</b>	<b>Comparison between success cases and failure cases regarding diaphragmatic excursions in each mode of mechanical ventilation (NIV, VC, BIPAP and PS).</b>	<b>121</b>
<b>Table (9)</b>	<b>Comparison between success and failure cases regarding TV, RSBI and days of MV.</b>	<b>123</b>
<b>Table (10)</b>	<b>Receiver operating characteristic curve (ROC) for the predictors of success</b>	<b>125</b>

<b>Table No.</b>	<b>Title</b>	<b>Page</b>
<b>Table (11)</b>	<b>Receiver operating characteristic curve (ROC) for tidal volume, RSBI and days of mechanical ventilation as predictors of success</b>	<b>126</b>
<b>Table (12)</b>	<b>Logistic regression analysis for predictors of success cases (represent every parameter as independent factor as a predictor of successful weaning</b>	<b>127</b>

## List of Figures

<b>Figure No.</b>	<b>Title</b>	<b>Page</b>
<b>Figure (1)</b>	<b>Cells and Mediators Involved in the Pathogenesis of COPD.</b>	<b>20</b>
<b>Figure (2)</b>	<b>Combined assessment of COPD.</b>	<b>28</b>
<b>Figure (3)</b>	<b>Combined assessment of COPD 2017.</b>	<b>28</b>
<b>Figure (4)</b>	<b>Probe position for B and M mode diaphragmatic excursion measurements</b>	<b>50</b>
<b>Figure (5)</b>	<b>Probe position for B and M mode diaphragmatic thickness measurements in the zone of apposition</b>	<b>52</b>
<b>Figure (6)</b>	<b>The pressure, volume, and flow to time waveforms for controlled ventilation.</b>	<b>76</b>
<b>Figure (7)</b>	<b>The pressure, volume, and flow to time waveforms for assist-control ventilation</b>	<b>77</b>
<b>Figure (8)</b>	<b>The pressure, volume, and flow to time waveforms for pressure-regulated volume-controlled ventilation.</b>	<b>81</b>
<b>Figure (9)</b>	<b>The pressure, volume, and flow to time waveforms for proportional-assist ventilation</b>	<b>84</b>
<b>Figure (10)</b>	<b>The pressure, volume, and flow to time waveforms for airway pressure-release ventilation.</b>	<b>85</b>
<b>Figure (11)</b>	<b>Description of the setup used for NAVA.</b>	<b>86</b>
<b>Figure (12)</b>	<b>The flow to time waveform demonstrating auto-positive end-expiratory pressure.</b>	<b>91</b>

<b>Figure No.</b>	<b>Title</b>	<b>Page</b>
<b>Figure (13)</b>	<b>Diaphragmatic movement during inspiration and expiration using B mode and M mode.</b>	<b>108</b>
<b>Figure (14)</b>	<b>Mindray DP 1100 ultrasound.</b>	<b>109</b>
<b>Figure (15)</b>	<b>The position of transducer on the anterior subcostal abdominal wall at the mid-clavicular line.</b>	<b>109</b>
<b>Figure (16)</b>	<b>Outcome of the studied cases.</b>	<b>114</b>
<b>Figure (17)</b>	<b>Correlation between diaphragmatic excursions in VC mode with TV, RSBI and days of mechanical ventilation.</b>	<b>117</b>
<b>Figure (18)</b>	<b>Correlation between diaphragmatic excursions in BIPAP mode with TV, RSBI and days of mechanical ventilation.</b>	<b>118</b>
<b>Figure (19)</b>	<b>Correlation between diaphragmatic excursions in PS mode with TV, RSBI and days of mechanical ventilation.</b>	<b>119</b>
<b>Figure (20)</b>	<b>Comparison between success cases and failure cases regarding age and gender</b>	<b>120</b>
<b>Figure (21)</b>	<b>Comparison between success cases and failure cases regarding diaphragmatic excursions in each mode of mechanical ventilation</b>	<b>122</b>
<b>Figure (22)</b>	<b>Correlation of success and failure outcomes with mean of tidal volumes, RSBI and days of mechanical ventilation.</b>	<b>124</b>

## **INTRODUCTION**

COPD is mainly defined as a disease characterized by airway obstruction and air trapping that is not fully reversible. Studies dealing with inspiratory muscle weakness in COPD patients focus mostly on diaphragm since it are the principal generator of tidal volume (*Kang et al., 2011*).

The diaphragm is the principal respiratory muscle, and its dysfunction predisposes to respiratory complications and can prolong the duration of mechanical ventilation (*Tobin et al., 2009*).

Serve as a bedside screening test for investigating postoperative diaphragmatic dysfunction and detect synchronization of spontaneous breathing efforts with the ventilator, potentially allowing an optimized adjustment of the ventilator settings (*Lerolle et al., 2009*).

Bedside ultrasonography has become a valuable tool in the management of intensive care unit patients .This is especially true in emergency situations 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 (*Beaulieu et al., 2005*).

Diaphragmatic sonography can provide valuable information in the evaluation of patients during partial ventilatory support. Simultaneous recordings of diaphragmatic sonography and airway pressures waveforms can allow visualizing that each patient's inspiratory effort triggers the ventilator appropriately. Therefore, real-time hemi-diaphragmatic sonography could be used in the evaluation of patient-ventilator interactions in clinical practice, in order to detect cases of patient-ventilator asynchrony. In these cases, diaphragmatic sonography could even allow a proper adjustment of the ventilator settings in order to optimize synchronization of the patient's inspiratory effort with the assisted mechanical breath. This hypothesis, however, needs to be prospectively tested. Mechanical ventilation in controlled mode and possibly with high levels of partial ventilatory assist can also result in ventilator-induced diaphragm dysfunction (*Petrofet et al., 2010*).

## **AIM OF THE WORK**

To assess diaphragmatic mobility by chest ultrasound in COPD patients on different modes of mechanical ventilation and to distinguish which mode has the best diaphragmatic excursion with detection of its role as an independent noninvasive tool for predicting successful weaning .



# CHAPTER ONE

## CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Chronic Obstructive Pulmonary Disease (COPD) is a common preventable and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases. The chronic airflow limitation that is characteristic of COPD is caused by a mixture of small airways disease (e.g., obstructive bronchiolitis) and parenchymal destruction (emphysema), the relative contributions of which vary from person to person (*GOLD, 2018*).

### Prevalence

The lowest estimates of prevalence are usually those based on self-reporting of a doctor diagnosis of COPD or equivalent condition. For example, most data show that less than 6% of the population has been told that they have COPD these estimates may have value, however, since they may most accurately reflect the burden of clinically significant disease that is of sufficient severity to require health services (*Halbert et al., 2006*).

The third National Health And Nutrition Examination Survey (NHANES 3) a large national survey conducted in the US between 1988 and 1994, the prevalence of respiratory symptoms varied markedly by smoking status (current > ex-smoker > never).