



# **The Role of Ultrasonography in Respiratory Intensive Care Unit**

## ***An Essay***

*Submitted for partial fulfillment of Master Degree  
in General Intensive Care*

**By**

**Shehata Hamed Shehata Issa**

(M.B., B.CH.)(Al Azhar University)

**Under supervision of**

**Prof. Dr. Hatem Said Abdel Hamid**

Professor of Anesthesia, Intensive Care and Pain  
Management- Faculty of Medicine- Ain Shams University

**Dr. Neveen Gerges Fahmi**

Ass . Prof of Anesthesia, Intensive Care and Pain  
Management- Faculty of Medicine- Ain Shams University

**Dr. Mayada Ahmad Ibrahim**

Lecturer of Anesthesia, Intensive Care and Pain  
Management- Faculty of Medicine- Ain Shams University



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قَالَ نوحٌ سُبْحَانَكَ اللَّهُمَّ إِنِّي أَعْلَمُ أَنَّكَ اللَّهُ إِنِّي

أَعْلَمُ أَنَّكَ أَنْتَ اللَّهُمَّ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم  
سورة البقرة  
آية رقم: (٣٢)

## **Contents**

<b><i>Subjects</i></b>	<b><i>Page No</i></b>
<b><i>Introduction</i></b>	<b>1</b>
<b><i>Aim of the work</i></b>	<b>2</b>
<b><i>Chapter (1) : Chest ultrasonography</i></b>	<b>3</b>
<b><i>Chapter (2) : The pleura and pleural effusion</i></b>	<b>34</b>
<b><i>Chapter (3) :Lung consolidation</i></b>	<b>49</b>
<b><i>Chapter (4) : Pneumothorax</i></b>	<b>75</b>
<b><i>Chapter (5) : Ultrasound Guided Interventions</i></b>	<b>82</b>
<b><i>Summary</i></b>	<b>103</b>
<b><i>References</i></b>	<b>105</b>
<b><i>Arabic Summary</i></b>	<b>1</b>

### List of Abbreviations

ACCP	American College of Chest Physicians .
AHRQ	Agency for Healthcare Research and Quality.
AIDS	Acquired Immune Deficiency Syndrome.
AQPS	Aquaporin's.
ARDS	Acute Respiratory Distress Syndrome.
C A	Carotid Artery
CBC	Complete blood count.
C I	Confidence Interval.
CmH2O	Centimeter Water.
COPD	Chronic Obstructive Pulmonary Disease
CT	Computed Tomography.
CVC	Central Venous Catheter.
CXR	Chest x ray.
ESR	Erythrocyte sedimentation rate.
EVLW	Extra vascular lung water.
FEV1	Forced expiratory volume in 1 <sup>st</sup> second.
FNA	Fine Needle Aspiration.
F V	Femoral Vein.
FVC	Forced Vital Capacity.
G/dL	Gram per deciliter.
HIV	Human Immune Virus.
ICU	Intensive Care unit.
I JV	Internal Jugular Vein
LDH	Lactic acid dehydrogenase.
M P E	Malignant pleural effusion.
MHz	Megahertz.
ml	Milliliter.
ml/kg	Milliliter per Kilogram.
M- mode	M-mode.
MRI	Magnetic Resonance Imaging.
NICE	National Institute for Clinical Excellence.
P-A	Postero- Anterior.
Pao2	Partial pressure of oxygen in arterial blood.
PICC	Peripherally inserted central catheters.
RICU	Respiratory Intensive Care unit .
R R	Relative Risk.
S C V	Subclavian Vein.
TB	Tuberculosis.
TLC	Total lung capacity.
TNM	Tumor-Lymph Node-Metastasis.
US	Ultrasound.

## ***List of Abbreviations***

---

<b>U S A</b>	United States of America.
<b>Ve-</b>	<b>Negative.</b>
<b>Ve+</b>	<b>Positive.</b>
<b>VEGF</b>	<b>Vascular endothelial growth factor.</b>

## **List of Figures**

<b>No</b>	<b>Title</b>	<b>Page No</b>
<b>1</b>	<b>Various types of ultra sound transducers.</b>	<b>7</b>
<b>2</b>	<b>Transducer equipped with probe indicator.</b>	<b>9</b>
<b>3</b>	<b>The probe transducer location and the indicator direction in various planes.</b>	<b>10</b>
<b>4</b>	<b>The various patient position and transducer location on thoracic ultrasound examination.</b>	<b>12</b>
<b>5</b>	<b>Normal thoracic ultrasound image display in the transverse and sagittal planes.</b>	<b>13</b>
<b>6</b>	<b>Pleural effusions ultrasound image.</b>	<b>15</b>
<b>7a</b>	<b>A large anechoic effusion with passive atelectasis of the underlying lung.</b>	<b>19</b>
<b>7b</b>	<b>Complex and septated pleural effusion.</b>	<b>20</b>
<b>7c</b>	<b>Empyema.</b>	<b>20</b>
<b>8</b>	<b>Bat sign.</b>	<b>23</b>
<b>9</b>	<b>Seashore sign.</b>	<b>24</b>
<b>10</b>	<b>A pattern of B-lines.</b>	<b>25</b>
<b>11</b>	<b>Stratosphere sign.</b>	<b>26</b>
<b>12</b>	<b>Lung point (arrow).</b>	<b>27</b>
<b>13</b>	<b>The same location as in previous Figure after placement of a chest tube.</b>	<b>27</b>
<b>14</b>	<b>Left inferior lobe atelectasis with small pleural effusion.</b>	<b>28</b>
<b>15</b>	<b>Large area of consolidation in a patient with pneumonia, with an attendant small quantity of pleural fluid.</b>	<b>29</b>
<b>16</b>	<b>Numerous B3 lines in all lung fields in a patient with pulmonary oedema.</b>	<b>31</b>
<b>17</b>	<b>US image of a patient with pulmonary fibrosis following acute respiratory distress syndrome (ARDS).</b>	<b>31</b>
<b>18</b>	<b>Patient with pleural effusion and atelectasis.</b>	<b>32</b>
<b>19</b>	<b>Patient with a large pleural effusion, haemothorax with left inferior lobe atelectasis and clots of blood inside the lesion.</b>	<b>33</b>

## **List of Figures**

<b>20</b>	<b>Pleural effusion formation.</b>	<b>35</b>
<b>21a</b>	<b>Left upper lobar a liver-like consolidation with a bronchoaerogram.</b>	<b>54</b>
<b>21b</b>	<b>Subpleural fluid alveologram.</b>	<b>54</b>
<b>21c</b>	<b>Air trappings extending to the periphery.</b>	<b>54</b>
<b>22</b>	<b>Oblique section of lobar pneumonia in the right lower lobe.</b>	<b>55</b>
<b>23</b>	<b>Ultrasonography of atypical pneumonia.</b>	<b>56</b>
<b>24</b>	<b>B mode image of pneumonia.</b>	<b>57</b>
<b>25</b>	<b>Poststenotic pneumonia.</b>	<b>57</b>
<b>26a</b>	<b>Sharply demarcated segmental shadow on the X-ray .</b>	<b>58</b>
<b>26b</b>	<b>Largely homogeneous consolidation on computed tomography.</b>	<b>58</b>
<b>26c</b>	<b>The morphology of the lesion on sonography.</b>	<b>59</b>
<b>26d</b>	<b>Longitudinal section one finds tubular structures; parallel to the vessel.</b>	<b>59</b>
<b>26e</b>	<b>The adenocarcinoma is verified on bronchoscopy.</b>	<b>60</b>
<b>27</b>	<b>On color-coded duplex sonography pneumonia is seen as an accentuated Regular pattern of circulation.</b>	<b>61</b>
<b>28</b>	<b>Engorgement phase of clinically typical pneumococcal pneumonia.</b>	<b>64</b>
<b>29a</b>	<b>Typical appearance of pneumonia on X-ray.</b>	<b>64</b>
<b>29b</b>	<b>On sonography the echotexture is similar to that of the liver, with a pronounced bronchoaerogram.</b>	<b>65</b>
<b>29c</b>	<b>X-ray there still is a marked residual infiltrate.</b>	<b>65</b>
<b>29d</b>	<b>Sonography only shows a receding infiltration.</b>	<b>66</b>
<b>30</b>	<b>A small hypoechoic lesion of squamous cell carcinoma.</b>	<b>68</b>
<b>31</b>	<b>Small-cell lung carcinoma invading the lower lobe of the left lung.</b>	<b>69</b>
<b>32</b>	<b>Hypoechoic space-occupying lesion of a mixed-cell lung carcinoma.</b>	<b>70</b>
<b>33a</b>	<b>X ray a shadow of adenocarcinoma.</b>	<b>72</b>
<b>33b</b>	<b>Coronary computed tomography of adenocarcinoma.</b>	<b>72</b>
<b>33c</b>	<b>Corresponding sonographic image of adenocarcinoma.</b>	<b>73</b>



## ***List of Figures***

---

<b>34</b>	<b>Sonography showed a large tumor in the upper lobe in left parasternal location, penetrating the mediastinum and fully destroying the bronchial branches Of adenocarcinoma.</b>	<b>74</b>
<b>35</b>	<b>M-Mode movement lung ultrasound in pneumothorax.</b>	<b>81</b>
<b>36a</b>	<b>Sagittal section of two-dimension ultrasound view of the subclavian vein.</b>	<b>88</b>
<b>36b</b>	<b>Transverse view of two-dimension ultrasound of the subclavian vein.</b>	<b>89</b>
<b>37a</b>	<b>Sagittal section of two-dimension ultrasound view of the internal jugular vein</b>	<b>91</b>
<b>37b</b>	<b>Transverse view of two-dimension ultrasound of the internal jugular vein.</b>	<b>92</b>
<b>38</b>	<b>Set up for vein cannulation using an ultrasound probe equipped with needle guide.</b>	<b>94</b>
<b>39a</b>	<b>Sagittal section of two-dimension ultrasound view of catheter with the vein lumen.</b>	<b>97</b>
<b>39b</b>	<b>Transverse view of two-dimension ultrasound of catheter with the vein lumen.</b>	<b>98</b>

***List of Tables***

<b><i>No</i></b>	<b><i>Title</i></b>	<b><i>Page No</i></b>
<b>1</b>	Uses of ultrasound in pulmonary medicine.	<b>15</b>
<b>2</b>	Categorizing risk for poor outcome in patients with para pneumonic effusion and empyema.	<b>45</b>



## Acknowledgment

*First great thanks to “**Allah**“ who gave me the power to complete this work , Without his care nothing could be achieved,*

*I would like to express my deepest thanks, great respect and supreme gratitude to*

***Prof. Dr. Hatem Said Abdel Hamid,***

*Professor of Anesthesia, Intensive Care and Pain Management Faculty of Medicine- Ain Shams University , for his constant and continuous encouragement and unlimited help. He gave me a lot of his time,*

*I would like to express deepest and most sincere thanks and gratefulness to*

***Dr. Neveen Gerges Fahmi,***

*Ass. Professor of Anesthesia, Intensive Care and Pain Management Faculty of Medicine- Ain Shams University, for her generous support and advice throughout this work,*

*I would like to express my deepest thanks, great respect and supreme gratitude to*

***Dr. Mayada Ahmad Ibrahim,***

*Lecturer of Anesthesia, Intensive Care and Pain Management Faculty of Medicine- Ain Shams University, for her constant and continuous encouragement and unlimited help. she gave me a lot of her time,*

*I wish also to express my respective gratitude and great appreciation to **my Professors, my colleagues** in the Department of Anesthesia, Intensive Care and Pain Management Faculty of Medicine- Ain Shams University, for their great efforts, valuable advices and continuous help throughout this work.*

## **Introduction**

Modern lung ultrasound (U.S) is mainly applied not only in critical care, emergency medicine, and trauma surgery, but also in pulmonary and internal medicine. Many international authors have produced several studies on the application of lung ultrasound in various settings (*Elbarbary M,et al.,2010*) .

Management of critically ill patients requires imaging techniques, which are essential for optimizing diagnostic and therapeutic procedures. The diagnosis and management of pneumothorax, pleural effusion and lung consolidation all require direct visualization of the lungs. To date, chest imaging has relied on bedside chest radiography and lung computed tomography (CT). In the Intensive Care Unit (ICU), bedside chest radiography is routinely performed on a daily basis and is considered as a reference for assessing lung status in critically ill patients. Limited diagnostic performance and efficacy of bedside portable chest radiography have been reported in several previous studies (*Bélaïd Bouhemad1,et al.,2007* ).

Although lung CT is now considered as the gold standard for the diagnosis and guiding therapeutic procedures in critically ill patients but to perform a lung CT scan requires transportation to the department of radiology, a risky procedure necessitating the presence of trained physicians and sophisticated cardio-respiratory monitoring. In addition helical multi-detector row CT exposes the patient to a substantial radiation dose, which limits the repeatability of the procedure (*MayoJR,et al.,2003*).

Recently, chest ultrasound can be used easily at the bedside to assess initial lung morphology in critically ill patients (*Lichtenstein DA and Meziere.2005*).

## **Aim of the work**

The aim of this study is to assess the value of chest ultrasonography in Respiratory Intensive Care Unit (R.I.C.U).

# **Chapter1**

## **Chest ultrasonography**

### **Background:**

Until recently, the use of lung ultrasound (US) as a diagnostic tool was considered unjustifiable, on the grounds of conventional knowledge that lungs are filled with air, and that the US beam cannot normally pass through air-filled structures, this theory has been rejected and lung US is currently considered the fastest, non-invasive and sophisticated diagnostic approach in the Intensive Care Unit (ICU) and in other in-patient settings, It is associated with minimal complications and has low cost (*Islam and Tonn, 2009*).

Ultrasound examination is a valuable method in diagnosis of various thoracic conditions including pleural or pericardial effusion, empyema, pneumothorax, pulmonary embolism, pneumonia and primary or metastatic lung cancer, ultrasound guidance during thoracocentesis or tube thoracostomy assures minimal complications, It can also assist with staging of lung cancer by defining the extension of thoracic wall invasion or by real-time ultrasound-guided biopsy of a supraclavicular lymph node, thoracic ultrasound is mostly used to locate a target organ or a disease-specific condition and is often used as a complement to other imaging such as chest radiograph, computed tomogram or magnetic resonance imaging (*Islam and Tonn, 2009*).

Ultrasound is helpful to locate the best site for chest tube placement or the insertion of a trocar prior to thoracoscopy or to drain a complicated pleural effusion,also it can be used to localize parenchymal consolidation, tumor,chest wall,pleural masses or lymph nodes,intrathoracic invasion of tumor masses in addition to cardiac function may also be detected easily (*Mathis et al., 2010*).

**Advantages:**

Ultrasound involves no ionizing radiation or nephrotoxic contrast dye exposure. As opposed to other imaging techniques such as computed tomogram (CT), magnetic resonance imaging (MRI) or even simple radiographs, ultrasound examination may be performed anywhere and on any critically ill patient as a preliminary examination or to further investigate an existing finding noted on other radiographic imaging (*Mathis et al., 2010*).

Thoracic ultrasound has several advantages over traditional radiographic imaging of the pleura, including absence of radiation, better portability, real-time imaging, and the ability to perform dynamic imaging, also ultrasound is substantially better at determining the location of pleural fluid than bedside physical examination and, in experienced hands, is associated with a lower rate of complications during thoracentesis, in addition, ultrasound guidance increases the likelihood of a successful tap compared to using physical examination for guidance, as an example, in a study of 17 patients who had a failed thoracentesis without ultrasound imaging, thoracentesis with ultrasound was successful in 15 (*Weingardt et al., 1994*).

Ultrasound examination of the pleura is more sensitive than a plain chest radiograph at detecting the presence of pleural fluid and differentiating pleural fluid from lung consolidation, compared with computed tomography (CT), pleural ultrasound has a 95 percent sensitivity for detection of pleural disease in patients with a “white out” on plain chest radiograph, but is slightly less sensitive in detecting small amounts of fluid (*Yu et al., 1993*).

Compared with CT scanning, ultrasound may better differentiate pleural fluid from pleural thickening and pleural masses (*Feller and Kopman, 2006*).