ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

Diagnostic Importance of Lung Ultrasonography in the Follow-up of Patients with Blunt Chest Trauma

Künt Toraks Travmalı Hastaların Takibinde Toraks Ultrasonografisinin Tanısal Önemi

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ABSTRACT

Aim: *Radiological follow-up of patients with blunt thoracic trauma is essential in providing a chance for early intervention for complications that may develop. The study aims to investigate lung ultrasound's diagnostic value in patients with blunt thoracic trauma.*

Material and Method: *Patients of adult age who were treated for blunt chest trauma in the thoracic surgery clinic of our center between February 2022 and June 2022 were evaluated retrospectively. Among these patients, those who radiologically followed up with a combination of lung US and chest radiography were included in the study. Radiological data that indicates pneumothorax, hemothorax, and atelectasis were recorded.*

Results: *A total of 60 patients with blunt thoracic trauma were included in the study. Forty-nine of the patients were male, and 11 were female. The mean age was 45.7±17.8, and the median was 49 (range 18–74). While the perfect agreement was observed in the detection of hemothorax between the lung US and chest radiogram, substantial agreement was observed in the detection of pneumothorax and atelectasis.*

Conclusion: *In the follow-up of patients with blunt chest trauma, lung ultrasound is a good alternative to standard posterolateral chest X-ray with its similar diagnostic success, easy reproducibility, and the possibility to be applied at the bedside.*

Keywords: *atelectasis; chest trauma; hemothorax; lung ultrasound; pneumothorax*

ÖZET

Amaç: *Künt toraks travmalarında radyolojik takip gelişebilecek komplikasyonlara erken müdahale şansı sunması açısından büyük öneme sahiptir. Bu çalışmada toraks ultrasonunun künt toraks travmalı hastaların takibindeki tanısal değerinin araştırılması amaçlandı.*

Materyal ve Metot: *Şubat 2022 ile Haziran 2022 tarihleri arasında erişkin yaştaki künt toraks travmalı hastaların verileri analiz edildi. Radyolojik takiplerinde toraks ultrason ve akciğer grafisinin kombine olarak kullanıldığı hastalar çalışmaya dahil edildi. Pnömotoraks, hemotoraks ve atelektaziye ait radyolojik bulgular kaydedildi.*

Bulgular: *Çalışmaya toplamda 60 hasta dahil edildi. Hastaların 49'u erkek 11'i kadındı. Ortalama yaş 45,7±17,8, ortanca yaş 49 (aralık: 18–74) yıl olarak bulundu. Hemotoraks tanısında toraks ultrasonu ve akciğer grafisi arasında mükemmel uyumluluk tespit edildi. Pnömotoraks ve atelektazi tanısında ise iyi derecede uyum tespit edildi.*

Sonuç: *Künt toraks travmalı hastaların takibinde toraks ultrasonu benzer tanısal değeri, kolay tekrarlanabilirliği ve hasta başında uygulanabilme imkânı tanıması ile standard posterolateral akciğer grafilerine iyi bir alternatiftir.*

Anahtar Kelimeler: *atelektazi; hemotoraks; pnömotoraks; toraks travması; toraks ultrasonu*

Introduction

Chest traumas are responsible for 20–25% of trauma-related mortality, and blunt injuries constitute the majority[1–3]. Mortality and morbidity may develop in the acute period due to complications that may develop during follow-up. Therefore, clinical and radiological follow-up is essential in chest traumas, even if the general condition of the patients is stable. Today, tomography is frequently preferred in the first evaluation of patients with chest trauma because of its easy accessibility and high performance in providing detailed data.

Following the initial evaluation in a significant proportion of patients with chest trauma, follow-up is required regarding hemothorax, pneumothorax, and atelectasis that may develop or progress. In the radiological follow-up of these patients, chest radiography is generally preferred if there is no indication for further examination[4,5]. However, lung ultrasound (US) is used to diagnose

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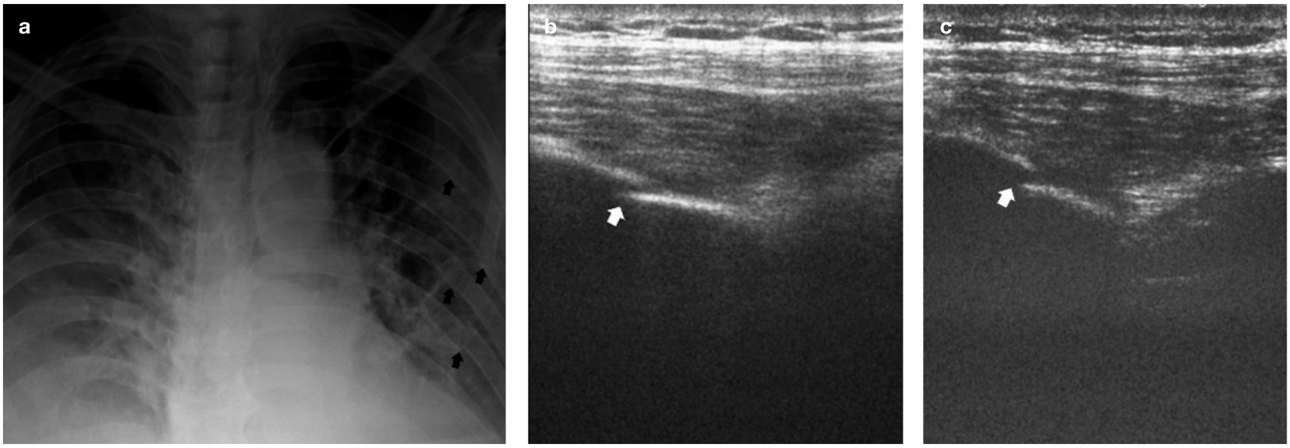

Figure 1. *Chest X-ray and US image of a patient with serial rib fractures on the left side. Arrows indicate fracture areas where cortical continuity is lost*

follow-up patients with chest trauma and has some potential advantages over the chest radiogram and CT scanning, including real-time imaging, being radiation-free, easy reproducibility, and point-of-care use[6].

This study explored lung US functionality in diagnosing hemothorax, pneumothorax, and atelectasis in the radiological follow-up of patients with chest trauma by comparing it with chest radiography.

Material and Method

The Institutional Ethics Committee approved this study, and informed consent was obtained from all participants. Patients of adult age who were treated for blunt chest trauma in the thoracic surgery clinic of our center between February 2022 and June 2022 were evaluated retrospectively. Among these patients, those who radiologically followed up with a combination of lung US and chest radiography were included in the study. Patients with multiple traumas open thoracic injuries, and needing surgical intervention were excluded from the study.

Lung ultrasound was performed by a thoracic surgeon with five years of ultrasound experience, using a Toshiba Aplio 500 machine with a high-resolution linear transducer of 7.5 MHz and a sector transducer of 3.5 MHz. Ultrasound examination was performed on the anterior, lateral, and posterior thorax in the sitting or supine position.

The diagnosis of pneumothorax was made by the disappearance of the normal sliding movement of the lung parenchyma and the presence of the "barcode/stratosphere" sign in M mode.

Fluid collection compatible with the trauma area on ultrasound was evaluated as hemothorax, and a "tissue-like" or "hepatized" appearance in which air bronchograms could be observed was evaluated as atelectasis.

Standard posteroanterior chest radiogram was obtained 1 hour before lung US in all patients. Radiological examinations were performed on the 1st and 3rd days of the follow-up. Data on pneumothorax, hemothorax, and atelectasis were recorded.

Statistical Analysis

Statistics analysis was performed with IBM Statistical Package for Social Sciences (SPSS) program version 25.0 (IBM Inc., Chicago, IL, USA). Continuous variables were expressed as mean value ± standard deviation (SD). Categorical variables were expressed with their ratios. The performance of ultrasound for detecting lung pneumothorax, hemothorax, and atelectasis was compared with that of CT using the Kappa agreement test. A p value less than 0.05 was considered statistically significant.

Results

A total of 60 patients with blunt thoracic trauma were included in the study. Forty-nine of the patients were male, and 11 were female. The mean age was 45.7±17.8, and the median was 49 (range 18–74). The data on the characteristic features of the patients are summarized in Table 1. On the 1st day of the follow-up, positive findings were detected in 29 (48.3 %) lung US patients; on the 3rd day, positive findings were detected in 36 (60.0 %) patients. At least one rib fracture was detected in 34 (56.7%) patients (Fig. 1). While the perfect agreement was observed in the detection of hemothorax between the lung US and chest radiogram, substantial agreement was observed in the detection of pneumothorax and atelectasis (Table 2).

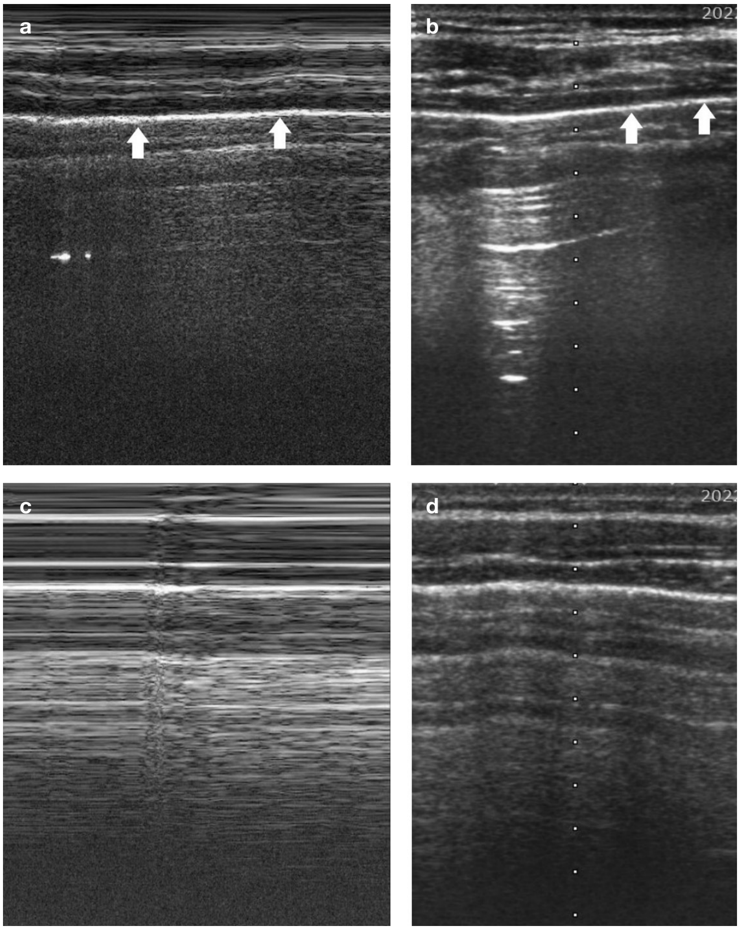

Figure 2. The presence of an image resembling sea waves caused by pleural sliding in "a" indicates the absence of pneumothorax. The arrows in "a" and "b" indicate the pleural line. "c" and "d" are images of the thorax US of a patient with pneumothorax. In "c" it is seen that the "seaside" finding has disappeared. This view in the M mode of ultrasound is also called the "barcode/stratosphere" sign which is highly sensitive for the diagnosis of pneumothorax.

Table 1. *Patient characteristics*

Variables	N=60 (%)
Age (mean ± SD)	45.7±17.8
Sex (male)	49 (81.7)
Trauma side	
Right	24 (40)
Left	27 (45)
Bilateral	9 (15)
Chest tube (yes)	14 (23.3)
Hospital stays (mean ± SD)	5.6±1.4

SD: Standard deviation.

Pneumothorax

On the 1st day of the follow-up, pneumothorax was detected in 8 patients on chest X-ray. Lung US detected pneumothorax in 6 patients (Fig. 2). The cases in which ultrasound could not detect pneumothorax were those with minimal pneumothorax observed in the apical region. On the 3rd day of the follow-up, the US detected pneumothorax in these cases because of the progression.

Hemothorax

On the first day of the follow-up, hemothorax that could not be detected in the chest X-ray was detected

Table 2. *Evaluation of the strength of agreement with Cohen's kappa*

	Day-1				Day-3			
	Thorax-US	Chest X-ray	Kappa	p-value	Thorax-US	Chest X-ray	Kappa	p-value
Pneumothorax	6 (10.0)	8 (13.3)	0.68±0.15	0.00	8 (13.3)	8 (13.3)	0.52±0.17	0.00
Hemothorax	18 (30.0)	14 (23.3)	0.83±0.08	0.00	20 (33.3)	15 (25.0)	0.88±0.07	0.00
Atelectasis	5 (8.3)	7 (11.7)	0.63±0.17	0.00	8 (13.3)	10 (16.7)	0.83±0.09	0.00

US: Ultrasound.

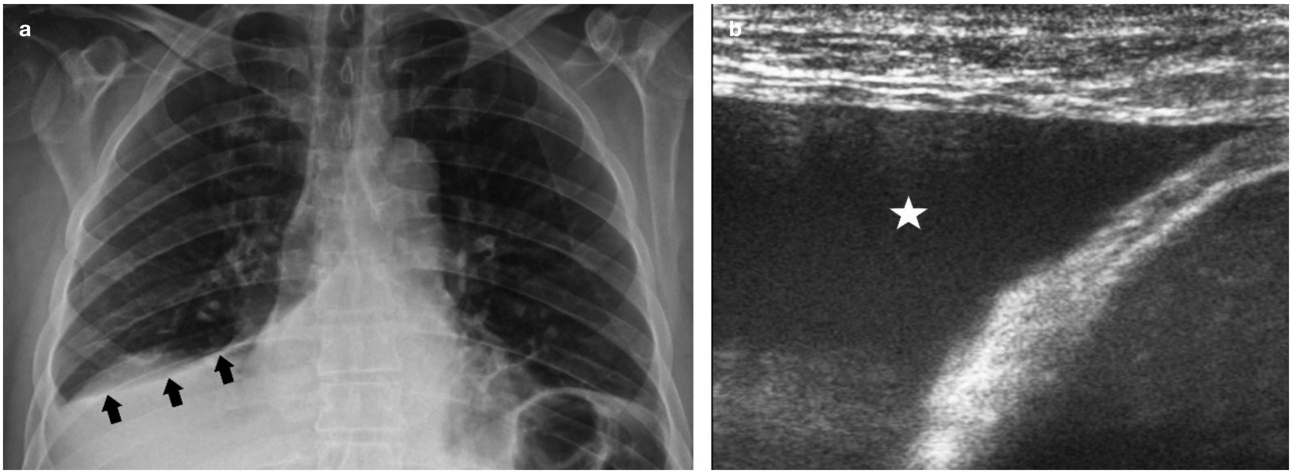

Figure 3. *In patients with suspected hemothorax, US is helpful in determining the characteristics (free flowing or loculated) and localization of pleural fluid. Chest X-ray of subpulmonary hemothorax (arrows) is shown in "a". In the lung US of the same patient, pleural fluid (asterisk) located in the costophrenic sinus is seen.*

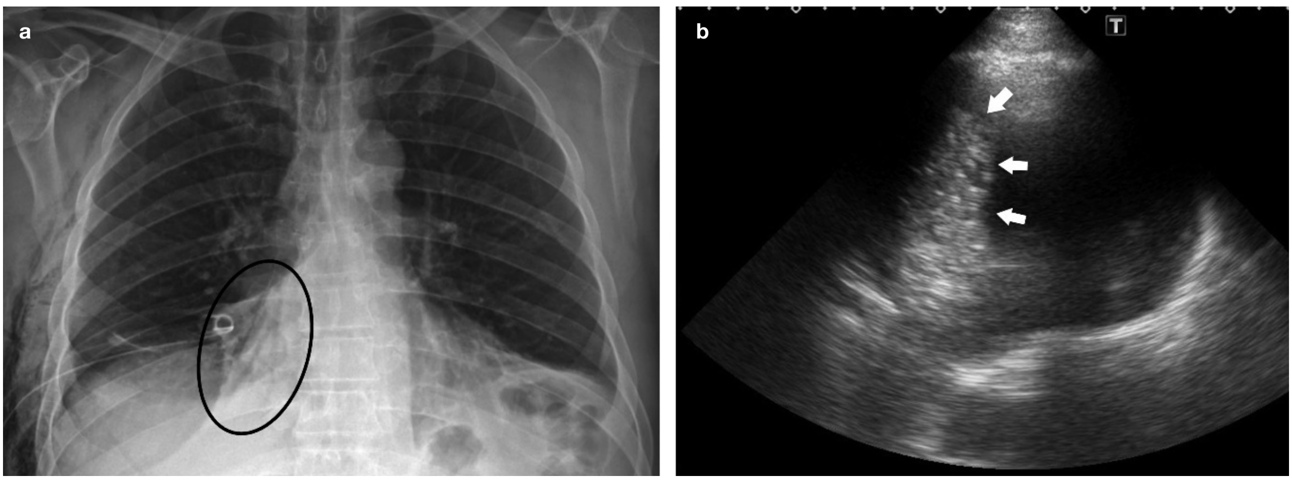

Figure 4. *The circled area in "a" is the entire right lower lobe in the atelectatic state. In "b", liver-like tissue in which air bronchograms are observed is the specific appearance of atelectasis.*

in 4 cases by the US (Fig. 3). On the 3rd day of the follow-up, this number increased to 5 patients. These cases were those with fluid accumulation in the posterior costodiaphragmatic recess.

Atelectasis

The rate of detecting atelectasis by ultrasound was lower than by chest radiography. The most easily detectable atelectasis localization by the US was the lower lobes (Fig. 4). Particularly, segmental/subsegmental atelectasis that did not cover the entire lobe could not be detected by ultrasound.

Discussion

Lung US has potential advantages over other radiological techniques in the follow-up of patients with blunt chest trauma. Lung US is a non-invasive method that provides real-time data, can be applied at the bedside, can be repeated, and does not carry the risk of radiation exposure[6–8].

It provides detailed information about the chest wall, diaphragm movements, pleural cavity, and lung parenchyma.

In this study, no significant difference was found between lung US and chest X-ray in the follow-up of patients with blunt thoracic trauma for the detection of pneumothorax, hemothorax, and atelectasis.

In studies in the literature, the sensitivity of lung US in the diagnosis of pneumothorax varies between 48% and 100%, and the specificity varies between 89.5% and 100%[7–10].

In the meta-analysis of Ebrahimi et al.[7], in which they included the data from 28 studies, lung US was superior to chest radiography in detecting pneumothorax.

In our study, 2 cases were detected by radiography but not by lung US. In these cases, the pneumothorax was partially located at the thoracic cavity's apex.

The feasibility of lung US in detecting hemothorax and rib fractures has been demonstrated in several studies[11–13]. Studies have shown that the sensitivity of the US in detecting hemothorax is between 81% and 97.5%; in particular, its superiority and reproducibility over chest X-rays were emphasized.

In the study of Sabri et al.[12], in which they included 107 patients with chest trauma, the success of lung US and tomography in detecting complications were compared, and the US was found to be particularly effective in detecting pleural lesions and rib fractures.

By the literature, hemothorax was detected by the US in 5 patients whose chest X-ray was interpreted as normal in our study.

Lung US is also functional in detecting changes in the lung parenchyma due to trauma, chest wall, and pleural complications. In a retrospective study by Helmy et al.[14], in which they analyzed the data of 50 patients with blunt chest trauma, the sensitivity of lung ultrasonography in the detection of lung contusion was 97.50%, and the specificity was 90.0%.

In the study of Yang et al.[15] in which they aimed to demonstrate the success of lung US in detecting atelectasis/consolidation in 81 patients with multi-trauma and under mechanical ventilator support, the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were found to be 81.8, 100, 100, 85.9, and 91.4%, respectively.

We did not include data on pulmonary edema, consolidation, or contusion findings in our study. While there was 100% agreement with the chest X-ray in detecting lobar atelectasis, the same success was not observed in the US in sub-lobar atelectasis.

There are some limitations in this study. First, this is a retrospective study, and bias in patient selection cannot be excluded. Second, the number of patients is limited. Therefore, some subgroup analyses could not be performed. Finally, the etiology of trauma is not homogeneous due to the characteristics of the region where the study was conducted. Different results can be observed in blunt thoracic traumas due to different etiologies. For this reason, it is recommended that different comprehensive studies confirm these data.

In conclusion, lung US is a good alternative to traditional chest radiographs in the follow-up of patients with blunt chest trauma regarding pneumothorax, hemothorax, and atelectasis. Reproducibility, real-time imaging, and point-of-care application are the main parameters that make lung US attractive.

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