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Original Article

Comparison of ultrasonography and radiography in diagnosis of rib fractures

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ABSTRACT

Purpose: Rib fractures are the most common skeletal thoracic injuries resulting from blunt chest trauma. Half of the rib fractures are not detected upon a precise physical evaluation and radiographs. Recently ultrasonography (USG) has been investigated to detect rib fractures. But based on literature the usefulness of USG varies widely. This study was conducted to investigate the role of USG in the detection of possible rib fractures in comparison with radiography.

Methods: In this cross-sectional study, consecutive patients with minor blunt chest trauma and suspected rib fractures presenting in Imam Reza Hospital located in Mashhad-Iran, between April 2013 and October 2013 were assessed by USG and radiography. The radiography was performed in a poster-oanterior (PA) chest projection and oblique rib view centered over the area of trauma. The time duration spent in taking USG and radiography were recorded. The prevalence and location of fractures revealed by USG and radiography were compared.

Results: Sixty-one suspected patients were assessed. The male to female ratio was 2.4:1 (43 men and 18 women) with a mean ± SD age of (44.3 ± 19.7) years. There were totally 59 rib fractures in 38 (62.3%) patients based on radiography and USG, while 23 (37.7%) patients had no diagnostic evidence of rib lesions. USG revealed 58 rib fractures in 33 (54.1%) of 61 suspected patients and radiographs revealed 32 rib fractures in 20 (32.8%) of 61 patients. A total of 58 (98.3%) rib fractures were detected by USG, whereas oblique rib view and PA chest radiography showed 27 (45.8%) and 24 (40.7%) rib fractures, respectively. The average duration of USG was (12 ± 3) min (range 7–17 min), whereas the duration of radiography was (27 ± 6) min (range 15–37 min). The kappa coefficient showed a low level of agreement between both USG and PA chest radiography (kappa coefficient = 0.28), and between USG and oblique rib view (kappa coefficient = 0.32).

Conclusion: USG discloses more fractures than radiography in most patients presenting with suspected rib fractures. Moreover USG requires significantly less time than radiography.

Introduction

Rib fractures are the most common skeletal thoracic injuries resulting from blunt chest trauma.[1,2] These fractures are rarely life-threatening themselves but can be an external marker of more severe visceral injuries inside the abdomen and the chest. A physical examination and radiography are the main diagnostic tools for detection of rib fractures. But only 49% of rib fractures are detected upon a precise physical evaluation and radiographs.[3] Radiography occasionally cannot demonstrate fractures in costal cartilages, except for densely calcified ones.[4] Therefore, some attempts have been made to detect unknown fractures with USG. In the literature, the usefulness of ultrasonography (USG) in detecting rib fractures varies widely: from not significant[2] to more sensitive than radiography.[4–7] On the other hand, the advantages of USG including non-

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invasiveness, portability, relative inexpensiveness, lack of radiation, and repeatability, make USG a valuable diagnostic tool.[8] This study compared USG and radiography in the detection of rib fractures.

Materials and methods

This cross-sectional study was conducted in the emergency department (ED) of Imam Reza Hospital, the largest teaching hospital in North-East Iran, between April 2013 and October 2013, and included consecutive patients with acute minor blunt chest trauma and suspected rib fractures. The probability of fractures was clinically assessed (aggravated chest wall pain by position change, cough, or deep breath, and focal tenderness over the rib). Exclusion criteria were severe or penetrating trauma, unstable hemodynamic conditions, and lack of patient consent.

USG was performed on suspected patients by emergency medicine specialist using a 7.5–12-MHz (Honda 2100: Honda Electronics Co., Ltd, Japan) linear transducer. Other related parameters were X-ray machine: made in Korea; Tube: Toshiba – Rotanode™ – Unit model: E7252X – Serial number: 12D1311; Detector: SYFM – Shinyoung for M – Product: 6-way patient table – Model: ST-3300; Montage: Mehran Teb; PA CXR: 80 kV & 10 mA; Oblique rib view: 65 kV & 32 mA.

All USG was performed by a resident trained for more than six months in the emergency department; while the operator of radiology was an expert technician of radiology. The transducer was placed over the most painful rib pointed by the patient in the long axis of the rib. Fractures in the rib, costochondral junction, and costal cartilage were indicated by a disruption of the anterior echogenic margin, a linear acoustic edge shadow, or a focal hematoma. For each patient, the duration time of USG and radiology was enrolled. Since portable USG was available in the emergency room, the duration time of USG was calculated from the time of insertion of the transducer over the most painful rib to removal of the transducer from the chest wall; while the duration time for radiology started from the time of transferring patient to the radiology department and ended whenever patient relocated in the bed in the emergency room.

Then the radiography was performed in a posteroanterior (PA) chest projection and the oblique rib view centered over the area of trauma. All radiographs were reviewed by chief resident of emergency medicine who was unaware of USG results. The time duration of the radiography was enrolled, too.

We assumed that there is no gold standard for rib fracture. On the other hand, we assumed that whatever we diagnose as fracture by X-ray and USG is a correct diagnosis and there is no false positive fracture diagnosis; then we can assumed that gold standard for rib fracture diagnosis is total amount of detection of rib fractures by one of two methods of USG or X-ray. Table 1 shows the sensitivity, specificity, positive and negative predictive value of USG and chest radiography.

All data were presented as mean ± SD. The levels of agreement in the diagnostic tools for the diagnosed rib fractures were assessed by kappa coefficients. Kappa statistics values less than 0.40 represent poor agreement; values of 0.41–0.60 represent moderate; values of 0.61–0.80 represent good agreement, and values over 0.80 represent excellent agreement.[9] PASW (SPSS Inc, Illinois, USA) was used for data handling; 95% confidence interval (CI) was calculated for the sensitivity, specificity, positive and negative predictive value of ultrasonography and chest radiography. The research ethics committees of the study hospitals approved the protocol and the patient consent form.

Results

A total of 61 consecutive patients with minor blunt chest trauma were enrolled into the study. The patients were 43 (70.5%) male and 18 (29.5%) female with a mean age of (44.3 ± 19.7) years (range: 14–81 years). The most common cause of trauma was fall in 31 (50.8%) patients, followed by road traffic crashes and direct blow, equally in 15 (24.6%) patients. Clinical examination revealed point tenderness in chest wall in almost all patients. The most painful region was in anterior chest in 20 (32.8%) patients, posterior chest in 13 (21.3%), hemi-thorax in 12 (19.7%), costovertebral angle in 12 (19.7%), and whole of chest in 4 (6.6%) patients. Associated complications of the rib fractures were pleural effusion in 4 (10.5%), pneumothorax in 3 (7.9%), and clavicle fracture in 1 (2.6%) patients which all could be diagnosed by sonography.

There were overall 59 rib fractures in 38 (62.3%) patients based on both radiography and USG, while 23 (37.7%) patients had no diagnostic evidence of rib lesions. USG revealed 58 out of 59 rib fractures in 38 (54.1%) patients and radiographs revealed 32 rib fractures in 20 (32.8%) of 61 patients. The only one sonography-missed rib fracture was posterior portion of the third rib located behind scapula. A total of 58 (98.3%) rib fractures were detected by USG, whereas oblique rib view and PA chest radiography showed 27 (45.8%) and 24 (40.7%) rib fractures, respectively. USG had a significantly higher sensitivity and negative predictive value than chest radiography in rib fracture diagnosis (Table 1). The only missed rib fracture in USG was detected by both PA chest X-ray and oblique rib view. USG showed a disruption of the anterior margin in 48 (82.8%) cases and a focal hematoma in 10 (17.2%) cases. Fig. 1 shows the number of fractures per rib. The average duration of USG was (12 ± 3) min (range 7–17 min), whereas the duration of radiography was (27 ± 6) min (range 15–37 min) ($p < 0.001$).

The kappa coefficient showed a low level of agreement between both USG and PA chest radiography (kappa coefficient = 0.28), and between USG and oblique rib view (kappa coefficient = 0.32).

Table 1
Sensitivity, specificity, positive and negative predictive values of ultrasonography and chest radiography.

	Ultrasonography		Chest radiography	
	Presence of rib fracture (%)	95% *CI*	Presence of rib fracture (%)	95% *CI*
Sensitivity	98.31	90.91–99.96	40.68	28.07–54.25
Specificity	100	95.18–100	100	85.18–100
Positive predictive value	100	93.84–100	100	93.84–100
Negative predictive value	95.83	78.88–99.89	39.66	27.05–53.36

Regarding the diagnosis of rib fracture, ultrasonography has a significant higher sensitivity and negative predictive value than chest radiography.

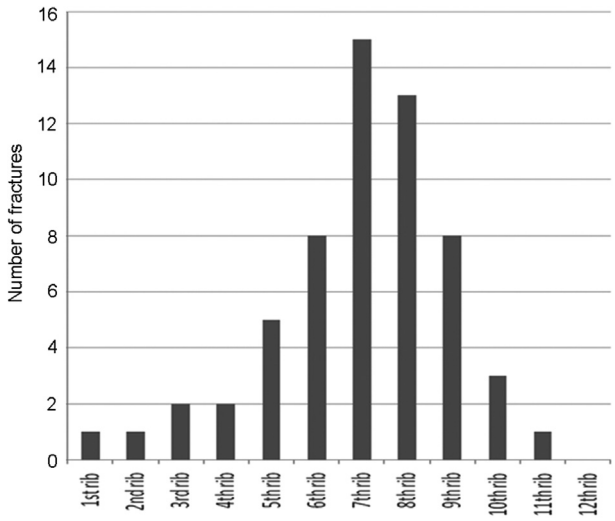

Fig. 1. The number of fractures per rib.

Discussion

In this study, USG disclosed more fractures than radiography in traumatic patients presenting with suspected rib fractures (USG: 98.3%, oblique rib view: 45.8%, and PA chest radiography: 40.7%). The majority of studies have obtained great discrepancy for rib fracture detection by USG and radiography and have proposed USG as the more sensitive one.[7,10,11] Mattox et al[5] showed higher sensitivity for USG compared with chest radiography in detecting rib fractures. We used oblique rib view in addition to PA view; therefore the overall sensitivity of radiography was shown higher than previous studies.[4–6] On the other hand, Hurly et al[2] reported that USG did not significantly increase the detection rate of rib fractures. It may be due to their small sample size (14 patients).

In our study, the average time of USG was (12 ± 3) min, which was similar to other studies[2] and significantly shorter than that of radiography, i.e. (27 ± 6) min. Most of the time of USG was spent in localizing the fracture site,[4] which may be time-consuming and uncomfortable for the patient. However, it was 15 min shorter than radiography. Meanwhile, in hemodynamically unstable patients with hemothorax and/or pneumothorax, USG is an easy, available, rapid and accurate diagnostic procedure.

In USG, discontinuity of cortical alignment and an acoustic linear edge shadow are two diagnostic criteria for detection of fractured rib.[2] In blunt chest trauma patients, USG can quickly confirm or rule out associated findings such as pleural effusion, pneumothorax and hemothorax.[12]

In the present study, the only rib fracture that was missed by USG was a third rib fracture in the costovertebral junction. This is one of USG's drawbacks in the evaluation of upper ribs under scapula and first rib under clavicle.[13] Obesity and large breasts are factors that reduce the quality of USG diagnosis.[6]

Conclusion

USG is more sensitive than radiography for diagnosis of rib fractures. But it is not adequate to assess the first rib under clavicle and upper ribs under scapula.

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