The Diagnostic Role of Lung Ultrasound in Critically Ill Patients In Comparison With Chest X-Ray

Thesis

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Mina Fayez Hanna

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List of Abbreviations

Abbreviations	Meaning
ARDS	Acute Respiratory Distress Syndrome.
AAL	Anterior Axillary Line.
ABG	Arterial Blood Gas.
AKI	Acute Kidney Injury.
ALT	Alanine Transaminase.
AST	Aspartate Transaminase.
BLUE	Bedside Lung Ultrasound in Emergency.
CKD	Chronic Kidney Disease.
CRP	C Reactive Protein.
CT	Computerized tomography.
CUS	Chest Ultra-Sound.
CXR	Chest X-Ray.
DCL	Decreased Conscious Level.
DM	Diabetes Mellitus.
ECG	Electro Cardio Graph.
FALLS	Fluid Administration Limited by Lung ultra Sonography.
HB%	Hemoglobin.
HTN	Hypertention.
ICU	Intensive Care Unit.
INR	International Normalization Ratio.
K	Potassium salt.
MCL	Mid Clavicular Line.

MHZ	Mega HertiZ.
MM	Milli-Meter.
Na	Sodium salt.
NPV	Negative Predictive Value.
PAL	Posterior Axillary Line.
PAOP	Pulmonary Artery Occlusion Pressure.
PNX	Pneumothorax.
PPV	Positive Predictive Value.
RADIUS	Rapid Assessment of Dyspnea with Ultrasound.
ROC	Receiver Operating Characteristics.
RUSH	Rapid Ultrasound for Shock and Hypotension.
SD	Standard Deviation.
SESAME	Sequential Echocardiographic Scanning Assessing Mechanism or Origin of Severe Shock of Indistinct Cause.
TLC	Total Leucocytic Count.

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Introduction

Management of critically ill patients in the emergency and critical care setting is challenging and imaging techniques are essential for optimizing diagnostic and therapeutic procedures in these patients. In the last two decades the use of bedside ultrasound techniques for critically ill patient management has become popular due to the availability of less expensive and more portable ultrasound machines. Point of care ultrasound **(POCUS)** is increasingly being recognized as the superior imaging option in the emergency and critical care setting ***(Valopicelli et al., 2012)***. Even though the bedside ultrasound utilization in the emergency and critical care setting became increasingly popular in the last two decades, lung ultrasound **(LUS)** was not widely recognized until very recently. The reason was that lung was considered poorly accessible by ultrasound due to the presence of pulmonary air within a bony thoracic cage resulting in poor transmission of ultrasound beams and production of artifacts.

Chest radiograph is considered the first line diagnostic imaging modality for almost all patients presenting with pulmonary symptoms ***(Bourcier et al., 2014)***.

However, studies showed that diagnostic accuracy of chest radiograph is relatively low. This leads to frequent false negative or false positive interpretations and hence inadequate therapy ***(Nazerian et al., 2015)***. In addition, chest radiograph has several technical limitations that further interfere with accurate diagnosis, especially in **ICU** patients.

Chest **CT** is considered the gold standard for detecting respiratory pathology in acute dyspneic patients ***(Bouhemad et al., 2007)***. Although accuracy of diagnosis is higher, **CT** has considerable limitations of its own, such as the transport of critically ill patients, contrast fluid and radiation exposure, and high cost.

It has been shown that **LUS** performs better than **CXR** and is a reasonable alternative to thoracic **CT** for diagnosing common lung pathologies (interstitial syndrome, lung consolidation, pleural effusion and pneumothorax) in emergency and critical care setting. The advantages of **LUS** are that it can be done at bedside easily without need of patient mobilization, it is a non invasive, does not utilize ionizing radiation and is easily reproducible ***(Dexheimer Neto et al., 2012)***.

Aim of the Work

To compare between lung ultrasound and chest X-ray in diagnosis of different lung pathologies in critically ill patients using lung CT as a gold standard.

Normal Sonography of the Lung

Technique and Findings

The ultrasound machine has different probes with different frequencies. The probe for each examination should be chosen for the lung region where pathology is suspected. A high frequency probe improves the resolution but sacrifices the depth of penetration. Hence a high frequency linear vascular probe (frequency range 7.5 – 10 **MHz**) is suitable to perform a detailed examination of the chest wall and pleura, while the low frequency curvilinear probe (frequency range 3.5 – 5 **MHz**) is best to examine deeper structures below pleura. However, we can use single probe for complete **LUS** examination in emergency and critical care setting ***(Lichtenstein et al., 2009)***. The sonographic modes used in **LUS** are real time B- mode (brightness mode) and M-mode (time motion). Real time B mode generates cross-sectional, two-dimensional images from the reflected ultrasound waves while M-mode records motion of the interfaces towards and away from the transducer. Doppler (color) technique is not usually required for **LUS** examination, but found to be useful when differentiating lower region lung pathology (like consolidation) from nearby organs like liver and spleen.

LUS includes the viewing of chest wall, pleural space, diaphragm and the lung parenchyma. All the intercostal spaces provide windows for **LUS** examination. In a simplified examination, one particular point per lung region can be examined, keeping the probe perpendicular to the ribs in the longitudinal plane ***(Garofalo et al., 2008).*** Screening is done through eight zone **LUS** examination ***(Valopicelli et al., 2012)***. In this protocol, each anterior chest wall separates into two regions; anterior and lateral, by using parasternal line, anterior axillary line and posterior axillary line as anatomical landmarks and then each of those regions subdivided in to upper and basal parts, finally making a total eight regions **(Fig. 1)**. If pathology is detected on this simple screening exam, one can adjust the probe to examine along the intercostal space (oblique scan) in the abnormal region to further define the extent of pathology. Alternatively, there are three specific locations in the chest wall calling them '**BLUE** points' (upper **BLUE** point, lower **BLUE** point and **PLAPS** point), for performance of fast **LUS** in patients with acute respiratory failure ***(Lichtenstein et al., 2011)***. These points are used when performing the **BLUE** (Bedside Lung Ultrasonography in an Emergency protocol).

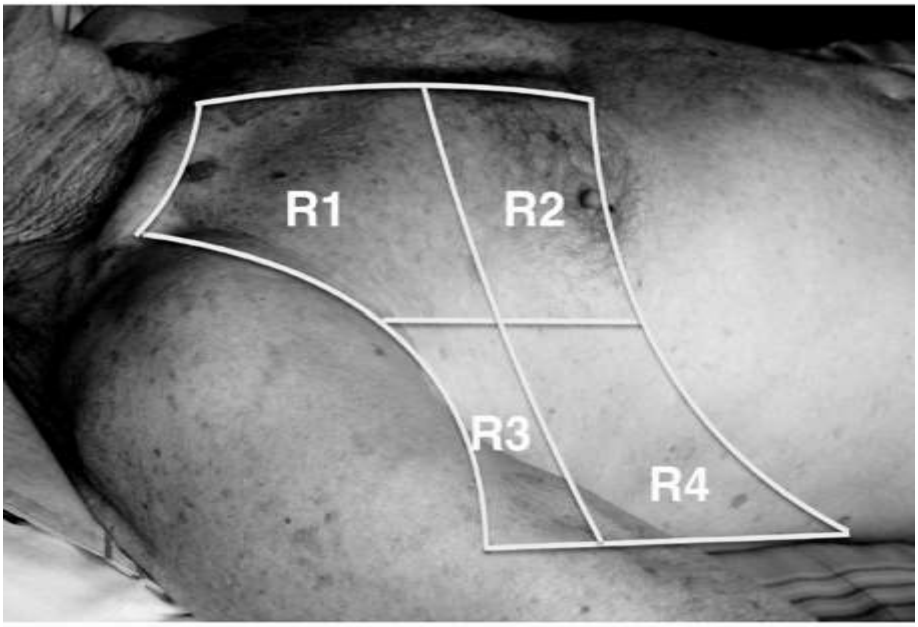

Fig. (1): Eight zone lung ultrasound examination: Each anterior chest wall is separated into two regions; anterior and lateral, by using parasternal line, anterior axillary line and posterior axillary line as anatomical landmarks and then each of those regions are subdivided into upper and basal parts (R1-R4).

Normal Pattern

The Normal Thorax

A series of echogenic layers of muscles and fascia planes are seen during the imaging as curvilinear structures on transverse scans, associated with posterior acoustic shadowing. When the ribs are scanned longitudinally, the anterior cortex appears as a continuous echogenic line. The visceral and parietal pleura are normally displayed by a low