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ARAŞTIRMA YAZISI / RESEARCH ARTICLE

ARTIK ELİMİZDE DAHA FAZLA KANIT VAR; ULTRASONOGRAFİ KABURGA KIRIKLARININ GÖSTERİLMESİNDE GÜVENİLİR BİR ARAÇTIR

WE HAVE MORE EVIDENCE THAN BEFORE; ULTRASONOGRAPHY IS A RELIABLE TOOL TO SHOW RIB FRACTURES

Elif Dilara TOPCUOĞLU[1], Sinan UZUNGET[2], Tevfik KAPLAN[3], Zamir Kemal ERTÜRK[4], Gökçe Kaan ATAÇ[5]

[1]Sağlık Bilimleri Üniversitesi Ümraniye Eğitim ve Araştırma Hastanesi, Radyoloji Ana Bilim Dalı
[2]Erkunt Sanayi Sağlık Birimi, Acil Tıp Kliniği
[3]Lokman Hekim Üniversitesi Tıp Fakültesi, Göğüs Cerrahisi Ana Bilim Dalı
[4]Türkiye Bilimsel ve Teknolojik Araştırma Kurumu (TÜBİTAK)
[5]Ufuk Üniversitesi Tıp Fakültesi Radyoloji Ana Bilim Dalı

ÖZET

AMAÇ: Bu çalışmanın amacı künt göğüs travmasında şüpheli kosta kırıklarının ultrasonografi (US) değerlendirmesinde gözlemciler arası güvenilirliği ölçerek US'un tanısal değerini belirlemektir.

GEREÇ VE YÖNTEM: Künt göğüs travması nedeniyle acil servise başvuran ve kosta kırığı şüphesi olan, yaş ortalaması 48 olan (18 ila 95 yaş) toplam 52 hasta (32 erkek, 20 kadın) çalışmaya dahil edildi. Tüm hastaların direk akciğer grafileri ve US incelemeleri iki radyolog (20 yıllık US deneyimi olan bir kıdemli radyolog hekim ve bir yıllık US deneyimi olan bir asistan hekim) tarafından bağımsız şekilde değerlendirildi.

BULGULAR: Akciğer grafisinde sadece iki kosta kırığı tespit edildi. Her iki radyolog tarafından yapılan US incelemede 19 hastada 22 kırık tespit edildi. Sadece bir kosta kırığı kıdemli radyolog hekim tarafından fark edildi, asistan hekim tarafından fark edilmedi. US ile kosta kırığı tespitinde gözlemciler arası uyum çok iyiydi (Kappa: 0.917) ve bu uyum istatistiksel olarak anlamlıydı (p=0.002). Tüm kırıklar kostanın kemik kısmında yer almaktaydı ve kostal kıkırdak veya kostokondral bileşkede kırık saptanmadı.

SONUÇ: Bu çalışma ile kosta kırığı tanısında US incelemenin, gözlemciler arası değişkenliğinin çok düşük olduğunu ve yüksek oranda tekrarlanabilir bir tanı aracı olduğunu gösterdik.

ANAHTAR KELİMELER: Gözlemciler arası değişkenlik, Kosta kırığı, Radyografi, Ultrasonografi.

ABSTRACT

OBJECTIVE: The aim of this study is to assess the value of ultrasonography (US) by determining the inter-observer reliability on US evaluation of suspected rib fractures in blunt chest trauma.

MATERIAL AND METHODS: A total of 52 patients (32 males, 20 females) with a mean age of 48 years (18-95 years) who presented to the emergency department with blunt chest trauma and suspected rib fracture were included in the study. All patients were assessed with US by two radiologists (a senior radiologist with 20 years of US experience and a resident with one year of US experience) independently and chest x-rays were also evaluated.

RESULTS: Only two rib fractures were detected on chest x-rays. 22 fractures were detected from 19 patients with US by both radiologists. One rib fracture was noted only by the senior radiologist and not by the resident. Interobserver agreement was very good (kappa: 0.917) and statistically significant (p=0.002). All fractures were located at the bony portion of the rib and no fracture was found at the costal cartilage or costochondral junction.

CONCLUSIONS: We demonstrated that US is a highly reproducible diagnostic tool for rib fractures with very low inter-observer variability.

KEYWORDS: Interobserver variability, Rib fractures, Radiography, Ultrasonography.

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Yazışma Adresi / Correspondence: Uzm. Dr. Elif Dilara TOPÇUOĞLU
Sağlık Bilimleri Üniversitesi Ümraniye Eğitim ve Araştırma Hastanesi, Radyoloji Ana Bilim Dalı
E-mail: elifdilaratopcuoglu@gmail.com
Orcid No (Sırasıyla): 0000-0001-8420-0752, 0000-0002-7945-0113, 0000-0002-4936-1515, 0000-0001-6837-2028, 0000-0002-4145-8275
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INTRODUCTION

Rib fractures constitute an important portion of admissions to emergency department (ER) and patients are usually present with a blunt thoracic trauma (1 - 4). Typical clinical history and chest pain are the main symptoms. Although conventional chest x-ray (CXR) has lower sensitivity, it is almost always used as a first line modality for detection of rib fractures (1, 5, 6). Sensitivity of CXR could show variability according to pulmonary parenchymal changes, age or bone mineral density. As reported by studies in the literature, sensitivity of CXR changes between 13.5% to 61.3% (7, 8). Whereas ultrasonography (US) is a widely used, cheap, safe and readily found in almost every ER, it can be used for a diagnosis of rib fracture (9). Thus, it remains to be determined whether it could be used for assessing rib fractures in routine clinical practice. There were studies reporting superiority of US over plain films for rib fractures (2, 5, 10). However, in order to put a diagnostic tool into routine usage as a robust technique, first of all, the results of it must be reproducible and reliable.

The aim of the current study is to assess the inter-observer agreement of US on suspected rib fractures in blunt chest trauma.

MATERIALS AND METHODS

Study Population

Within one-year period, patients who admitted to the ER, present with blunt chest trauma and localized chest pain were included. Multi-system trauma, patients having comorbidities or clinically unstable patients were excluded.

Chest X-ray and Ultrasound Evaluation

All patients assessed by two radiologists independently and they were blinded to each other's findings (first radiologist with a 20 years experience in body radiology and second radiologist with one year experience in US).

All patients underwent posteroanterior chest x-ray. Firstly, CXRs were examined on a high resolution diagnostic monitor. The presence and number of rib fractures were noted. Then, patients were evaluated consecutively with an approximately 30 minutes intervals by using 7.5-12 MHz transducers. Patients were both at the supine and lateral decubitis position and the tranducer was placed parallel to the axis of the costal surface (8). On the suspected hemithorax, whole ribs and also the site of tenderness were evaluated carefully. Every US examination took approximately 20-30 minutes. Normal US findings of the costal bone is a continuous echogenic line deep to the muscle and superficial to the pleural surface **(Figure 1)**.

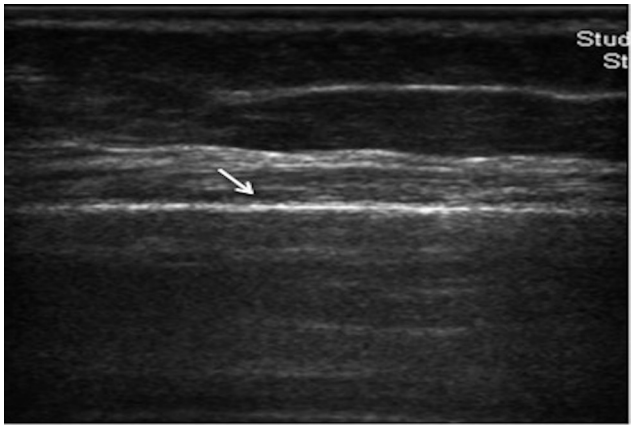

Figure 1: Continuity of costal surface in a normal patient.

Four US findings were recorded; cortical deformity, defined as separation of the fracture edges **(Figure 2)**; posterior acoustic shadowing at the fracture edges Figure 2; step-off deformity, defined as displacement or overlap of the fracture edges **(Figure 3)**; and localised haematoma at subperiostal area **(Figure 4)**. In order to make sure that the cortical irregularity area is not a nutrient vessel, the presence of sensitivity with probe pressure was noted and power Doppler US findings were evaluated. Computed tomography (CT) was not performed to avoid radiation in patients with minor trauma who were included in the study.

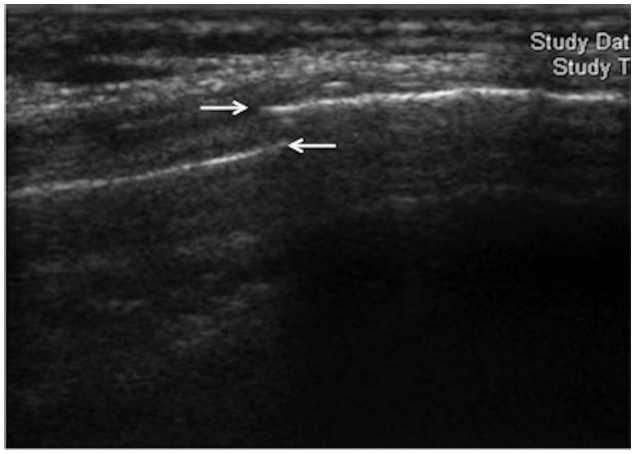

Figure 2: Cortical dehiscence at the costal surface (arrow) and posterior acoustic shadowing at the fracture ends (asterisk).

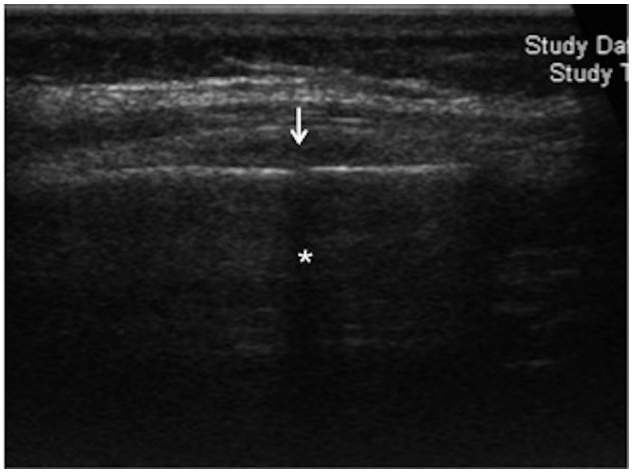

Figure 3: Displacement of the fracture edges at the costal fracture site (arrow).

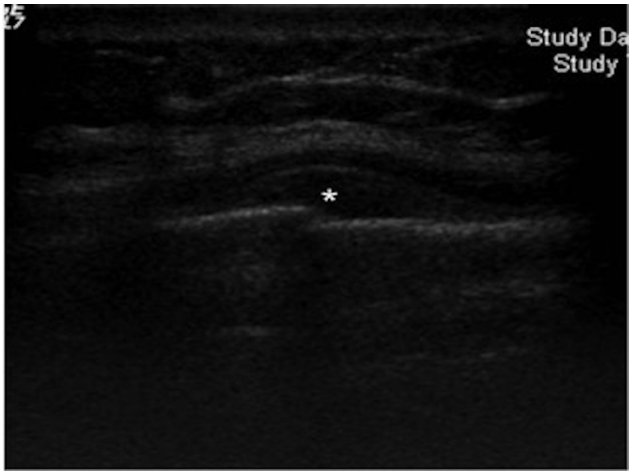

Figure 4: Local haematoma associated with step-off deformity of the fracture edges (asterisk).

Ethical Committee

The current study based on the retrospective analysis of the prospectively gathered data and Ufuk University ethics committee approved this single center study, dated 13.12.2022 and numbered 12024861-89. Written informed consent was obtained from all patients before the US examination. This study was made in accordance with the principles of the Declaration of Helsinki.

Statistical Analysis

Mean, standard deviation, and range were evaluated for all the demographic data. Inter-observer agreement was assessed by kappa statistics and Cohen's kappa value was calculated. All statistical analyses were made by using a commercially available software (version 20.0, IBM SPSS Statistics, IBM Corp.)

RESULTS

A total of 52 patients (32 males, 20 females) with a mean age of 48 years (range between 18 and 95 years) were enrolled, in this study. Dyspnea and chest pain increasing with inspiration were the most frequent complaints. All patients were evaluated within 0.5 to 6 hours after admitting to ER. On CXRs, only two rib fractures were detected. In 19 cases (36.5%), 22 fractures were found via US by both radiologists. The inter-observer agreement was remarkably high for US with a Cohen's kappa value of 0.917 **(Table 1)**. One rib fracture was noted only by the senior radiologist and not by the resident. 21 of 22 fractures were detected on the lateral aspect of the 5th to 10th ribs. All fractures were located at the bony part of the rib and no fracture was found at the costal cartilage or costochondral junction.

Table 1: Inter-observer agreement for US and chest X-ray in detection of rib fractures.

	Fracture (+) (n=19/52)	Senior radiologist	Junior radiologist	Kappa
Sonography (+)	19	19	18	0.917
Radiography (+)	2	2	2	1

DISCUSSION

Rib fracture is a relatively common finding in blunt chest trauma and accompanies approximately 35-40% of thoracic injuries (2). From 4th to 10th ribs are mostly and contiguously affected. Because of fragility, osseous parts affected more than chondral regions. In cases where clinical complaints and findings suggest rib fracture, imaging modalities are used to detect the fracture and associated injuries (11). In our study, out of 52 patients with suspected rib fracture, just 19 patients had a fracture. Prevalence of rib fractures relatively low in our study when compared to similar studies in the literature (4, 5). This might be due to the inclusion of only the outpatients without multi-system trauma, in this series. Furthermore, lower pre-diagnosis accuracy of the referring emergency medicine specialist regarding rib fractures in our study, might have caused diminished prevalence.

In order to make a definitive diagnosis, the clinician must use imaging modalities. There are several imaging modalities for the assessment of rib fractures including CXR, CT, US, nuclear medicine and magnetic resonance imaging (MRI) (12). CXR is the first-line imaging tool on traumatic injury at emergency department. It is specific but not sensitive and misses more than

50% of rib fractures (13). CT enables evaluation along the entire axis of the ribs with multi-planar imaging technique and has a high sensitivity in detecting rib fractures. CT is the recommended method for diagnosing rib fractures because it is highly sensitive and can reveal other underlying trauma pathologies (12, 14). Bone scintigraphy has sensitivity but not specificity for rib fractures (15). It can be accepted as "gold standard" method for rib fractures, but it is not cost-effective to perform bone scintigraphy for rib fractures in emergency departments and clinical practice. MRI is highly influenced by respiratory movements and therefore has the lowest diagnostic value in detection of rib fractures (1). Meanwhile, Capelastegui et al. (16) showed that MRI detected rib and/or sternum fractures in 86% of patients with work-related trauma and interobserver agreement was excellent. With the advanced techniques within MRI technology, it is possible that in equivocal cases, MRI findings could be useful. On the other hand, US enables the evaluation of ribs parallel to its long axis and also gives the opportunity of assessing costal cartilage and bony rib, simultaneously. When a suspected rib fracture was not detected with CXR, after waiting for two weeks, CXR was repeated for revealing callus formation. However, with the use of US, immediate diagnosis could be possible without radiation exposure. In the current study, we have found a high inter-observer agreement indicating that US is a reliable and reproducible imaging modality for the detection of rib fractures that we could use confidently (Table 1).

There are also disadvantages of the US. First of all, the examination time is long (1, 2, 9, 17). It takes approximately 10-15 minutes according to user experience and daily work load of the radiology department. In addition, duration of the examination depends on how cooperative the patient is. Secondly, pain resulting from the applied pressure on the fracture, during an US examination leads to patient discomfort. Thirdly, obesity and large breast tissue can limit the sonographic sensitivity and finally retro-scapular ribs and infraclavicular segment of the first rib cannot be assessed by the US (1, 8).

False positives must also be considered during sonographic assessment. If the transducer is not placed parallel to the long axis of the rib, pseudo-fracture appearance cannot be avoided (18, 19). The costochondral junction and the pleural echogenic surface are the main reasons causing that pitfall. The anterior surface of the costochondral junction is not regular as the bony costal surface and it can easily be mistaken as the angled rib edges. Pleura is similar with the anterior costal surface, both of which have bright linear appearance (8). In order to overcome this pitfall, the gliding sign of the pleura and the absence of posterior acoustic shadowing of the broken rib edge can be used (1). Just like the pleural echogenic surface, the costochondral junction has not the posterior acoustic shadowing that is seen in rib fractures.

Our results demonstrated that the US is an useful and reproducible imaging modality for assessing rib fractures and much more sensitive than the CXR. Griffith et al (1) and Hurley et al (2) showed that US is a more sensitive imaging modality than radiography for determining rib fractures. Turk et al (18) also found that US is more sensitive than X-ray by detecting 26 rib fractures in 18 patients who have normal CXRs. We found similar results as only 2 fractures were detected by CXR and 22 fractures were detected by US, in this series. In a systematic review and meta-analysis study, Gilbertson et al (6) showed that ultrasonography has high sensitivity (89.3%) and specificity (98.4%) for the diagnosis of any rib fracture. We already know that the sensitivity for detecting rib fractures was higher with CT (62.4%) than with X-ray, and that rib fractures were more likely to be detected at all sites with CT. Furthermore, if a rib fracture is suspected in a patient with minor trauma and no additional injury is expected, the US may be useful in establishing the diagnosis because of its superiority on rib fracture detection when compared to radiography. It is also useful in cases where ionising radiation should be avoided.

There are several limitations in the current study. First of all, there was no gold standard technique used for confirming rib fractures and assessing false positive and false negative results. Secondly, because US is an operator dependent technique, training and performance of the operator might hamper the quality (9). Finally, the small sample size and lack of

randomization were the other drawbacks. In conclusion, we have demonstrated that the US is a reproducible diagnostic tool for rib fractures with very low inter-observer variability. The widespread use of the US will contribute to the diagnosis and treatment of rib fractures.

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