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LUNG ULTRASOUND VS. CHEST RADIOGRAPHY: A COMPARATIVE STUDY FOR PNEUMOTHORAX DIAGNOSIS IN CRITICALLY ILL PATIENT

Medicine

Dr. Zoya Raju Junior Resident Department Of Respiratory Medicine, Rama Medical College, Mandhana Kanpur

Dr. Rajeev Yadav Junior Resident Department Of Radiodiagnosis, Rama Medical College, Mandhana Kanpur

Dr. Sunny Kumar Junior Resident Department Of Respiratory Medicine, Rama Medical College, Mandhana Kanpur

ABSTRACT

Objective: The aim of this study was to compare the sensitivity and specificity of bedside lung US with those for supine portable AP, CR, and thoracic CT scan (gold standard) for the detection of PTX in critically ill patients. **Materials And Methods:** We conducted a prospective, single-blind study on 150 critically ill patients; each patient received lung US examination, bedside CR, followed by thoracic CT scan searching for PTX. **Results:** Of the studied 150 patients, CT of the chest confirmed the diagnosis of PTX in 28 (18.7%) patients, of which 24 were diagnosed by thoracic ultrasound (US), while chest radiography (CR) detected only 15 cases. Overall, lung US showed considerably higher sensitivity than bedside CR (85.7% vs. 53.6%). Lung US also demonstrated higher negative predictive value (96.3% vs. 89.8%) and diagnostic accuracy (95.1% vs. 90.2%) compared to CR. However, CR had a slightly higher specificity than lung US (99.2% vs. 97.8%) and a higher positive predictive value (93.8% vs. 88.9%). **Conclusion:** Lung ultrasound demonstrated higher sensitivity (85.7%) than bedside chest radiography (53.6%) in detecting pneumothorax among critically ill patients. While chest radiography had slightly higher specificity, lung US provided better overall diagnostic accuracy (95.1% vs. 90.2%).

KEYWORDS

Intensive Care Unit, lung ultrasound, mechanical ventilation, pneumothorax

INTRODUCTION

Pneumothorax (PTX) is defined as the presence of air within the pleural space and is a common problem in the Intensive Care Units (ICU). The prevalence of PTX in mechanically ventilated patients is high ranging from 4% to 15%[1,2] and it is considered as one of the most serious complications of positive pressure ventilation. Traumatic PTX is also commonly seen in the ICU. It is the second most common sign of chest trauma following rib fracture, and its incidence is up to 50% of patients with chest trauma.[3]

Chest radiographs have traditionally been the first test ordered to both make and rule out the diagnosis of PTX in the setting of trauma or after invasive procedures.[4] In the critically ill, the supine or semi-recumbent anterior-posterior film is frequently obtained making the reliability of chest radiographs to be limited.[5,6] If there is doubt regarding the findings on a chest radiograph and the patient is stable, it is advised to conduct further imaging with ultrasonography (US) or chest computed tomography (CT) scan[7] [Figure 1]. Thoracic CT scan is considered the gold standard test for both diagnosing and determining the size of PTX.[8] However, it is expensive and cannot be performed on a routine basis. [Figure 2].

The use of lung US for diagnosis of PTX has recently emerged as the method of choice with physicians who can perform bedside US.[9,10] There are many advantages of US over the standard chest radiography (CR) and CT scanning, including the absence of radiation, being portable, real-time imaging, and the ability to easily repeat evaluations. Barcode sign is seen on US on M-mode (Figure 3).US has been used to rule out PTX after central line placement, as well as after transbronchial biopsy.[11,12].

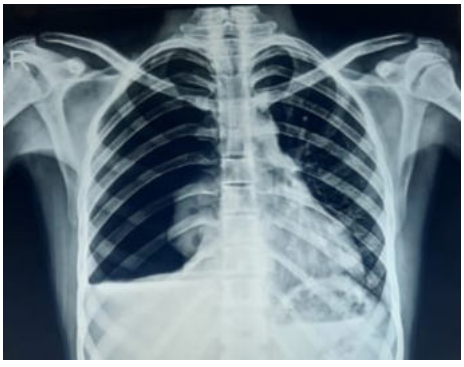

Figure (1). Chest radiograph showing right side pneumothorax

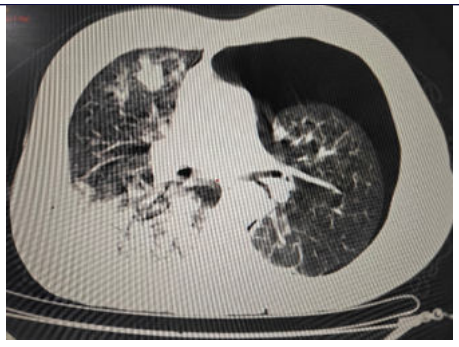

Figure (2). Thoracic computed tomography showing left side pneumothorax

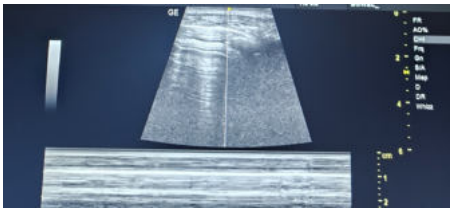

Figure (3). Barcode sign seen on US m-mode in case of PTX

MATERIALS AND METHODS

The study was conducted from March 2023 to July 2024. Enrolment criteria included adult patients admitted to the ICU and were at risk to develop PTX:

1. Mechanically ventilated patients with hypoxemia and/or elevated airway pressure.
2. Patients who underwent invasive procedures; thoracocentesis (pleural tapping) or central venous catheter insertion.
3. Polytraumatized patients who admitted to the ICU before imaging.

The final number of enrolled patients according to the initial criteria was 220, from which 10 patients were transferred or died before full radiological assessment, 55 patients could not undergo CT scans due to hemodynamic instability, and five patients were excluded from analysis, leaving 150 patients who completed the study.

RESULTS

Characteristics of the patients enrolled in the study are shown in (**Table**

1).

A total of 150 patients were evaluated using thoracic CT, lung ultrasound (US), and chest radiography (CR).

Among these patients - 70 were mechanically ventilated with hypoxemia and/or elevated airway pressure, 40 were polytraumatized, and 40 underwent invasive pro cedures such as thoracocentesis or central venous catheter insertion.

Thoracic CT, considered the gold standard, confirmed pneumothorax (PTX) in 28 (18.7%) patients. Of these, lung US diagnosed 24 cases, while CR detected only 15 cases.

Four pneumothoraces were missed by lung US, of which three were small and required no intervention. One case required chest tube insertion, with a delay of 3 hours between lung US and CT, potentially allowing progression of PTX. There were three false positives with lung US, observed in mechanically ventilated patients with severe chronic obstructive pulmonary disease (COPD) or subcutaneous emphysema.

Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of lung US and CR **(Table2)**

Table 1 – Patients Characteristics

Characteristic	Patients (n=150)
Age (years)	**Range:** 18-86 **Mean ± SD:** 49.2 ± 17.5
Sex (n [%])	**Male:** 98 (65.3%) **Female:** 52 (34.7%)
Enrollment diagnosis (n [%])	
Mechanically ventilated	70 (46.7%)
Invasive procedures	40 (26.7%)
Trauma patients	40 (26.7%)

Table 2 - Diagnostic Performance Of Lung Us And Chest Radiography

Parameter	Lung US (%)	Chest Radiography (%)
Sensitivity	85.7	53.6
Specificity	97.8	99.2
PPV	88.9	93.8
NPV	96.3	89.8
Diagnostic Accuracy	95.1	90.2

DISCUSSION

The incidence of PTX among mechanically ventilated patients is high and is considered as one of the most serious complications of positive pressure ventilation. This study showed that thoracic US is more accurate than CR in detecting PTX both in critically ill mechanically ventilated and in polytraumatized patient. We also used the high frequency linear US probe for better imaging quality and easy detection of presence or absence of lung sliding and comet tail signs. Switching to M-mode made the diagnosis easier, especially in difficult cases such as obese patients or patients with surgical emphysema.

In a study on 176 blunt trauma patients, attending emergency physicians performed bedside trauma US examinations using a micro convex US transducer to determine the presence of a sliding lung sign to rule out PTX, their results were higher as compared to ours as regard sensitivity of US for the detection of PTX.[13]

In another study by Garofalo et al., on a series of 184 patients who underwent chest US after percutaneous needle biopsy. US findings were compared with CT and to X-rays. Their results showed that PTX was identified in 46 patients by CT, in 44 by US, with no false positives, and in 19 by X-rays. US sensitivity, specificity, and diagnostic effectiveness were all higher than our results in spite of using the low frequency curved US probe.[14]

CONCLUSION

Lung ultrasound demonstrated higher sensitivity (85.7%) than bedside chest radiography (53.6%) in detecting pneumothorax among critically ill patients. While chest radiography had slightly higher specificity, lung US provided better overall diagnostic accuracy (95.1% vs. 90.2%).

These findings reinforce the superior diagnostic utility of lung ultrasound over bedside radiography for pneumothorax detection in critically ill patients.

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