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Relevance of chest sonography in the diagnosis of acute respiratory failure: Comparison with current diagnostic tools in intensive care units

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Abstract *Objectives:* This study compares chest ultrasonography to current diagnostic tools for diagnosing the etiology of acute respiratory failure (ARF) in the ICU.

Methods: The final etiology of ARF was diagnosed in 100 patients (excluding non-respiratory causes and multiple diagnoses) using conventional diagnostic tools (excluding ultrasound). They were pneumonia (49%), chronic obstructive pulmonary disease (COPD) (16%), acute respiratory distress syndrome (ARDS) (10%), pulmonary embolism (PE) (5%), empyema (5%), bronchial asthma (BA) (5%), pneumothorax (5%), idiopathic pulmonary fibrosis (IPF) (3%) and lung contusions (2%). Thoracic ultrasound was done on admission and the obtained profiles were compared to underling etiologies obtained by conventional methods. Characteristic ultrasound profiles that produced specificities >90% were considered diagnostic.

Results: The main diagnostic profiles were: AB profile (asymmetric anterior interstitial syndrome) and C profile (anterior consolidation) indicated pneumonia. The B profile (diffuse anterior interstitial syndrome with lung sliding) indicated ARDS or IPF. Also the B + PLAPS profile (anterior interstitial syndrome with posterior and/or lateral alveolar and/or pleural syndrome) indicated ARDS. The A profile (normal) indicated COPD or bronchial asthma

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(21%). The A profile (normal) plus DVT indicated pulmonary embolism (5%). The lung point and loss of lung sliding (A′ profile) indicated pneumothorax (5%). Considering CT chest as the radiological gold standard, chest ultrasound produced 90% sensitivity and 100% specificity.

Conclusions: Lung ultrasound provided an immediate diagnosis of the underlying etiology of acute respiratory failure in most cases; it can therefore be added to the armamentarium of ICU where urgent decisions are needed for rapid diagnosis and management of patients with ARF.

Introduction

Acute respiratory failure, which is frequently encountered in ICUs, remains a major cause of morbidity and mortality [1,2]. Furthermore, there are often situations of severe respiratory distress in which an urgent diagnosis is required within minutes to direct potentially life-saving therapy [3,4]. Management of such critically ill patients requires imaging techniques, which are essential for optimizing diagnostic and therapeutic procedures. To date, chest imaging has relied on bedside chest radiography and lung computed tomography (CT) [5]. Despite the fact that supine chest radiograph remains a cost-effective, and efficient method for routine evaluation, the interpretation of the portable chest radiograph is a challenging issue owing to the wide spectrum of potential pulmonary and pleural abnormalities and coexistence of several pathologies further complicating the analysis [6].

Although, CT scanning represents the gold standard examination for most pulmonary diseases, it still raises some important issues, such as the high dose of radiation administered to the patient, the cost, the need to move the patient into the radiology room, and the lack of CT scanning in some EDs and ICUs. Chest ultrasonography, on the other hand, enables a quick bedside examination of the patient, the patient does not absorb any ionizing radiations, and the scan can be performed by the emergency physician (EP), who can immediately integrate the findings with the clinical data [7].

The aim of the current study was to prospectively investigate the clinical relevance of applying early chest ultrasonography to patients with ARF in the ICU for diagnosing its underlying etiology in comparison to the standard evaluation by clinical and radiologic and biologic tools.

Patients and methods

The present study was done in the respiratory intensive care units in the chest department as well as the general intensive care units of the hospital, Faculty of Medicine, Alexandria University. The period of study was 2 years. The study protocol was approved by the ethics committee of the hospital. We prospectively recruited 119 adult patients admitted for acute respiratory failure (ARF) to the ICU. Acute respiratory failure was defined based on the classical clinical and biological criteria of admission to the ICU. Patients were diagnosed with acute respiratory failure clinically according to symptoms and signs of hypoxemia with or without hypercapnia, and biologically by arterial blood gases indicating very low oxygen tension (PO_2 less than 60 mmHg) or hypoxic index less than 300 with or without hypercapnia (CO_2 more than 45 mmHg) and low PH [8].

19 Patients were subsequently excluded from the study as they met the following exclusion criteria; patients with non-respiratory as or rare causes of acute respiratory failure and patients given multiple final diagnoses at the end of hospitalization.

Routine clinical assessment

For every patient, standard medical care was provided including the following:

- History.
- Clinical examination.
- Plain X-ray chest and CT chest or other imaging techniques (when needed).
- Routine laboratory investigations.
- Other diagnostic tools when needed (as pleural aspirate examination and fibro-optic bronchoscopy).

The diagnosis of the underlying etiology of acute respiratory failure was established by exhausting all investigations and standardized tests by the ICU staff and not including lung U/S.

Thoracic ultrasound

Thoracic ultrasound examination was done for all patients by a specialist who did not participate in the patients' management. The ultrasound was performed to all patients on admission without interrupting their management.

Ultrasound was performed with both deep (2.5 MHZ) and superficial (5 MHZ) probes in a semi-recumbent position, or supine if intubated.

Regarding ultrasound examination, signs with dual answers (Absent or Present) were assessed, as follows: artifact analysis (A or B lines), lung sliding, abnormal ultrasonic shadow (alveolar consolidation or pleural effusion). A lateral sub-posterior search for posterolateral alveolar and/or pleural syndrome (PLAPS) was essential. Other ultrasonic signs such as lung point sign and sinusoid signs were reported when they were identified (Table 1) [9,10,22].

In patients suspected to have pulmonary embolism, deep venous thrombosis was sought using the same probe. Visualization of anatomic echoic intraluminal thrombosis or absence of compressibility was considered as a positive finding.

The signs observed in each disease were methodically collected; then the ultrasound data were compared with the diagnosis established by the ICU team.