



# PoCUS evaluating blunt thoracic trauma: a retrospective analysis of 18 months of emergency department activity

Alessandro Riccardi<sup>1</sup> · Maria Beatrice Spinola<sup>1</sup> · Valeria Ghiglione<sup>1</sup> · Marco Licenziato<sup>1</sup> · Roberto Lerza<sup>1</sup>

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## Abstract

Blunt thoracic injury (BTI) constitutes a common presentation in emergency department: rib fractures are the most common injuries. Chest X-ray (CXR) has a limited sensitivity to identify rib fractures. We perform this retrospective study in our emergency department collecting all patients with BTI during an 18-month period. PoCUS was performed prior to acquire CXR or CT. We evaluated 1672 patients with BTI, and we reported rib fractures in 689 patients (41.21%). PoCUS was performed in 190 patients. PoCUS in emergency medicine has an increasing role, especially in BTI, but less clear is its role in detecting ribs fracture. PoCUS seems to be an effective method for diagnosing rib fracture in patients with blunt chest trauma if collaborative and with a well-isolated trauma. We used the trick of patients' self-positioning probe in the most painful site, and this could reduce the time and the pain of the examination.

**Keywords** Blunt thoracic trauma · Emergency ultrasound · PoCUS

## Background

Blunt thoracic injury (BTI) is a common presentation in the emergency department (ED) [1–3]. Rib fractures are the most common (25–40%), and injuries resulting from BTI are usually revealed on radiographs. Chest X-ray (CXR) with rib views has limited sensitivity to identify rib fractures and vary significantly among studies [4–6]. Computed tomography (CT) is considered the gold standard to detect rib fractures and any complication due to BTI, but it exposes patients to substantial amounts of radiation [7]. Serious pulmonary complications, such as pneumothorax, haemothorax and lung contusion, may result from rib fractures [8–10]. CXR is only able to detect fluid shifts when trauma-related haemothorax is above a certain level and may miss some pneumothoraxes and small pulmonary contusions. A delay in diagnosing rib fracture-related lung complications can lead to life-threatening conditions. During the past decade, point-of-care ultrasound (PoCUS) has become an important part of emergency physicians' (EP) daily practice, and

its applications have become numerous [11]. Studies have reported that ultrasound was more sensitive than X-ray for the detection of rib fractures and their pulmonary complications [3, 6, 12]. Therefore, PoCUS in BTI could be a useful tool for patient management. Our aim in this study was to investigate the role of US in the detection of rib fractures and their complications compared with CXR and to evaluate its role in BTI.

## Materials and methods

We performed this retrospective study in our emergency department (city hospital, 55,000 access/years, Ospedale San Paolo, Savona) by collecting and retrieving all patients with BTI and a diagnosis of rib/s fracture/s (using specific query) during an 18-month period (1 June 2015–31 December 2016). We reviewed clinical records compiled by emergency physicians at arrival. PoCUS was performed and recorded prior to acquiring CXR or CT, using the Esaote MyLab 25 or Esaote MyLab 30 Gold with linear array (12–10 MHz) for evaluating bones, pulmonary contusions and pneumothoraxes, and the convex array (3.5–6 MHz) for evaluating haemothorax. We evaluated walking patients with BTI: PoCUS was primarily used to evaluate the exact number of rib fractures (the physician

✉ Alessandro Riccardi  
dottricarcardi@gmail.com

<sup>1</sup> S.C. Medicina e Chirurgia d'Accettazione e d'Urgenza, Ospedale San Paolo Savona, Pronto Soccorso, Via Genova, 17100 Savona, Italy

invited the patients to place the probe directly in the most painful sites with the transducer parallel to the long axis of the rib) and to identify any possible complications related to BTI. The probe was placed on sagittal plane in supine patients to view a possible pneumothorax (absence of pleural sliding or presence of a lung point) or a possible lung contusion (sub-pleural consolidation or localized interstitial syndrome); then, the convex probe was used to view a possible haemothorax, and the physicians ordered a posterior anterior CXR, followed by an oblique rib view. In patients with multiple trauma or any trauma potentially involving the vertebral column, PoCUS was used to rapidly identify the possible complication of BTI or rib fractures but there was no time to define the exact number or sites of the fractures. Baseline data included demographics (age, gender) as well the number of rib fractures and location (upper, 1–4; mid, 5–7; lower, 8–12). All the emergency physicians performing ultrasound were well trained in emergency ultrasound and fulfilled the “Società Italiana di Medicina d’Emergenza-Urgenza (SIMEU)” standards for competency in emergency clinical ultrasound.

### Results

Between 1 June 2015 and 31 December 2016, we evaluated 1672 patients with blunt thoracic trauma. We did not apply exclusion criteria. Among these, we reported rib fractures in 689 patients (41.21%). In this group, a PoCUS was performed in 190 patients (27.58%, 101 male, 89 female), with a mean age of 59.48 years (SD 18.541). In 173 patients, a CXR followed PoCUS; among these, 33 patients also underwent a CT scan of the chest, and 16 patients, after initial PoCUS, underwent a CT scan; 1 patient underwent only PoCUS (Table 1).

### Rib fractures

In 173 patients, PoCUS revealed ribs fractures with subsequent confirmation by CXR or CT. In Table 2 we report patient characteristics in detail. PoCUS conducted in 145 walking patients revealed the exact number and position of the rib/s fracture as shown by CXR; none of these patients underwent a CT scan; and they had a mean of 1.87 rib fractures (range 1–4). We found 7 (3.68%) patients who were diagnosed with rib fractures on the basis of PoCUS examination who were not diagnosed with standard radiography; the rib fractures were all in the mid-segment, mean 1.14, range 1–2. Two patients presented with rib pain after cough, and 5 patients after fall. The mean age was 55.29 years (range 18–86).

**Table 1** Demographic and trauma distribution of patients with BTI

	Fall	Car accident	Motorbike accident	Fall from height > 2 m	Bicycle accident	Spontaneous (movement)	Cough	Pedestrian accident	Assault	Sport accident	Iatrogenic (RCP)
<i>n.</i>	474	53	48	24	23	22	17	11	7	6	4
Mean age	70.63	57.66	53.66	63.88	53.91	67.45	53.63	60.09	47.2	30.17	77
Mean rib fractures	1.87 (range 1–8)	1.9 (range 1–5)	2.07 (range 1–8)	2.6 (range 1–6)	2.24 (range 1–5)	1.68 (1–4)	1.13 (range 1–3)	1.67 (range 1–5)	2 (range 1–3)	1.33 (range 1–2)	2 (range 1–3)
<i>n.</i> CT scan in Rx	57 (12.02%)	14 (26.41%)	16 (33.33%)	14 (58.33%)	8 (34.78%)	0	0	6 (54.54%)	0	0	0
Mean rib fractures in CT scan	4.5 (range 2–8)	4.93 (range 1–14)	5.56 (range 2–18)	4.78 (range 1–10)	5.25 (range 2–7)	–	–	4.1 (range 1–7)	–	–	–

**Table 2** 173 patients with concordance between PoCUS and CXR and CT

	Mean age	60,034
Side	Upper (1–4)	38
	Mid (5–8)	124
	Lower (9–12)	81
No. ribs fracture	<2	95
	3–5	64
	>5	12
Mean ribs fractures	2,61	
Range	1–12	
Cause	Fall	87
	Road accident	67
	Fall from height	10
	Other	9

## Pneumothorax

Seventeen patients (8.94%) presented with pneumothorax. PoCUS detected pneumothorax in 16 patients, and it was subsequently confirmed by a CT scans. Seven patients underwent CXR; however, in 3 patients this technique did not reveal a pneumothorax but instead it was confirmed by a CT. Nine patients did not undergo a CXR but underwent a CT directly after PoCUS. In 1 patient, a pneumothorax that was detected by a CT scan was not detected by either PoCUS or CXR; this was a 57-year-old man, who after a motorbike accident had 7 rib fractures and a small pneumothorax with a substantial mediastinal development. Overall, PoCUS had 100% specificity and 94% sensitivity to detect pneumothorax (PPV 100%, NPV 99.40%).

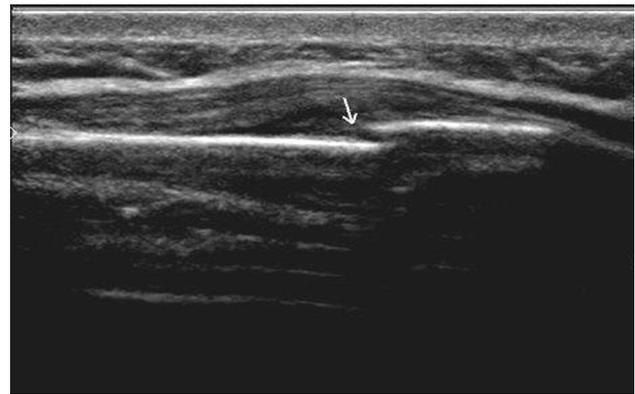
## Haemothorax

Twenty-seven patients presented with haemothorax (14.21%) that was detected by PoCUS in all cases at arrival. CT confirmed these findings in 23 patients (13% had a negative CXR); in 4 cases, CXR confirmed PoCUS. PoCUS had 100% specificity and sensitivity for haemothorax (100% PPV and NPV).

**PULMONARY CONTUSION:** Twelve patients had a pulmonary contusion on CT (6.32%), 10 were detected by PoCUS, and 2 were missed by PoCUS. PoCUS showed 100% of specificity and 83% sensitivity for pulmonary contusion (PPV 100%, NPV 98,90%).

## Discussion

PoCUS in emergency medicine has an increasing role and is useful in many settings [11]. Its role in trauma is well defined, and its ability to detect haemothorax and



**Fig. 1** PoCUS reveals a rib fracture: the probe was placed in the rib's long axis to look for discontinuity of cortical alignment, visualized as a break in the hyperechoic rib margin

pneumothorax is already proven [12–15]. While its role in evaluating chest trauma is clear, its role in detecting rib fractures is less clear [16–25]. There is no agreement regarding the role of PoCUS in this application because it is a painful examination. Although PoCUS examination is superior to CXR, in many circumstances it is not necessary to report the exact number of fractures, and PoCUS could be a waste of time for physician in a busy ED. Turk et al. [26] suggested that PoCUS could be reserved for patients who had unexplained pain after a negative plain chest radiograph. Incidentally, the technique of ultrasound scanning for detecting rib fractures is not complicated and can easily be learned by an emergency physician [16]. We used PoCUS in BTI in two different conditions: in walking patients and in non-walking patients. In walking patients with minor trauma, we used a high-frequency (12-MHz) linear transducer directly at the painful site (or we asked to patient to position the probe at these sites). The probe was placed in the rib's long axis to look for discontinuity of cortical alignment, visualized as a break in the hyperechoic rib margin (Fig. 1). PoCUS could identify with high precision the site and the number of fractures and seemed to be an accurate technique for detecting rib fractures in a CXR-negative patient.

In non-walking patients, we used PoCUS primarily to rapidly detect at least one rib fracture and to identify the complications of trauma (pneumothorax, pulmonary contusion and haemothorax) to guide further examinations. In this type of patient, PoCUS is a very useful tool for identifying pulmonary complications of BTI [12, 14, 24–26]. The role of PoCUS in pneumothorax has been described since its first veterinary application. A typical US examination for pneumothorax involves the use of transthoracic B-mode (greyscale) imaging with a high-frequency probe applied to the patient's anterior and lateral chest wall; the absence of sliding of the lung at the pleural line or the presence of a lung point (the alternating phenomenon of lung sliding and

absent lung sliding in the same interspace, representing the movement of the lung at the border of the pneumothorax) is diagnostic. Pneumothorax after trauma can be a life-threatening injury, and its care requires expeditious and accurate diagnosis and possible intervention. PoCUS could accelerate this diagnosis. Our data confirmed the role of PoCUS for detection of pneumothorax in trauma patients, but its primary role is to identify its presence, not to exclude it. In our opinion, it is not possible to use only PoCUS to exclude a small pneumothorax, and in patients in need of ventilation of any type, or in major thoracic trauma, we suggest performing a CT scan (if permitted by clinical condition) in any patient who is PoCUS negative for pneumothorax. In our population, PoCUS missed a small anterior pneumothorax with a mediastinal component. A further limitation of PoCUS is the difficulty to evaluate the size of the pneumothorax [13–15].

In conclusion, ultrasound examination appears to be an effective method for diagnosing rib fractures in cooperative patients with blunt chest trauma. Particularly, if patients with blunt chest trauma who have had no rib fractures determined on plain chest radiography continue to complain of pain, symptoms do not improve, or a definite diagnosis is required for legal and insurance-related purposes, ultrasound imaging appears to be a supplementary diagnostic tool that offers greater accuracy. We had patients self-position the probe at the most painful site, and this may have reduced the time and the pain of the examination. PoCUS could identify some complications of BTI including haemothorax, pulmonary contusion and pneumothorax. For pneumothorax specifically, PoCUS showed great diagnostic accuracy; nevertheless, it may miss a small pneumothorax or a mediastinal pneumothorax, and patients with need of ventilation with negative PoCUS require a CT scan.

This study has a limitation: our ED is not a trauma centre, and the most-injured patients (with penetrating chest trauma or with major trauma in other districts) were directly transported by EMT to trauma centres. Therefore, the prevalence of any complications in our population is less than would be reported by different papers.

### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no competing interests.

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