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Research Article

Adequateness of radiography in recognizing rib fractures in minor chest trauma: A comparison of the efficacy of sonography and radiography

Minör göğüs travmasında radyografinin kaburga kırıklarını tanımada yeterliliği: Sonografi ve radyografinin etkinlik kıyaslaması

Emre Yurdakul[a], Servet Kahveci[b]

[a] Department of Orthopedics, System Hospital, Clinic of Orthopedics, Kayseri, Türkiye

[b] Department of Radiology, Qatar University Health Center, Qatar

Abstract

Introduction: The most common injury resulting from blunt chest trauma is a rib fracture (25%) which is usually visible on radiographs. However, radiographs sometimes cannot show fractures, especially those in cartilage, unless they're densely calcified. The present study aimed to investigate the role of ultrasonography (US) in detecting rib fractures with minor blunt chest trauma and comparing its success with posteroanterior (PA) chest radiography.

Methods: Patients with minor blunt chest trauma who had previously undergone US and radiography to assess suspected rib fractures, between June 2017– March 2019, were included. Radiography was obtained in the PA projection. US was performed by a radiologist who identified fractures by the disruption of the anterior margin of the rib on the US. The incidence and location of the fractures detected by US and radiography were then compared.

Results: Totally 126 patients were included in the study. Ninety-eight patients (78%) were admitted to the hospital for the first time, and 28 patients (22%) for the second time (they previously admitted to the other hospitals and were evaluated as 'normal' by radiography). A total of 108 fractures (in 79 patients (63%)) were detected based on radiography and US examination, while 47 patients (37%) had no diagnostic evidence of fracture. All fractures were correctly detected by ultrasonography (100%), whereas radiography revealed 16 fractures (14.81%). A statistically significant difference in diagnostic capability was found between patients diagnosed by radiography and US (p=0.001).

Conclusion: Ultrasonographic imaging is significantly superior to radiography in terms of accuracy in diagnosing rib fractures. Ultrasound was found to be significantly superior to radiography regardless of trauma site, localization, and location. Even though some rib areas are inaccessible on ultrasonographic evaluation, rapid evaluation of the most affected areas is most effective with ultrasonography when it comes to minor energy chest trauma. For this reason, the US increases the accuracy of diagnosis in minor chest traumas and rib fractures and decreases the repetitive referral of patients to health institutions by reducing the missed diagnosis.

Keywords: Rib fractures, thoracic injuries, trauma, ultrasonography, radiography

Öz

Giriş: Minör enerjili künt göğüs travması sonrası meydana gelen en yaygın yaralanma, genellikle kaburga kırığıdır (%25) ve genellikle teşhis için radyografik görüntüleme kullanılır. Bununla birlikte, radyografiler bazen, özellikle kıkırdaktaki kırıkları olmak üzere veya yoğun bir şekilde kalsifiye olmadıkça kırıkları gösteremezler. Bu çalışmadaki amaç minör künt göğüs travmalı hastalarda kaburga kırıklarını saptamada ultrasonografinin (US) rolünü araştırıp değerlendirmek ve başarısını posteroanterior (PA) akciğer grafisi ile karşılaştırmaktı.

Yöntem: Çalışmamızda, Haziran 2017 ve Mart 2019 tarihleri arasında travma sonrası şüpheli kaburga kırıklarını değerlendirmek adına daha önce hem US hem de radyografi uygulanmış minör künt göğüs travması olan hastalar dahil edilmiştir. Hastaların tamamına PA projeksiyonunda radyografi çekildi. US çekimi, kaburga kırıklarını ve bütünlüğünü değerlendirme ve tanımlamada uzman bir radyolog tarafından yapıldı. Daha sonra US çekimi ile saptanan ve radyografi ile saptanan kırıkların insidansı, özellikleri ve lokalizasyon bilgileri karşılaştırıldı.

Bulgular: Mevcut çalışmaya toplam 126 hasta dahil edildi. Hastalar arasında 98 hasta (%78) ilk kez, 28 hasta (%22) ise ikinci kez hastaneye başvurmuş olduğu bilgisi tespit edildi (bu hastaların daha önce başka hastanelere başvurmuş olduğu ve radyografik değerlendirme ile 'normal, sağlıklı' olarak değerlendirilmiş ve taburcu edilmiş olduğu tespit edilmiştir). Radyografi ve US incelemeye göre toplam 108 kırık tespit edilmiştir (tamamı 79 hastada (%63)), 47 hastada ise (%37) tanı konulan kırık bulgusu yoktu. Ultrasonografi ile tüm kırıklar (%100) doğru tespit edilirken, radyografide 16 kırık (%14,81) tespit edildi. Radyografi ve US ile tanı konulan hastalar arasında tanısal yetenek açısından istatistiksel olarak anlamlı fark bulundu (p=0,011).

Sonuç: Kaburga kırıkları teşhisinde, ultrasonografik çekim, doğruluk açısından radyografiden önemli ölçüde üstündür. Ultrasonografi travma bölgesinden, lokalizasyon ve yerleşiminden bağımsız olarak radyografiye göre anlamlı üstün bulunmuştur. Ultrasonografik değerlendirmede bazı kaburga alanlarının erişilemeyeceği gerçeğine rağmen, söz konusu minör enerjili göğüs travması olduğunda, en çok etkilenen bölgelerin hızlı bir şekilde değerlendirilmesi en etkili olarak ultrasonografi ile olmaktadır. Bu nedenle US, minör göğüs travmalarında kot kırıklarında tanı doğruluğunu arttırır ve tanı atlanmasını azaltarak da hastaların sağlık kuruluşlarına tekrar tekrar başvurularını azaltmış olur.

Anahtar kelimeler: Kaburga kırıkları, toraks travmaları, travma, ultrasonografi, radyografi

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December 7, 2021	July 25, 2022	July 31, 2022	Emre Yurdakul, M.D.	md.emreyurdakul@gmail.com
Correspondence	Dr. Emre Yurdakul, System Hospital, Clinic of Orthopedics, Kayseri-Türkiye			
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Key Points

1. Ultrasonography is highly sensitive in detecting rib fractures following minor chest trauma.
2. Ultrasonography of the thoracic examination of the patients after blunt chest trauma results lower hospital readmissions.

Introduction

Rib fractures are common injuries admitted to the hospital following blunt thoracic trauma, yet severe coughing, athletic activities, and non-accidental trauma might also cause them. Besides, injuries to the abdominal organs are sometimes associated with lower rib fractures. Minor blunt chest trauma is mostly treated on an outpatient basis and without any complications such as pneumothorax, hemothorax, or pulmonary contusion. Patients with rib fractures who have not sustained major trauma can localize the pain to the extent that is consistent with the area of trauma, an area often limited to one or two ribs. A deep breath typically elicits pain at the fracture site [1].

Standard PA chest radiography is adequate to identify some rib fractures, though the overall sensitivity is low. Chest radiographs enable clinicians to look for pneumothorax, hemothorax, and other signs of intrathoracic injury, which is the main reason they are obtained. However, on chest radiographs, 33% to 50% of rib fractures are likely to be missed [2]. Despite its inefficiency, chest radiography remains the primary diagnostic method for blunt chest wall trauma and rib fractures. Dedicated rib radiography (including anteroposterior (AP) and oblique view) with lower kV higher mAs technique to highlight bony structures is superior to PA chest radiography for detecting rib fractures [3, 4].

In recent years, the ultrasonography US - a valuable, alternative imaging modality with its non-invasive nature, portability, inexpensiveness, lack of radiation, and repeatability- has been used with significantly higher diagnostic accuracy in most bone fractures [5]. However, evidence for US use in the diagnosis of rib fractures remains controversial [6]. Therefore, in this study, we aimed to investigate the role of the US in detecting rib fractures, compare its accuracy with radiography, and evaluate the potential benefits of using the US as a diagnostic choice in minor blunt trauma of the chest.

Methods

Subjects

This prospective study was conducted in the radiology, emergency, and orthopedics clinic of Private Sevgi Hospital, Osmaniye, Türkiye between June 2017-March 2019. A total of 126 consecutive patients with minor blunt chest trauma and suspected rib fracture were included in the study in which both radiography and ultrasonography were performed. The duration between the time of trauma and radiographic examination is also recorded. Patients who were uncooperative, unstable, or had suffered major trauma were not included in this study group.

Diagnosis of Rib Fractures

The radiography was performed in a PA chest projection. All radiographs were reviewed by an emergency physician or an orthopedist who was unaware of US results. Ultrasonography was performed using (Toshiba Aplio 300, Otawara, Japan) a 7-11 MHz linear probe by an experienced radiologist. Patient examinations have all been conducted by the same radiologist. In the supine and lateral decubitus position, the entire rib in the painful area was detected by the probe and above and below the rib. Fractures were identified by disruption of the anterior margin of the rib on ultrasound. The incidence and location of fractures detected by US and radiography were then compared. The injured rib location was classified as upper (1-4), mid (5-8), and lower (8-12) hemithorax and anterior, lateral (anterolateral, posterolateral), and posterior parts of a rib. Besides, patients were examined for hemothorax and pneumothorax.

Ethical approval

In this study, national and international ethical rules are observed. Board Ahi Evran University School of medicine, Number 2021-03/30, Date 09-02-2021. The hospital's management granted permission for the use of hospital information. All patients participating in the study signed a written informed consent form.

Statistical Analysis

All analyses were performed on SPSS v21 (SPSS Inc., Chicago, IL, USA). A normality check analysis was performed on the data. Data are given as mean ± standard deviation or median (minimum-maximum) for continuous variables concerning normality and frequency (percentage) for categorical variables. Non-normally distributed variables were compared with the Mann-Whitney U test. Categorical variable evaluations were done through Chi-square tests $p<0.05$ values were accepted as statistically significant.

Results

In this study, 126 patients (70 males and 56 females) were assessed; the mean age was 52.11+17.53 years. The cause of trauma was fall (85 patients, 67.46%), direct blow (34 patients, 26.98%), and traffic accident (7 patients, 5.56%). Ninety-eight patients (78.8%) had applied to our center directly, while 28 patients (22.2%) had initially applied to other centers and were discharged after being evaluated as normal by radiography. These 28 patients applied to our emergency department due to the persistence of their complaints. The primary characteristics of patients are shown in Table 1.

Rib fractures were detected in 79 patients (63%) out of 126 patients; a total of 108 fractures were detected in those patients. 47 patients (37%) had no diagnostic evidence of fracture, neither by radiography nor with the US. Rib fracture levels were found to be upper-level ribs in 9% (n=10), mid-level ribs in 60% (n=65) and lower-level ribs in 31% (n=33). According to US results, 53.70% (n=58) of fractures were located in the anterior,

28.70% (n=31) in the anterolateral, 15.75% (n=17) in the posterolateral and 1.85% (n=2) in the posterior part of the rib. Characteristics of rib fractures are shown in Table 2. Comparing the US and X-ray results, radiography detected 16 fractures, 12 on the left hemithorax and 4 on the right. X-rays did not reveal any posterior fractures; 11 fractures were found anteriorly, three were anterolateral, and two were posterolateral. The X-rays have revealed no fractures on the upper side of the thorax, 7 fractures in the middle, and 9 fractures in the lower part. There were significant differences in the accuracy of fracture detection between the right and left directions, anterior and posterior directions, upper-mid and lower directions between US and X-ray (p=0.01, p=0.01, p=0.01 respectively).

Table 1. Summary of patients' characteristics

Suspected rib fractures, *n*	126
Age, *mean ± SD*	52.11 ± 17.53
Gender, *n (%)*	
Male	70 (55.56%)
Female	56 (44.44%)
Cause of trauma, *n (%)*	
Fall	85 (67.46%)
Direct Blow	34 (26.98%)
Traffic Accident	7 (5.56%)
Admission, *n (%)*	
First Time	98 (77.78%)
Second Time	28 (22.22%)
Hemithorax (location of trauma), *n (%)*	
Right	59 (46.83%)
Left	66 (52.38%)
Bilateral	1 (0.79%)
Location of pain, *n (%)*	
Anterior	61 (48.41%)
Anterolateral	38 (30.16%)
Posterolateral	22 (17.46%)
Posterior	5 (3.97%)
Fractured Ribs, *n (%)*	Patient n (%)
0	47 (37.30%)
1	57 (45.24%)
2	16 (12.70%)
3	5 (3.97%)
4	1 (0.79%)

Data are given as mean ± standard deviation or median (minimum-maximum) for continuous variables concerning normality and frequency (percentage) for categorical variables.

Table 2. Summary of detected fractures' characteristics*

	n (%)	US (n)	X-ray (n)	p**
Patients with fractures	79 (100%)			
Fractures	108 (100%)	108	16	0.001
Hemithorax				0.001
Right	53 (49.07%)	58	4	
Left	55 (50.93%)	55	12	
Location of Fractures				0.001
Anterior	58 (53.70%)	58	11	
Anterolateral	31 (28.70%)	31	3	
Posterolateral	17 (15.75%)	17 (15.75%)	2	
Posterior	2 (1.85%)	2 (1.85%)	0	
Fractured Rib number				0.001
1st	0(0%)	0	0	
2nd	0(0%)	0	0	
3rd	4 (3.70%)	4	0	
4th	6 (5.56%)	6	0	
5th	12 (11,11%)	12	2	
6th	14 (12.96%)	14	2	
7th	19 (17.59%)	19	3	
8th	20 (18.52%)	20	7	
9th	16 (14.81%)	16	2	
10th	12 (11.11%)	12	0	
11th	5 (4.63%)	5	0	
12th	0(0%)	0	0	
Level of Fracture				0.001
Upper	10 (9.26%)	10	0	
Mid	65 (60.18%)	65	7	
Lower	33 (30.56%)	33	9	
X-ray				
Negative	92 (85.19%)			
Positive	16 (14.81%)			
US				
Negative	0 (0%)			
Positive	108 (100%)			

*Frequency (percentage) for categorical variables

** Student -t test, Mann Whitney U test

All fractures were correctly detected via US (100%), whereas radiography revealed only 16 fractures in 11 patients (14.81%). A statistically significant difference was found between the diagnostic capability of the methods utilized in this study (Radiography and US) (p=0.011). Figure 1 a-c demonstrates a radiograph and the US scan of patients whose fracture was misdiagnosed via radiograph and was detected with the US.

Discussion

In this study, the US revealed more fractures than PA chest radiography in patients with minor chest trauma (US: 100%, PA chest radiography: 14.81%). There were no cases in which US results did not determine a conclusively diagnosed fracture via PA chest radiography.

Comparing radiography and US in the evaluation of rib fractures, previous research suggests different results. Many studies have found remarkable differences in the detection of rib fractures by US and radiography, and steel has suggested the US as the more sensitive approach [7-9]. Studies that used both PA and oblique view to detect rib fractures reported an overall close positive diagnostic rate to the US [10, 11]. In our study, we used only plain PA images for the detection of rib fracture. This may explain the extensive gap in the competition of the diagnostic techniques we used.

It may be due to obtained radiographic images, such as PA chest views or dedicated rib views. We used only PA chest radiography as radiographic imaging; therefore, this study also showed higher sensitivity than radiography.

Most rib fractures due to minor blunt trauma are uncomplicated (pneumothorax, hemothorax, pulmonary contusion) and treated with outpatient management [12, 13]. In this study, neither US nor radiography has shown such complications of minor blunt trauma as well. Only 6 patients that have three and more fractures were consulted for thorax surgent and were hospitalized.

In this study, rib fracture levels were mid in 60.18% and lower in 30.56% of the fractured bones. According to US results, 50% of fractures were located in the anterior and 48% in the lateral location. These findings imply that, in minor traumas, rib fractures usually occur in the middle and lower ribs, especially in the anterior and lateral portions. This may be since these minor traumas mostly affect these regions, which are more vulnerable to such trauma due to soft tissue support weakness compared to posterior hemithorax. In anterior and lateral hemithorax, thin, soft tissue allows well detection of superficially located ribs, and these areas can be easily examined in supine and lateral decubitus positions. Most studies that compared the radiographic imaging and US for detecting rib fractures [6, 10, 14] used the patients' pain location to determine the pathology: thus, they reduced the examination time and focused on the probably fractured bone. In our study, methodologically we examined the patient throughout the entire chest in order to avoid misdiagnosed rib fracture and also aim to standardize the US examination. Again, we detected no fractures in the levels of the 1st and 2nd ribs. As we know that obesity and anatomic level (evaluation of upper ribs under scapula and first rib under clavicle) may reduce the accuracy of the US examination [15], here we cannot avoid bias in our study.

The most recent revision by the American College of Radiology suggests that chest radiography is unnecessary for diagnosing rib fractures in adults with minor trauma because revealing rib fractures does not usually influence treatment decisions in minor blunt traumas, which are mostly uncomplicated [2]. However, most rib fractures cannot be detected on X-ray, and these patients may present to the hospital a second time or more due to the persistence of unexplained pain. In this study, 28 patients (22%) applied to the hospital for the second time who were admitted to the other hospitals before and were evaluated as normal by radiography. Ultrasonography is more sensitive than radiography in revealing rib fractures, and thus multiple visits of the patients to the hospital can be prevented. Additionally, on sonography, multiple rib fractures could be shown in patients with no fracture, or a single fracture detected on radiography, and they may necessitate referral to a thoracic surgeon for further assessment.

For medicolegal and insurance-related purposes the US could be used for a definite diagnosis. In this manner, more rib fractures can be shown, which are interpreted as negative in radiography. This situation may bring some problems with it. To avoid these problems, rib fractures should be revised and recategorized as complicated and uncomplicated or displaced and displaced or detected on the US and detected on radiography. Medicolegal issues and insurance policies should be rearranged according to this classification.

Limitations

There are two significant limitations in this study. First, only standard PA Chest radiography was obtained as radiographic imaging. In terms of effectivity revealing rib fractures, dedicated rib views- including AP and oblique views with a low kilovoltage to optimize bone details - should have been added to compare US and radiography. Second, the US was accepted as a gold standard imaging modality, and the accuracy of radiography was compared with its results.

Conclusion

The results of this study showed that the US is superior to radiography in diagnosing rib fractures. Radiography is evidently inadequate compared to US examinations. Most rib fractures cannot be detected on X-ray, and these patients may present to the hospital for the second time or more due to the persistence of unexplained pain. Therefore, the US's higher efficiency in diagnosing rib fractures may be utilized to prevent misdiagnoses and multiple admissions to the hospital and provide proper management. For a more advanced recommendation and optimization of the present study, it may be helpful to repeat the diagnostic results with radiography, ultrasonography, and computed tomography (the gold standard for the diagnosis of rib fractures).

Conflict of Interest: The authors certify that they have no affiliation with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the manuscript (e.g., employment, consultancies, stock ownership, and honoraria).

Author Contributions		Author Initials
SCD	Study Conception and Design	EY, SK
AD	Acquisition of Data	EY, SK
AID	Analysis and Interpretation of Data	EY, SK
DM	Drafting of Manuscript	EY, SK
CR	Critical Revision	EY, SK

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