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Brief Report

Clinical application of rapid B-line score with lung ultrasonography in differentiating between pulmonary infection and pulmonary infection with acute left ventricular heart failure

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ABSTRACT

Background: We have found that there are usually 2 causes of acute dyspnea in our emergency department: (1) pulmonary infection only and (2) pulmonary infection in the setting of acute left ventricular heart failure (LVHF). These conditions are sometimes difficult to differentiate. Lung ultrasonography (LUS) is easily performed at the bedside and provides accurate information for diagnosis. In this study, we propose a simple B-line score to allow rapid differential diagnosis between these 2 lung conditions.

Methods: A prospective, single-blind trial was conducted on 98 patients with acute dyspnea in the emergency department. Lung ultrasonography and transthoracic echocardiography were performed within 30 minutes after enrollment. The final clinical diagnosis was recorded for all patients. Using the Bedside Lung Ultrasound in Emergency protocol, we recorded the number of B lines at 4 standardized points. Based on the theory of Lichtenstein, scores of 1, 2, 3, and 4 were categorized by the number of B lines on a static screen (0 to <3, 3 to <6, 6 to <8, and ≥8, respectively). The B-line score of 4 Bedside Lung Ultrasound in Emergency protocol points was recorded, and the total B-line score was calculated. Receiver operating characteristic (ROC) curves were used to evaluate the accuracy of the rapid ultrasound measurements for the final clinical diagnosis.

Results: In our study, 27 patients were diagnosed with pulmonary infection and acute LVHF. The total number of B lines and the B-line score in patients with pulmonary infection in the setting of acute LVHF were 24.2 ± 2.5 and 11.5 ± 1.5, respectively, which were significantly higher than those in patients with pulmonary infection (12.5 ± 6.4 and 7.2 ± 1.9) ($P = .000$). In patients with pulmonary infection and acute LVHF, the effective diagnostic value of left ventricular ejection fraction and the total B-line score were similar (area under the ROC curve: 0.986 vs 0.962, $P = .2607$). The cutoff value of the total B-line score was 8, with a sensitivity of 80.7% and a specificity of 100%. A combination of LUS and echocardiography might improve the diagnostic accuracy (area under the ROC curve: 0.994; 95% confidence interval, 0.981-1.000; $P = .000$).

Conclusions: This simple B-line score with LUS can help make a rapid differential diagnosis between pulmonary infection and pulmonary infection with acute LVHF. The diagnostic accuracy may be enhanced when used in conjunction with echocardiography.

1. Introduction

Acute dyspnea is a distressing condition, and its cause is sometimes difficult to identify [1]. Care of patients with dyspnea in the emergency department (ED) can be challenging, as traditional physical examination techniques and laboratory tests may be misleading and result in an incorrect diagnosis. Initial mistakes may lead to disastrous outcomes. Therefore, initial diagnosis and care must be accurate to optimize patient outcome. Lung ultrasonography (LUS) is easily performed at the bedside by the physician and provides accurate information of diagnostic and therapeutic relevance; therefore, it is considered a "visual stethoscope."

We have found that there are usually 2 causes of acute dyspnea in our department, especially in elderly patients in winter: (1) pulmonary infection and (2) pulmonary infection in the setting of acute left ventricular heart failure (LVHF). A rapid and correct diagnosis is difficult to make on the basis of symptoms and physical examination only. In 2008, Lichtenstein and his team [2] proposed the Bedside Lung Ultrasound in Emergency

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(BLUE) protocol, which provides a step-by-step diagnosis of the main causes of acute respiratory failure—that is, the 6 diseases seen in 97% of patients in the ED—providing an overall accuracy of 90.5%. However, although the BLUE protocol can distinguish between pulmonary edema and pneumonia, it cannot distinguish between pulmonary edema and interstitial pneumonia. The B line is the core measurement of LUS, which moves in concert with lung sliding. In practice, counting the number of B lines is difficult and time consuming. Therefore, in the present study, we attempted to devise a simple and rapid B-line score based on the BLUE protocol to differentiate pulmonary infection from pulmonary infection with acute LVHF.

2. Materials and methods

2.1. Study subjects and design

This was a prospective study. The study protocol was approved by the local institutional review boards in accordance with the Declaration of Helsinki.

Patients received routine care and treatment according to our standard clinical practice, and this was not affected by participation in the study. In total, 98 patients with acute dyspnea admitted to our ED from November 2014 to April 2015 were enrolled. Enrollment took place in the ED, and immediately after enrollment, the general clinical data of patients were collected. Bedside LUS and transthoracic echocardiography examination were performed within 30 minutes of enrollment by the attending physicians, who each had at least 5 years of experience of point-of-care emergency ultrasonography (US). The physicians were aware of the presenting symptoms but were blinded to the other clinical information. The number and score of B lines for 4 BLUE protocol standardized points (Fig. 1) and the left ventricular ejection fraction (LVEF) were the main results of the point-of-care US that were recorded. At the same time, routine clinical indicators such as the blood levels of troponin T (TNT), B-type natriuretic peptide (BNP), and C-reactive protein (CRP) were recorded for the final diagnosis. We followed up all patients and recorded the final clinical diagnosis, which was determined by 3 attending doctors in the ED who each had at least 6 years of experience. Diagnosis was based on a combination of clinical assessments, laboratory tests, and imaging scans. Patients with rapid arrhythmia or severe bradycardia, conduction disturbance, acute coronary syndrome, acute pulmonary embolism, hypertensive crisis, cardiac tamponade, peripartum cardiomyopathy, anemia, kidney dysfunction, hypothyroidism or hyperthyroidism, and iatrogenic causes were excluded from the study.

2.2. Methods

A multiprobe machine (GE Co, Wuxi City, Jiangsu, China) was used. Lung ultrasonography was performed using a 4- to 8-MHz linear probe to recognize B lines and a 3.5- to 5-MHz curved array probe to find the consolidation or pleural effusion. The lung was examined by longitudinal and oblique scans at 4 points, following the BLUE protocol. The examination was performed with the patient in a supine or semirecumbent position, depending on the patient's clinical condition. In accordance with the conclusion of the study of Volpicelli et al [3], we counted the number of B lines at 4 points only, following the BLUE protocol: the upper BLUE points and the lower BLUE points (Fig. 1). To allow rapid examination, we devised a simple B-line scoring system based on the theory of Lichtenstein, using 3-4 B lines called *septal rockets*, which correlate with Keler B lines [4], and 6-8 B lines called *ground-glass rockets*, which correlate with ground-glass areas [5]. The scoring system is a 4-point scale, with the points 1, 2, 3, and 4 corresponding to the number of B lines: 0 to <3, 3 to <6, 6 to <8, and ≥8, respectively, on a static screen. We recorded the B-line score of every BLUE point and calculated the total B-line score.

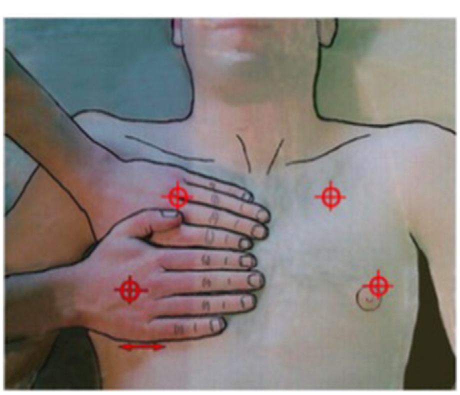

Fig. 1. The 4 standardized BLUE points. Two hands are placed as shown (size equivalent to the patient's hands), with the upper hand touching the clavicle and thumbs excluded; this placement corresponds to the location of the lung. The upper BLUE point is at the middle of the upper hand, and the lower BLUE point is at the middle of the lower hand.

We performed echocardiography using a 2- to 5-MHz phased array probe. The value of LVEF was measured by the Simpson method. The mean of 5 measurements taken was used for statistical analysis.

2.3. Analysis

Normally distributed data are expressed as mean ± SD and nonnormally distributed data as median (minimum-maximum). The unpaired Student *t* test and the nonparametric test were used to compare normally distributed and nonnormally distributed data, respectively. Fisher exact test was used for the comparison of noncontinuous variables. $P < .05$ indicates statistical significance. The diagnostic performance of US measurements was assessed by the receiver operating characteristic curve. Calculations were performed using SPSS software (version 22.0; IBM Inc, Armonk, NY).

3. Results

3.1. Baseline characteristics

A total of 58 patients were included in the study. There were 31 patients with pulmonary infection: 16 cases of pneumonia, 6 cases of acute bronchitis, 3 cases of lung interstitial fibrosis complicated by infection, 5 cases of infection with chronic obstructive pulmonary disease (COPD), and 1 case of lung metastasis carcinoma complicated by infection. There were also 27 patients with pulmonary infection and acute LVHF: 6 cases with pneumonia, 18 cases with acute bronchitis, and 3 cases with acute exacerbation COPD. Mean age of the patients was 76.6 ± 10.1 years, and 60.3% of the patients were male. Mean (min-max) number of and score for B lines were 20.0 (0.0-29.0) and 9.5 (4.0-14.0), respectively. Based on the final clinical diagnosis, 31 patients were assigned to the pulmonary infection group and 27 patients to the pulmonary infection with acute LVHF group. Patient data are presented in the Table. There were significant differences between the 2 groups with respect to blood pressure; levels of TNT, BNP, and CRP; value of LVEF; number of B lines; and the total B-line score (all $P < .001$). There was no significant difference in age, sex, or patient prognosis between the 2 groups.

3.2. Main results

Pulmonary infection is a common cause of acute LVHF. The diagnosis of pulmonary infection in the setting of acute LVHF needs an appropriate combination of clinical assessment, laboratory tests, and imaging scans. Left ventricular ejection fraction, a measure reflecting the real-time left ventricular systolic dysfunction, is widely used as a diagnostic basis of acute LVHF. Therefore, LVEF was used as an important reference indicator for the accuracy of final diagnosis in this study. As mentioned above, traditional physical examination techniques may be misleading and lead to incorrect diagnosis, whereas laboratory tests may delay