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BRIEF REPORT

D. Lichtenstein
G. Mezière

A lung ultrasound sign allowing bedside distinction between pulmonary edema and COPD: the comet-tail artifact

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D. Lichtenstein (✉)
Service de Réanimation Médicale,
Hôpital Ambroise-Paré,
9 avenue Charles-de-Gaulle,
F-92100 Boulogne (Paris), France
Tel. + 33149095601; Fax + 33149095892

D. Lichtenstein · G. Mezière
Service de Réanimation Polyvalente,
Centre Hospitalier Général,
F-92270 Saint-Cloud (Paris), France

Abstract *Objective*: Acute cardiogenic pulmonary edema and exacerbation of chronic obstructive pulmonary disease (COPD) can have a similar clinical presentation, and X-ray examination does not always solve the problem of differential diagnosis. The potential of lung ultrasound to distinguish these two disorders was assessed.
Design: Prospective clinical study.
Setting: The medical ICU of a university-affiliated teaching hospital.
Patients: We investigated 66 consecutive dyspneic patients: 40 with pulmonary edema and 26 with COPD. In addition, 80 patients without clinical and radiologic respiratory disorders were studied.
Measurements: The sign studied was the comet-tail artifact arising from the lung wall interface, multiple and bilaterally disseminated to the anterolateral chest wall.
Results: The feasibility was 100 %. The length of the examination was always under 1 min. The described pattern was present in all 40 patients with pulmonary edema. It was absent in 24 of 26 cases of COPD as well as in 79 of 80 patients without respiratory disorders. The sign studied had a sensitivity of 100 % and a specificity of 92 % in the diagnosis of pulmonary edema when compared with COPD.
Conclusions: With a described pattern present in 100 % of the cases of pulmonary edema and absent in 92 % of the cases of COPD and in 98.75 % of the normal lungs, ultrasound detection of the comet-tail artifact arising from the lung-wall interface may help distinguish pulmonary edema from COPD.

Key words Pulmonary edema · Interstitial syndrome · COPD · Ultrasound diagnosis · Ultrasound studies, lung · Intensive care unit

Introduction

Acute cardiogenic pulmonary edema is conventionally easy to diagnose, as is exacerbation of chronic obstructive pulmonary disease (COPD). Chest X-ray is rarely necessary. However, with the increase in life expectancy, the problem of overlapping pathologies is frequent [1]. Chest X-ray in a dyspneic patient is not always contributive, and diagnostic confusion at this stage may be deleterious [2]. Ultrasound is not traditionally used for investigating lung parenchyma. It is, however, an immediately implemented, bedside technique. A correlation between the comet-tail artifact arising from the lung surface and interstitial syndrome has been highlighted recently [3]. The comet-tail artifact was investigated in the present study with the aim of distinguishing pulmonary edema from COPD. To our knowledge, this subject has not been dealt with in the literature, except in one abstract [4].

Patients and methods

Patients

During a 20-month period, 146 consecutive patients seen by the intensivist in a university-affiliated teaching hospital were enrolled in a prospective study.

The pulmonary edema group included 40 patients (29 men, 11 women, mean age 73, range 18–89 years) suffering from pulmonary edema. Seventeen patients needed immediate mechanical ventilation. The diagnosis was confirmed by the cardiac history, the clinical presentation, the radiologic data with bilateral alveolar-interstitial syndrome, recovery after appropriate treatment and by the results of echocardiography revealing alterations in left ventricular function. The COPD group included 26 patients (15 men, 11 women, mean age 74, range 63–88 years) with exacerbation of COPD. Ten patients needed immediate mechanical ventilation. The diagnosis was confirmed by the respiratory history, the clinical presentation, the radiologic data with signs of lung distension, laboratory data and by functional tests and echocardiography revealing alterations in right ventricular function. A control group comprised 80 patients (39 men, 41 women, mean age 50, range 18–93 years) admitted to our ICU and free of respiratory disorders.

In this study, cases where data (especially X-ray) were insufficient to allow definite diagnoses were excluded.

Methods

Anteroposterior chest X-rays were performed at the bedside, with a VMX portable unit (General Electric, CGR, Monza, Italy), and read by radiologists. A Hitachi-405 (Hitachi Medical Corporation, Tokyo, Japan) with a 3.5 MHz cardiac probe and an ADR-4000 portable unit (Advanced Diagnostic Research, Tempe, Arizona, U.S.A.) with a 3.0 MHz cardiac probe were used by the intensivist on call (D.L.), unaware of the X-ray findings. Dyspneic patients were studied by longitudinal scans in the position they assumed spontaneously, i.e. semi-recumbent. Patients who needed immediate intubation were studied in the supine position within 1 h following mechanical ventilation. The anterior chest wall was delineated from the clavicles to the diaphragm, and from the sternum to the anterior axillary line. The lateral chest wall was delineated from the armpit to the diaphragm and from the anterior to the posterior axillary line.

The pleural line is a hyperechogenic line visible between two ribs and half a cm lower. It shows the lung-wall interface, i.e. the interface between chest wall and lung surface. Two opposed types of artifacts arising from the pleural line can be differentiated. One type is horizontal, the other vertical. The "horizontal artifact" may be a convenient term for the repetition of the pleural line reverberating at regular intervals, yielding parallel, roughly horizontal hyperechogenic lines (Fig. 1). Comet-tail artifacts are roughly vertical hyperechogenic narrow-based repetition artifacts (Fig. 2). The comet-tail artifact described here extends to the edge of the screen (whereas short comet-tail artifacts may exist in other regions), and arises only from the pleural line (whereas comet-tail artifacts can be seen above the pleural line in parietal emphysema or parietal shotgun pellets). Comet-tail artifacts arising from the pleural line can be localized or disseminated to the whole lung surface, or again isolated or multiple (when at least three artifacts are visible in a frozen image in one longitudinal scan, with a distance ≤ 7 mm between two artifacts). In the interest of brevity, this precise pattern will be referred to as "multiple comet-tail artifacts".

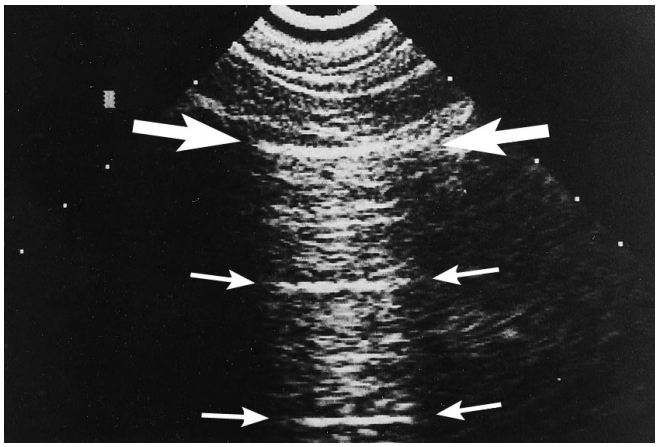

Fig. 1 Pleural line (*large arrows*) visible between two ribs. Roughly horizontal parallel reverberation lines (*small arrows*). The distance between two horizontal lines is equal to the distance between the skin and the lung surface. This patient had exacerbation of COPD, but the same pattern was observed in normal subjects

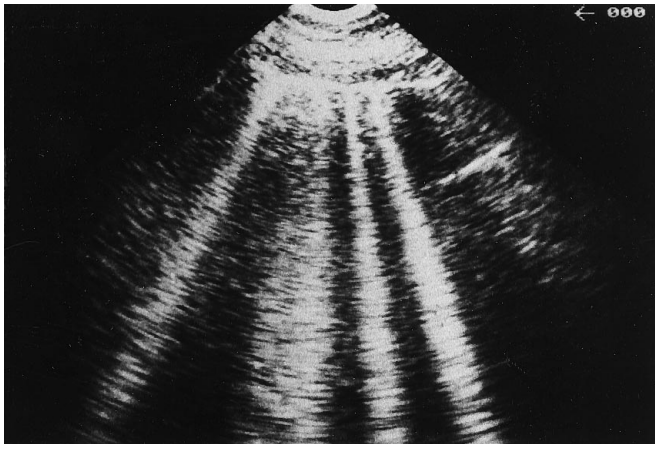

Fig. 2 Multiple comet-tail artifacts arising from the pleural line and distant from each other by a distance of 7 mm or less. As the pattern is suggestive of a rocket at lift-off, one may use a short and suggestive label: "lung rockets". This patient had pulmonary edema

Lung sliding is a to-and-fro movement observed at the level of the pleural line synchronized with respiration. If lung sliding is present, this allows pneumothorax to be ruled out [5]. Care was taken to check the presence of the lung sliding, in order to be sure that the artifacts under focus were generated by the lung itself.

Study design

A positive (or pathologic) test was defined as bilateral "multiple comet-tail artifacts", either disseminated (defined as all over the anterolateral lung surface) or lateral (defined as limited to the lateral lung surface). A negative test was defined as the absence of comet-tail artifacts, replaced by the "horizontal artifact", or when

rare, isolated comet-tail artifacts were visible or when "multiple comet-tail artifacts" were confined laterally to the last intercostal space above the diaphragm. In the present study comparing cardiogenic pulmonary edema and COPD, the unilateral presence of lateral "multiple comet-tail artifacts" was also considered negative.

Results (Table 1)

The feasibility of the ultrasound study was 100 %. The examination always lasted under 1 min, our unit being on hand at the emergency site. In the pulmonary edema group, all 40 patients had a positive test: 38 patterns were disseminated to the whole anterolateral chest wall and two were only lateral. In the COPD group, 24 of 26 patients had a negative test: comet-tail artifact was completely absent in nine cases, confined to the last intercostal space in 13 cases, and limited to the lateral surface of one lung in two patients with pneumonia. Two of 26 patients had a positive test, with "multiple comet-tail artifacts" disseminated in one, and limited to the lateral surface but bilateral in the other; both had pneumonia. In the control group, 79 of 80 patients had a negative test: comet-tail artifacts were absent in 58 cases, confined to the last intercostal space in 20, and limited to a small anterior location in one. One of 80 patients (admitted for acute renal failure requiring urgent dialysis) had disseminated bilateral comet-tail artifacts with normal X-ray.

The ultrasound test was positive in 100 % of patients with pulmonary edema, negative in 92 % of patients with COPD, and negative in 98.75 % of patients without clinical or radiologic respiratory anomalies. The comet-tail artifact had a sensitivity of 100 % and a specificity of 92 % in the diagnosis of pulmonary edema when compared with COPD.

Table 1 Ultrasound pattern at the lung surface in pulmonary edema, COPD and normal lungs

Ultrasound	Pulmonary edema group	COPD group	Control group
Positive test			
Diffuse pattern	38	1	1
Lateral pattern (both lungs)	2	1	0
Negative test			
Lateral pattern (one lung)	0	2	0
Localized anterior location	0	0	1
Last intercostal space location	0	13	20
Absence of comet-tail artifact	0	9	58
Total	40	26	80

Discussion

The comet-tail artifact is generated by the marked difference in acoustic impedance between air and water. Sub-pleural thickened interlobular septa as well as subpleural ground-glass areas are patterns responsible for the comet-tail artifact [3]. In the present study, when compared to normal subjects, the lung surface appeared pathologic in pulmonary edema and normal in COPD. This difference is logical when one considers that the interstitial compartment reaches the lung surface, whereas the bronchial compartment does not. In our study, the interstitial syndrome was always detected in patients with pulmonary edema. Comet-tail artifacts confined laterally to the last intercostal space above the diaphragm, if not associated with alveolar consolidation, should be considered normal [3].

The present study, conducted with cases in which the diagnosis was definite, should be considered as a first step. A subsequent study will deal with cases of non-interpretable or ambiguous X-ray findings, a frequent situation. Usually, the chest X-rays allow adequate recognition of pulmonary edema, with signs evolving as a function of the wedge pressure [6]. However, flaws in bedside chest X-ray are highlighted in the literature [7–11]. The correlation between radiologic signs of pulmonary edema and wedge pressure may be approximate [12]. Genuine cases of pulmonary edema with high wedge pressure can coexist with paucity or absence of radiologic signs of pulmonary edema [12, 13]. In comparison, bedside lung ultrasound has numerous advantages. Recognition of the comet-tail artifact provides immediate non-invasive information. The feasibility is high. The learning curve is short. The inter-observer variation is weak, not to say nil [14]. An unsophisticated portable unit is suitable. With the device described, the critically ill patient can benefit from many other applications, including cardiac ones at the bedside [15]. *Note that bulky units as well as transducer frequencies lower than 3 MHz will not be appropriate.*

The present study has its limitations. Ultrasound detection of interstitial syndrome does not necessarily imply a cardiogenic origin: pneumonia, ARDS or chronic interstitial lung diseases will give comet-tail artifacts [3]. Further refinements may provide information in these cases. Rare cases in the COPD group and the control group gave a positive test. Lastly, if the use of ultrasound results in a delay in treatment, it should be avoided.

In conclusion, screening for the comet-tail artifact arising from the pleural line can help to distinguish between cardiogenic pulmonary edema and exacerbation of COPD (when not due to pneumonia). It may thus contribute to quicker relief for dyspneic patients.

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