Review

BEDSIDE LUNG ULTRASOUND IN INTENSIVE CARE UNITS

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Abstract

Background*: With the recent increase in the number of patients admitted to Intensive Care Units with respiratory failure and the need for fast, reliable, repeatable, non-invasive, little or no radiation examinations, lung ultrasound has emerged as an attractive alternative to chest radiography.*

Summary*: Despite the relatively short learning curve for the physician, the possibility of using ultrasound examination on any patient, no matter the age or medical history, there are some patient-related limitations to be considered (mechanically ventilated patients, non-compliant patients). With the progression of literature on this topic, new protocols have emerged, aiming to minimize the intra- and inter-observer variability. Bedside Lung Ultrasound in Emergency Protocol proposes a guided, step-by-step approach, helpful for diagnosing or ruling out life-threatening lung pathologies.*

Keywords: bedside lung ultrasound, pneumonia, pneumothorax, pleural effusion, alveolar interstitial syndrome, chest radiography, computed tomography, BLUE protocol

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Introduction

Sepsis and septic shock are major healthcare problems, affecting millions of patients all around the world. A study performed in USA showed that acute organ dysfunction that accompanies severe sepsis is a leading cause of death and the most common cause of death among critically ill patients in non-coronary intensive care units (ICU) [1]. In addition, epidemiological studies showed that respiratory tract infections, particularly pneumonia, are the most common site of infection, as well as associated with the highest mortality [2]. However, diagnosing acute pneumonia is often difficult, since clinical, biological and imaging signs are not specific [3]. International accepted guidelines recommend using chest x-rays as first line examination, despite having low sensitivity and specificity [4]. Computed tomography (CT) scans are the gold standard imaging technique for thoracic evaluation, but transportation of patients

outside the ICU is very difficult and might be harmful [5]. CT is useful not only for diagnosing alveolar-interstitial syndrome, pneumothorax, pleural effusion, atelectasis, or lung consolidation, but also for guiding therapeutic procedures in critically ill patients, such as trans-thoracic drainage of localized pneumothorax, abscess or empyema [6].

In the textbook "Harrison, Principles of Internal Medicine", it was stated: "Because ultrasound energy is rapidly dissipated in air, ultrasound imaging is not useful for evaluation of the pulmonary parenchyma. However, it is helpful in the detection and localization of pleural abnormalities and is often used as a guide for placement of a needle for sampling of pleural liquid (i.e., for thoracentesis [7]. French Intensivist Daniel Lichtenstein proposed studying the artifacts that appear due to the relationship of air and water in the lungs.

Lung ultrasound (LUS) has become more popular during the last years, especially considering the SARS-COV 2 pandemic, which increased the need for fast, readily available imaging options. Although LUS has not been used for diagnosing COVID 19 pneumonia, it has been helpful for rapid assessment for changes or evolution over time, most often at the point of care (POC) or on the ICU setting.

Conventional lung imaging

In the ICU setting, bedside chest radiography (CXR) is performed daily to assess the evolution of lung pathologies. However, many studies have proven that portable chest radiography has limited diagnostic performance and efficacy [8,9]. The low reliability is because during the acquisition procedure, the patient often moves and does not hold his breath. In addition, the incidence used is antero-posterior, with the cassette being placed posterior to the thorax. Moreover, the x-ray beam is often not tangentially to the diaphragmatic cupola, modifying the silhouette sign. All these additional problems may lead to incorrect assessment of alveolar-interstitial syndrome, consolidation, and pleural effusion.

Lung CT scan, although considered as the gold standard, is often very difficult to perform. One of the many challenges is transportation of the patient to the CT scan, a risky procedure, necessitating trained physicians and cardio-respiratory monitoring [10]. In addition, helical multi-detector row CT exposes the patient to high radiation doses, which limits to repeatability of the imaging procedure [11].

Bedside lung ultrasound

Ultrasound machines are compact, lightweight, and easy to transport. LUS can assess lung condition without the use of radiation, being suitable for all patients, including children and pregnant women [12,13]. The equipment suitable for LUS imaging should have linear, convex and sector transducers, each having its advantages and disadvantages. The best practice is using the linear probe for superficial structures (i.e. pleura) and a curved probe for deeper structures (i.e. diaphragm, pleural effusion) [14]. The patient can be examined satisfactory in the supine position, but lateral decubitus will give a better view on dorsal regions of the lower lobes and seated position will facilitate scanning both anterior and posterior areas in a systematic approach [15].

Although LUS has many advantages (rapid diagnosis of numerous pathologies, repeatability, no limitation with setting or clinical conditions), physician and patient limitations are important to note. LUS examination and interpretation require formally trained physician, with reasonable experience. However, in the case of daily basis US examinations, the learning curve is short, approximately 6 weeks [6]. With regards to patient limitations, US images have a lower quality in the mechanically ventilated patient due to the presence of the inflated lung between the thoracic wall and the heart. Also, obesity and COPD may worsen the image quality [6]. In addition, chest dressings and surgical injuries may alter the transmission of ultrasound beams, adding artifacts.

A study published by Lichtenstein et al in 2008 assessed the utility of LUS in patients admitted in ICU with acute respiratory distress and developed the "Bedside Lung Ultrasound in Emergency (BLUE) Protocol" [16]. The step-by-step approach of the protocol (in addition to the clinical examination of the patient) can rule out or confirm pneumothorax, acute pulmonary edema, pneumonia, pulmonary embolism, severe asthma or exacerbated COPD, providing the correct diagnosis in approximately 90,5% of the cases [16,17].

Conclusions

LUS is a non-invasive, fast, reliable, repeatable, inexpensive, no-radiation examination. It is suitable for any patient, regardless of allergies, age, pregnancy or renal failure. It is a useful tool for emergency and intensive care physicians to use at all stages of diagnosis, as well as for guiding invasive procedures. With the progression of literature on the topic of non-invasive imaging that has recently become evidence-based, the use of point-of-care ultrasound in the ICU setting appears as an attractive alternative to bedside chest radiography.

Author Contributions:

A.M. conceived the original draft preparation. A.C., A.M., and O.P. were responsible for conception and design of the review. VA.I., and O.P. were responsible for the data acquisition. V.A.I, A.M., and O.P. were responsible for the collection and assembly of the articles/published data, and their inclusion and interpretation in this review. A.C., A.M., VA.I., and O.P. contributed equally to the present work. All authors contributed to the critical revision of the manuscript for valuable intellectual content. All authors have read and agreed with the final version of the manuscript.

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