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Original Research

Differentiate pleural effusion from hemothorax after blunt chest trauma; comparison of computed tomography attenuation values

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Abstract

Background/Purpose: Hemothorax should be suspected in any patient with blunt chest trauma. However, not every fluid detected by ultrasound or computed tomography (CT) is a hemothorax, especially in elderlies and multi-morbid patients. To avoid unnecessary emergent tube thoracostomy, we have to make the differentiation in a time fashion.
Purpose: To assess the applicability of the CT attenuation value in differentiating hemothorax from pleural effusions.
Methods: In this retrospective study, we identified patients who underwent chest CT during a 39-month period. Patients with definitive diagnoses of hemothorax, pleural effusion, and empyema were enrolled. We selected the 3 non-enhanced CT scan slices containing the largest amount of fluid to measure the Hounsfield unit (HU) values of the pleural fluid, and those of the aortic blood. The HU value ratios of the pleural fluid over aortic blood (P/A) were calculated. We compared the HU and P/A values between the patient groups. Receiver operating characteristic (ROC) curves were constructed to determine the validity and cutoff values.
Results: Hemothorax had significantly higher attenuation values and P/A ratios than did pleural effusion or empyema ($P < 0.001$, respectively). In differentiating hemothorax from pleural effusion, excellent accuracies were obtained with an area under the ROC curve (AUC) of 0.964 (95% CI: 0.931~0.998) for HU values and 0.951 (95% CI: 0.914~0.988) for P/A ratios. The optimal cutoff values were 15.6 HU (sensitivity: 86.8%; specificity: 97.4%) and 30.0% (sensitivity: 94.7%; specificity: 83.3%). To distinguish hemothorax from empyema, good accuracies were obtained with an AUC of 0.866 (95% CI: 0.797~0.935) for HU values and 0.870 (95% CI: 0.801~0.938) for P/A ratios. The optimal cutoff values were 15.9 HU (sensitivity: 86.8%; specificity: 71.2%) and 56.0% (sensitivity: 76.3%; specificity: 90.4%).
Conclusions: CT attenuation values and P/A ratios are distinguishable between hemothorax, pleural effusion, and empyema.

Keywords: hemothorax; pleural effusion; empyema; computed tomography; attenuation value

1. Introduction

Hemothorax should be suspected in any patient with blunt chest trauma. Although dullness to percussion and decreased tactile fremitus are the most useful physical findings, further examinations are usually needed.[1] Chest radiography (CXR) is readily available in almost every emergency department (ED) and its proper use can improve the diagnosis of hemothorax.[2] Emergent ultrasonography (EUS) can be readily performed and rapidly interpreted at the bedside to provide vital information about life-threatening conditions in trauma patients. The use of EUS expands greatly and has become an integral diagnostic tool in trauma survey and resuscitation.[3] It has proved to be more

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sensitive than clinical examination and CXR for the diagnosis of hemothorax,[4,5] pneumothorax and lung contusions.[6,7]

Chest computed tomography (CT) has been accepted as the gold standard imaging study for evaluating chest trauma. It can influence therapeutic management in a significant number of patients.[8−11] Chest CT is usually performed in patients with grossly severe chest trauma or those with have ultrasonographic or roentgenographic evidence of chest injury. In trauma patients, fluid detected in the pleural space is usually considered blood.[12] Tube thoracostomy is often performed to release the pressure except the fluid volume is minimal. Diagnostic thoracocentesis may be used to characterize the fluid if the fluid volume is small. Although needle thoracocentesis is less-invasive than tube thoracostomy, it carries small but definitive risks, even when guided with ultrasonography.[13] Emergent tube thoracostomy or diagnostic thoracocentesis may increase the procedure-related risk without any benefit in trauma patients whose pleural fluid was a pre-existing effusion but not a traumatic hemothorax.

Currently, there is an expanding population of elderlies and multi-morbid patients. They often present to the ED with blunt trauma involving the chest. Imaging studies can readily reveal pleural fluid; however, not every pleural fluid is hemothorax. An increasing number of cases involving pleural fluid that is eventually confirmed to be effusion but not hemothorax.[14] In patients with blunt chest trauma, especially in elderlies and multi-morbid patients, differentiating pleural effusion from traumatic hemothorax is essential for avoiding unnecessary emergent thoracocentesis and tube thoracostomy procedures. We designed and undertook this study to check the hypothesis that the CT attenuation value of the pleural fluid can be used to distinguish the hemothorax from pleural effusions in patients with blunt chest trauma.

2. Methods

2.1. Study design and setting

This was a retrospective observational study at a tertiary referral hospital with an annual census of 100,000 ED visits and 33,000 hospitalizations. The hospital's institutional review board (IRB) approved the study. Informed consent was waived by the IRB. We reviewed electronic health records (EHR) of a consecutive sample of patients treated in the hospital between January 1st, 2010 and March 31st, 2013.

2.2. Selection of participants

For this study, the EHR was reviewed. The patients receiving a diagnosis of hemothorax, pleural effusion, or empyema were identified by International Classification of Diseases, Ninth Revision Clinical Modification (ICD-9CM) diagnosis codes. Patients were included if they underwent CT scanning of the chest. Patients were excluded if they did not receive diagnostic studies of the pleural fluid, were diagnosed at other hospital or had incomplete records. Based on the history, laboratory results and discharge diagnoses, enrolled patients were grouped into hemothorax, pleural effusions, and empyema. Hemothorax was diagnosed based on its gross appearance or laboratory examinations showing hematocrit (Hct) > 50% of blood in the fluid drained from the pleural cavity. Empyema was defined as macroscopic purulent drainage, positive pleural fluid culture, or when there was a very high WBC count (>50,000/mmc), pleural LDH (≥1,000 IU/L), low pH (<7.2), or low glucose (<40 mg/dL) values.[15]

2.3. Interventions

Multidetector CT (MDCT) was performed in all of the cases using a 16-channel scanner (Brilliance 16, Philips Medical System, Hamburg, Germany) or a 64-channel scanner (Brilliance 64, Philips Medical System, Hamburg, Germany) installed adjacent to our ED. Chest CT scanning was performed at a slice thickness of 5 mm, 1-1 pitch, 120 kV, and 200−250 mAs. Intravenous contrast agent was injected using a standard protocol (100 mL of iopamidol-300 [Ultravist, Bayer Schering Pharma, Berlin, Germany]) at an injection rate of 2−3 mL/s. Intravenous contrast agent was not administered in patients without indication, with renal dysfunction, high risk for contrast nephropathy, or known allergy to the agent. The imaging data were assessed using our picture archiving and communication system (PACS) (Centricity, GE Healthcare, Milwaukee, WI, U.S.A.).

2.4. Methods of measurement

All CT scans were reviewed by two experienced radiologists who were blinded to the clinical and laboratory information. Interobserver disagreements were resolved by consensus. To measure the attenuation values of the pleural fluid, we chose three non-enhanced slices with the largest amount of fluid determined by the anteroposterior diameter of the fluid. The circular region of interest (ROI) was used for the quantitative measurements of the Hounsfield unit (HU) values of the maximal amount of fluid on the selected slices (Figure 1). To reduce the interference from partial volume effects, the radiologists were careful not to include bone, pleura, lung parenchyma, or air if there was concomitant pneumothorax. Previous studies reported that anemia decreases the CT attenuation of the blood.[16,17] To reduce the influence of anemia on the CT attenuation value in hemothorax, we measured the HU values of blood within the thoracic aorta in selected slices. The attenuation value ratios of pleural fluid to aortic blood (P/A) were calculated.

We reviewed the hemoglobin (Hb) and Hct levels on the day of CT scanning. If there was no blood test on the scanning date, values within 3 days before the scans were used. We compared Hb, Hct and HU values of aortic blood for correlation. Similar analysis was performed on the Hb, Hct and HU values of hemothorax.

2.5. Primary data analysis

CT attenuation values in the HUs and P/A ratios were expressed as the mean value and 95% confidence intervals