American Journal of Emergency Medicine 33 (2015) 352–358

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Original Contribution

Diagnostic performance of cardiopulmonary ultrasound performed by the emergency physician in the management of acute dyspnea ☆

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ARTICLE INFO

Article history:
Received 25 July 2014
Received in revised form 4 November 2014
Accepted 1 December 2014

ABSTRACT

Objective: The etiologic diagnosis of acute dyspnea in the emergency department (ED) remains difficult, especially for elderly patients or those with previous cardiorespiratory medical history. This may lead to inappropriate treatment and potentially a higher mortality rate. Our objective was to evaluate the performance of cardiopulmonary ultrasound compared with usual care for the etiologic diagnosis of acute dyspnea in the ED.
Methods: Patients admitted to the ED for acute dyspnea underwent upon arrival a cardiopulmonary ultrasound performed by an emergency physician, in addition to standard care. The performances of the clinical examination, chest x-ray, N-terminal brain natriuretic peptide (NT-proBNP), and cardiopulmonary ultrasound were compared with the final diagnosis made by 2 independent physicians.
Results: One hundred thirty patients were analyzed. For the diagnosis of acute left-sided heart failure, cardiopulmonary ultrasound had an accuracy of 90% (95% confidence interval [CI], 84-95) vs 67% (95% CI, 57-75), $P = .0001$ for clinical examination, and 81% (95% CI, 72-88), $P = .04$ for the combination "clinical examination–NT-proBNP–x-ray". Cardiopulmonary ultrasound led to the diagnosis of pneumonia or pleural effusion with an accuracy of 86% (95% CI, 80-92) and decompensated chronic obstructive pulmonary disease or asthma with an accuracy of 95% (95% CI, 92-99). Cardiopulmonary ultrasound lasted an average of 12 ± 3 minutes.
Conclusions: Cardiopulmonary ultrasounds performed in the ED setting allow one to rapidly establish the etiology of acute dyspnea with an accuracy of 90%.

1. Introduction

The etiologic diagnosis of acute dyspnea in the ED remains difficult, especially in elderly patients or those with previous medical history of cardiorespiratory disease [1-6]. If the diagnostic hypothesis and the resulting treatment are wrong, mortality increases significantly among elderly subjects with acute heart failure [7], stressing the importance of finding reliable diagnostic tools. The European Society of Cardiology has recently reviewed the limitations of commonly used methods: electrocardiogram, chest x-ray, N-terminal brain natriuretic peptide (NT-proBNP) testing, or blood samples [8]. Performance of an echocardiogram is recommended, but in practice, this is rarely possible because of lack of an available cardiologist in the ED. The significant value of lung ultrasound for the diagnosis of acute respiratory failure has also been suggested [9,10]. Recently, the interest of early chest ultrasonography for the diagnosis of severe dyspnea cases admitted into intensive care units has been shown [11], but there is little data concerning acute dyspnea in the ED [12-15].

The aim of our study was to evaluate the performance of cardiopulmonary ultrasound performed by an emergency physician in the ED setting for the etiologic diagnosis of acute dyspnea, considering routine examinations as the standard of care.

2. Methods

This prospective cohort study was conducted between January 2012 and December 2012 in the ED of a general hospital with approximately 19 000 ED visits per year. The study protocol was approved by the local ethics committee (ref. 130627), which did not require the signing of a written consent form.

2.1. Patients

Patients 18 years or older and admitted for nontraumatic acute dyspnea, defined as the sudden onset of shortness of breath, were eligible

☆ Conflict of interest: The authors have no conflict of interest to disclose.

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http://dx.doi.org/10.1016/j.ajem.2014.12.003
0735-6757/

and included in the study if an ED physician trained in cardiopulmonary ultrasound was available. Patients who received prehospital medical care, except oxygenotherapy administration, were not included as well as patients with very unstable medical condition requiring mechanical ventilation and patients who received hospital care before inclusion.

The following reasons were causes for secondary exclusion: the impossibility of a precise final diagnosis by the experts, dyspnea not being the main reason for admission, and the duration of hospitalization being less than 24 hours.

2.2. Clinical, laboratory, and radiographic data

The patient's medical history, clinical examination, and vital signs were recorded by the ED physician in charge of the patient. Thereafter, a conclusion for initial clinical diagnosis had to be made by the ED physician in charge of the patient: acute left-sided heart failure (ALSHF), non-ALSHF, or "do not know". All the patients then benefited from additional tests as part of this study (electrocardiogram, arterial blood gases, chest x-ray, blood assessment, and NT-proBNP testing obtained within 60 min on average in our hospital).

The laboratory diagnosis of ALSHF by NT-proBNP assay was chosen taking into account the thresholds redefined according to the patient's age [16]: NT-proBNP was considered negative if less than 300 pg/mL and, in favor of an ALSHF, if greater than 1800 pg/mL in patients older than 75 years, 900 pg/mL in patients from 50 to 75 years old, and 450 pg/mL in patients younger than 50 years. In all other situations, NT-proBNP was considered noncontributory ("gray zone").

An x-ray diagnosis was made a posteriori from the interpretation of chest x-rays by an independent radiologist: presence or absence of ALSHF signs.

Finally, an overall diagnosis "clinical examination–NT-proBNP–chest x-rays" was established: ALSHF, non-ALSHF, or "unability to conclude" if the clinical, biologic, and radiographic diagnoses were discordant.

2.3. Ultrasounds data

In the absence of an immediate life-threatening condition and before any medication, a trained ED physician performed cardiopulmonary ultrasound at the bedside, without knowledge of the clinical data. He was not in charge of the patient and did not provide care to patients at the same time. The total duration of the ultrasonography examination was recorded.

The competence required to carry out this review included, in accordance with the recommendations of the American College of Emergency Physicians [17,18], a 4-day theoretical and practical training in an approved center, a companionship practice with the cardiologists of our structure, and a maintenance of knowledge by "e-learning". Three of 10 emergency physicians who account the department met the ultrasounds training requirement. They had an average of 2 years of practice in cardiac and thoracic ultrasound. The ultrasound system used was a SONOSITE Fujifilm M Turbo (Bothell, WA) equipped with a sector probe (3-5 MHz) for the cardiac ultrasounds and with an abdominal probe (3-5 MHz) for the pulmonary ultrasounds.

Cardiac ultrasound performed at the bedside included firstly the acquisition of a left parasternal long axis view and a view of the 4 chambers for a visual estimation of left ventricular ejection fraction (LVEF), which was considered to be decreased when less than 45% or normal when LVEF is 45% or greater. Then, on the apical 4-chamber view, a mitral Doppler in pulsed mode was performed (Fig. 1A). The maximum speed of the E and A waves expressed in centimeters per second and the decay time of the waveform E (TDE) expressed in milliseconds were then measured and the E/A ratio calculated. Finally, in the same view, a tissue Doppler of the lateral edge of the mitral ring was performed (Fig. 1B), for gathering the maximum speed of the wave e′ expressed in centimeters per second and therefore to calculate the E/e′ ratio. The left ventricular filling pressure (LVFP) was then evaluated according to a predefined algorithm (Fig. 2). Left ventricular filling pressure was in favor of an ALSHF if elevated.

Lung ultrasound was performed in the thoracic region anteriorly, laterally, and posteriorly of each lung [9,19,20]. Several lung ultrasound signs were searched to conclude on typical profiles [9] (Fig. 3): B profile in favor of ALSHF; AB, C, or PLAPS profile in favor of pneumonia or pleural effusion; normal profile in favor of decompensated chronic obstructive pulmonary disease (COPD) or asthma. The abolition of pleural sliding in the anterior thoracic region was considered as a sign of pneumothorax.

2.4. Final diagnosis

The final diagnosis of acute dyspnea was determined by 2 independent experts who reviewed the entire medical chart of each patient, taking into account the evolution of the patients. Without knowledge of the ultrasound data collected in the ED, they had to classify patients into 2 groups: ALSHF or non-ALSHF. In the latter group, the etiologic diagnosis of dyspnea was also investigated. The primary end point was to compare the diagnosis performance of cardiopulmonary ultrasound and standard examinations (clinical, NT-proBNP, and x-ray diagnosis) for the diagnosis of ALSHF. The secondary end point was to evaluate the performance of cardiopulmonary ultrasound to diagnose other causes of acute dyspnea.

2.5. Statistical analysis

Data were assigned to the laboratory of biosatistics of the university hospital and analyzed using the STATA software 11.2 (StataCorp; College Station, TX).

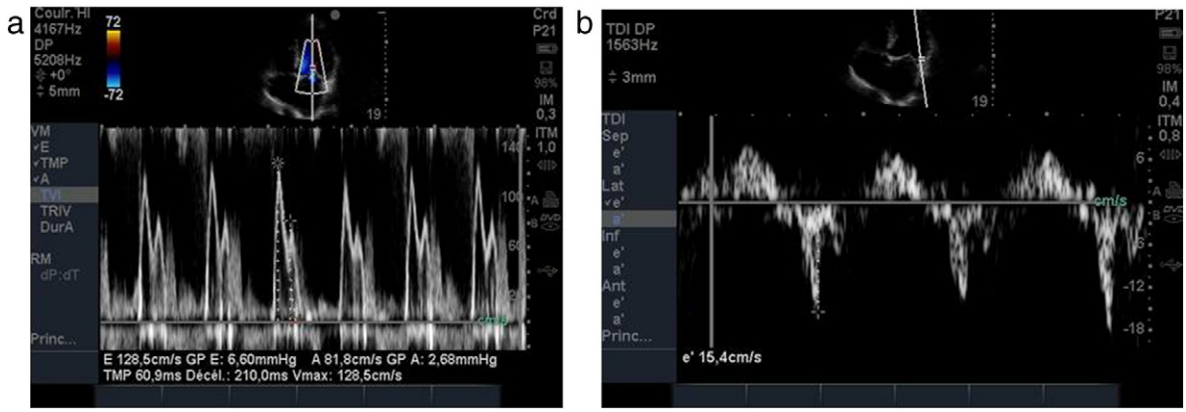

Fig. 1. Cardiac ultrasound data: mitral Doppler in pulsed mode and tissue Doppler on the lateral edge of the mitral annulus on the apical 4 chamber view.