CHEST
Original Research
CHEST TRAUMA

Chest Ultrasonography in Lung Contusion*

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Study objective: **Despite the high prevalence of chest trauma and its high morbidity, lung contusion (LC) often remains undiagnosed in the emergency department (ED). The present study investigates the possible clinical applicability of chest ultrasonography for the diagnosis of LC in the ED in comparison to radiography and CT.**
Materials and methods: **One hundred twenty-one patients admitted to the ED for blunt chest trauma were investigated using ultrasonography by stage III longitudinal scanning of the anterolateral chest wall to detect LC. Data were retrospectively collected in an initial series of 109 patients (group 1) and prospectively in the next 12 patients (group 2). All patients who presented with pneumothorax were excluded. After the ultrasound study, all patients were submitted to chest radiography (CXR) and CT. The sonographic patterns indicative of LC included the following: (1) the alveolointerstitial syndrome (AIS) [defined by increase in B-line artifacts]; and (2) peripheral parenchymal lesion (PPL) [defined by the presence of C-lines: hypoechoic subpleural focal images with or without pleural line gap].**
Results: **The diagnosis of LC was established by CT scan in 37 patients. If AIS is considered, the sensitivity of ultrasound study was 94.6%, specificity was 96.1%, positive and negative predictive values were 94.6% and 96.1%, respectively, and accuracy was 95.4%. If PPL is alternatively considered, sensitivity and negative predictive values drop to 18.9% and 63.0%, respectively, but both specificity and positive predictive values increased to 100%, with an accuracy of 65.9%. Radiography had sensitivity of 27% and specificity of 100%.**
Conclusions: **Chest ultrasonography can accurately detect LC in blunt trauma victims, in comparison to CT scan.** ***(CHEST 2006; 130:533–538)***

Key words: chest trauma; chest ultrasound; lung contusion; lung sonography; pulmonary contusion; thoracic ultrasonography

Abbreviations: AIS = alveolointerstitial syndrome; CXR = chest radiography; ED = emergency department; ISS = injury severity score; LC = lung contusion; PPL = peripheral parenchymal lesion

Lung contusion (LC) is a frequent clinical entity. Previous studies[1] have found a 26% rate of lung involvement in blunt chest trauma, with varying severity scores. The need for surgical intervention in chest trauma is not high (10 to 15%),[2] but the diagnosis of LC determines the need of a close physiologic follow-up. This injury is an independent risk factor for the development of ARDS,[3] pneumonia,[4] and long-term respiratory dysfunction, and is associated with a 10 to 25% mortality rate.[5]

Despite its relatively high incidence, LC is a difficult diagnosis to make in the ED. Unless an advanced diagnostic method such as CT is used,

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traditional radiology will underestimate its prevalence. The existing data show that plain chest radiography (CXR) is able to accurately diagnose only major traumatic events. Minor pleural effusions, pneumothoraces, fractures, and LCs, particularly the very recent ones, are missed.[6,7]

Ultrasonography is an optimal diagnostic method in the emergency department (ED) setting, with an extensive and validated usage in the diagnosis of hemoperitoneum,[8,9] as well as of pleural and pericardial effusions. More recently, there is a growing body of evidence supporting the use of ultrasound in the diagnosis of pneumothorax,[10] characterizing a chest-focused or goal-directed approach, instead of the transabdominal or specialty-directed approach. This study was developed with the objective of analyzing the capability of chest sonography to diagnose LCs in comparison to standard radiology and CT, thus expanding the applicability of a tool that is already present in the ED.

Materials and Methods

This study took place in the EDs of three hospitals in Italy: Lucca and Valle del Serchio general hospitals in Lucca, and Policlinico A. Gemelli in Rome. Consecutive patients who presented with isolated blunt chest trauma or polytrauma with chest involvement and an injury severity score (ISS) > 15 were enrolled between April 2001 and December 2003. The population comprised 121 patients (Fig 1) who were classified into two groups. Group 1 consisted of 109 patients who were simultaneously registered for a pneumothorax study (unpublished data). They were blindly analyzed retrospectively by chart review. This analysis was possible because thorax ultrasound at hospital admission in trauma patients is routine in the enrolling hospitals, and a standard form was used for registry, which included signs of extravascular lung water (B-lines), with topographic annotations and thermal prints using video printers (UP-895MD; Sony Corporation; New York, NY) connected to the ultrasound gear. Group 2 was analyzed in a prospective fashion with a population of consecutive patients. Patients who presented with pneumothorax of any size or subcutaneous emphysema large enough to compromise the quality of the examination, in the examiner's opinion, were excluded.

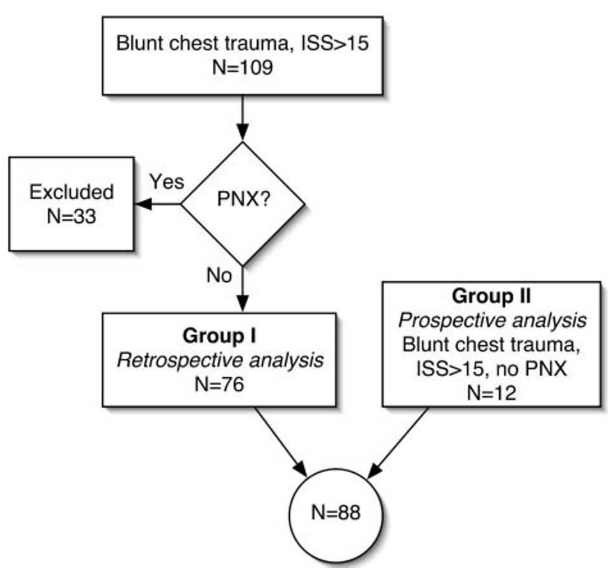

Figure 1. Study flowchart. PNX = pneumothorax.

One examiner performed the ultrasound scan (G.S. or A.T.) within 15 min of arrival as the first imaging test (model 220 SSA, convex 3.5-MHz probe; Toshiba; Tokyo, Japan; or convex multifrequency 3.5- to 5-MHz probe; Esaote Megas; Genova, Italy; or model H21, convex multifrequency 2- to 5- MHz probe; Hitachi; Tokyo, Japan). The chest was scanned in search of pneumothorax and signs of LC according to a stage III approach, as described by Lichtenstein[11]: focused scan of the anterior and lateral walls and the most posterior accessible region beyond the posterior axillary line, not compromising patient immobilization in supine position. We suggest the readers to access more details on lung ultrasound technique and findings in the work by Lichtenstein et al.[12] Chest ultrasound was considered a part of the routine initial examination of the patient, being the first imaging test. The ultrasound units are kept in the EDs.

The normal sonographic appearance of the lung is shown in Figure 2: a longitudinal scan of an intercostal space, with the ribs as topographic reference. The gliding sign is usually found, an echogenic line with a to-and-fro movement that is synchronous with the ventilation movements. The gliding sign is present when the visceral pleura slides on the parietal pleura, excluding pneumothorax. Horizontal artifacts—the A-lines—appear cyclically at an interval that reproduces the distance of the transducer to the pleural line. The gliding sign is not always evident, and the pleural contact and lung movement may be shown in the M mode (Fig 2, *right*). This image is called the *seashore sign*, characterized by horizontal lines ("waves") representing the static chest wall and by a scattered region ("sand"), formed by the dynamic artifacts beyond the pleural line, which would be absent in the case of pneumothorax. Eventually, a type of vertical artifact—B-lines—(formerly called *comet tails*) can be found in normal examination. They are generated by ultrasound resonance in a thin structure of soft tissue surrounded by air, as in a thickened interalveolar septum.[11,13–16] B-lines are roughly vertical and well defined (laser-like) and are spread to the edge of the screen without fading, erasing the A-lines and moving synchronically with the lung sliding.

The recognition of a few other artifacts must be mastered when looking for B-lines: Z-line artifacts are lines that arise from the pleural line and fade away vertically, do not reach the edge of the screen, do not erase the A-lines, and do not accompany the lung sliding. This artifact does not seem to have a pathologic meaning.[16] E-lines are generated by subcutaneous emphysema; they are vertical laser-like lines that reach the edge of the screen but do not arise from the pleural line. They arise from the chest wall, usually not allowing the visualization of underlying structures, making the study unfeasible.

An examination was considered normal in the presence of the gliding sign, the presence of fewer than six B-line artifacts in the entire scanned surface, and the absence of peripheral consolidations. LC was diagnosed in the presence of the following: (1) alveolointerstitial syndrome (AIS), ultrasonographically defined as the presence of multiple B-lines (Fig 3) arising from the pleural line, in a patient with no clinical suspicion of cardiogenic pulmonary edema; or (2) by the presence of a peripheral parenchymal lesion (PPL), defined as the observation of C-lines[11] (Fig 4), confluent consolidations ("hepatization"), or the presence of parenchymal disruption with localized pleural effusion.

Immediately after the ultrasound examination, anteroposterior