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Original article

Emergency physicians performed Point-of-Care-Ultrasonography for detecting distal forearm fracture



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ABSTRACT

Objectives: Several studies focusing diagnosis of forearm fracture using Point-of-Care-Ultrasonography (POCUS) had been carried out in children. There is a lack of evidence for the utility of sonographic (US) examination for detecting of distal forearm fracture in adults. We aim to determine the diagnostic sensitivity and specificity of POCUS examination for the fracture of the distal radius and ulna in adult patients presenting with blunt forearm trauma.

Material and Methods: Adult patients presenting with acute distal forearm trauma and suspicion of fracture were enrolled into study. POCUS had been performed by blinded emergency physicians, than anteroposterior and lateral x-rays was obtained. If inconsistency between x-rays and POCUS has been occurred, computed tomography were ordered. Assessment of orthopedic surgeon was accepted as a gold standard diagnosis.

Results: Ninety three POCUS were performed in 90 patients. Fifty nine radius and 19 ulna fracture had been diagnosed. POCUS detected all radius fracture, but missed 2 ulna fracture. There were 4 false positive results for both radius and ulna with POCUS. X-ray missed 4 radius, and 1 ulna fractures. Diagnostic sensitivity and specificity of POCUS for fracture of ulna were 89.5% (CI%95, 65.5–98.1) and 94.6 (CI%95, 86–98.2), for fracture of radius were 100% (CI%95, 92.4–100), and 88.2%. (CI%95, 71.6–96.1).

Conclusion: Emergency physician performed POCUS examination is very sensitive and specific the diagnosis of distal forearm fracture. Diagnostic sensitivity of POCUS for radius fracture is higher than x-ray.

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1. Introduction

Distal forearm fractures is one of most common fractures in adult emergency department (ED) population. Several studies focusing diagnosis and guided reduction of forearm fracture using Point-of-Care-Ultrasonography (POCUS) had been carried out in children. There is a lack of evidence for the utility of sonographic (US) examination for detecting of distal forearm fracture in adults.

Standard imaging tool for the diagnosis of distal forearm fracture is X-ray, however it's sensitivity is low.^{1,2}

The studies assessing diagnostic accuracy of ultrasonographic examination for the fracture detection in ED patients is increasing. It was reported that emergency physician performed US examination is highly sensitive for the diagnosis of long bone fracture.^{3–5} Sonographic examination also has some advantages; it's readily available, cost effective and radiation free. One of the major advantages of POCUS is the opportunity to extensive investigation of the most painful and swelling area. Most of the study assessing sonographic diagnosis of forearm fracture is performed in pediatric patients.^{6–13} Distal forearm fracture is one of most managed fracture in emergency department, therefore the new diagnostic algorithm using US examination for those large ED population may alter emergency medicine practice.

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We aim to determine the utility of emergency physicians performed POCUS examination in patients presented to the ED with acute forearm trauma. Moreover, we also intend to determine the diagnostic sensitivity and specificity of POCUS examination for the fracture of the distal radius and ulna in adult patients presenting with blunt forearm trauma.

2. Material and Methods

This cross-sectional study has been performed at level 3 emergency department with 95,000 annual adult admission rate between 2014, January and 2015, June. After obtaining hospital ethical review board approval, patients over 17 years old (adult patients) with blunt and acute distal forearm trauma were enrolled into study. One of the study authors that experienced on musculoskeletal sonography gave brief didactic presentation to the rest of other 4 sonographer. Three of sonographers were attending emergency physicians and two of sonographers were senior resident of emergency medicine. After that all sonographer diagnosed 5 cases of distal forearm fracture that were confirmed with x-ray, they had been received the patients into study.

All patients were signed consent form. POCUS examination had been performed by blinded emergency physicians, than 2 sided (anteroposterior and lateral) forearm x-rays was obtained. If inconsistency between x-rays and POCUS examination has been occurred, computed tomography (CT) were ordered.

Sonographic examination were performed with Mindray M7[®] (Mindray, Szechuan, China) 6–12 MHz linear probe. All sonographic investigations were performed at 10 MHz frequency. The lateral, dorsal and volar surface of distal forearm were examined in transverse and longitudinal plans. Presence of cortical disruption or stepping were accepted as fracture by POCUS examination. Anteroposterior and lateral X-rays taken with Siemens Optilix 150/50/50 HC-100[®] (Siemens Medical Solutions, USA).

After patients managed in the ED according to emergency physician decision independently from the study settings. An orthopedist that blinded to the sonographic results, evaluated to the patients x-ray and if taken CT images and decided to there were fracture or not. Orthopedic surgeons are more experienced in assessment of direct radiography and CT than radiologist in our institution therefore assessment of orthopedic surgeon was accepted as a gold standard diagnosis.

Statistical analyses were performed using SPSS V.15 software (Chicago, Illinois, USA). Qualitative data are presented as the number of observations and percentage while quantitative data are presented as mean \pm standard deviation (SD). The sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio were calculated with 95% confidence intervals using “vassarstats” website for statistical computation (<http://vassarstats.net/>).

Exclusion criteria were as follows:

- (1) Patient refusal,
- (2) The patients admitted to the ED when the sonographer has not been at ED,
- (3) Patients with open fracture or penetrating injury,
- (4) Patients who presents to ED 1 week after trauma.

3. Results

During the study period, 157 patients with distal forearm trauma had been admitted to the ED. Sixty-seven of those were excluded (65 patients were admitted at the time that there were no sonographers in the ED, 2 of cases rejected to participate in the study) from the study. Ninety patients were enrolled into study.

Table 1
The study characteristics.

Age (years), mean \pm SD	46.7 \pm 20.4
Female, %	52.7
Trauma to left hand, %	59.1
Trauma mechanism, %	
Fall on outstretched hand	81.1
Sprain	8.9
Crush injury	1.1
Other	8.9
Examination findings, %	
Deformity	41.9
Edema	55.9
Orthopedic consultation, %	68.8
Forearm splint, %	76.3

Three of them had two sided forearm trauma, therefore 93 US examination had been performed. Clinical features of patients are reviewed in Table 1.

Gold standard test revealed 59 radius and 19 ulna fracture. Fracture prevalence were 63.4% for radius, 20.4% for ulna and 41.9% for both of them. POCUS examination have 4 false positive results for radius fracture; 4 false positive and 2 false negative results for ulna fracture. X-ray have 2 false positive and 4 false negative results for radius; 1 false negative results for ulna. Results of sonographic examination and x-ray compared with gold standard diagnosis are shown in Table 3. Diagnostic sensitivity and specificity of POCUS examination for fracture of ulna were 89.5% (CI%95, 65.5–98.1) and 94.6 (CI%95, 86–98.2), for fracture of radius were 100% (CI%95, 92.4–100), and 88.2% (CI%95, 71.6–96.1).

Sixty three radius fracture and 21 ulna fracture identified with POCUS examination, whereas 57 radius fracture and 18 ulna fracture identified with x-ray. 33 patients (35.5%) underwent CT because of inconsistency between POCUS exam and x-ray. CT revealed 5 additional fracture (1 ulna, and 4 radius fractures) that underdiagnosed with x-ray, and two normal imaging were observed which were considered fracture with x-ray. Fracture types and location are summarized in Table 2.

Sensitivity, specificity, positive likelihood ratio (LR) and negative LR of POCUS examination and x-ray for radius, ulna and overall fracture are shown in Table 4. The images of US, x-ray and CT of patient with false negative x-ray result were shown in Fig. 1.

4. Discussion

Recently, several studies showed that diagnostic sensitivity of x-ray for distal forearm fracture is very low. Balci et al, examined diagnostic performance of conventional radiographs for wrist fractures using multidetector CT as a reference standard.¹ They revealed that sensitivity of x-ray for radius fracture is only 72.8% and 80% for ulna fracture. Jørgsholm P et al assessed the diagnostic value of direct radiographs in patients with carpal fractures that verified by MRI.² They revealed that the sensitivity of x-ray for

Table 2
Location and types of fracture.

Fracture	n, (%)
Non angulated radius fracture	25, (32.1)
Colles' fracture	24, (30.8)
Smith's fracture	4, (5.1)
Volar Barton fracture	2, (2.6)
Dorsal Barton fracture	2, (2.6)
Intraarticular radial fracture	2, (2.6)
Non angulated ulna fracture	17, (21.9)
Angulated ulna fracture	2, (2.6)

Table 3
Results of US examination and x-ray compared with gold standard diagnosis.

		Gold standard test for radius (n)		Gold standard test for ulna (n)		Gold standard test for ulna and radius (n)	
		Fracture	Normal	Fracture	Normal	Fracture	Normal
US (n)	Fracture	59	4	17	4	76	8
	Normal	–	30	2	70	2	100
X-ray (n)	Fracture	55	2	18	–	73	2
	Normal	4	32	1	74	5	106
Total (n)		59	34	19	74	78	108

Table 4
Sensitivity, specificity, positive LR and negative LR for radius, ulna and overall fracture.

	Radius		Ulna		Overall	
	X-ray %, (95% CI)	US %, (95% CI)	X-ray %, (95% CI)	US %, (95% CI)	X-ray %, (95% CI)	US %, (95% CI)
Sensitivity	93.2 (82.7–97.8)	100 (92.4–100)	94.7 (71.9–99.7)	89.5 (65.5–98.1)	93.6 (85–97.6)	97.4 (90.2–99.5)
Specificity	94.1 (78.9–99)	88.2 (71.6–96.1)	100 (93.8–100)	94.6 (86–98.2)	98.1 (92.8–99.6)	92.6 (85.5–96.5)
LR (+)	15.8 (4.1–60.9)	8.5 (3.4–21.3)	∞	16.5 (6.3–43.5)	50.5 (12.8–199.7)	13.1 (6.7–25.6)
LR (–)	0.07 (0.05–0.32)	0	0.05 (0.01–0.35)	0.11 (0.03–0.41)	0.06 (0.03–0.15)	0.02 (0–0.10)

CI = Confidence interval, US = Ultrasonography, LR (+) = Positive likelihood ratio, LR (–) = Negative likelihood ratio.



Fig. 1. A 39 years old female presented to the ED with fall on outstretched hand. Anteroposterior (A) and lateral (B) X-rays were negative for fracture. US examination (C) revealed cortical disruption. (White arrow) CT (D) was confirmed displaced distal radius fracture.

distal radius fracture was 43% (95% CI 7–65). These studies concluded that x-ray is not sensitive for the detection of fracture in adult patients with distal forearm trauma. CT has some disadvantages such as a radiation exposure and high cost. Also, MRI in emergency setting is not readily available. We previously showed that emergency physicians performed POCUS examination is very sensitive for fracture identification in metacarpals, metatarsals and ankle.^{3–5} It's practical and ease to perform by inexperienced ED

physicians for musculoskeletal US after brief learning periods. Now we attempted to reveal that diagnostic sensitivity of POCUS examination for fracture in adult ED population with distal forearm trauma. Our study showed that emergency physician performed POCUS examination is very sensitive and specific for the distal forearm fracture. Ultrasound-assisted closed reduction of distal radius fractures had been largely studied, however the number of studies assessing the diagnostic sensitivity of ultrasound for forearm fracture were limited.^{11,13–15} The studies evaluating diagnostic accuracy of so-

Table 5
The clinical and diagnostic characteristics of the studies focused on the sonographic evaluation of forearm trauma.

Authors, years	n, population	Fracture prevalence %	Gold standard test	Sensitivity %	Specificity %
Alvarez, ⁶ 2011	115, pediatric	67.8	x-ray	94.9	98%
Herrn, ⁷ 2015	201, pediatric	51.7	x-ray	100 for radius 99.5 for ulna	–
Eckert, ⁸ 2012	76, pediatric	55.2	x-ray	96.1	97
Williamson, ⁹ 2000	26, pediatric	61.5	x-ray	100	100
Ackerman, ¹⁰ 2009	93, pediatric	68.8	x-ray	94	99
Chen, ¹¹ 2007	68, pediatric	70.5	x-ray	97	100
Javadzadeh, ¹² 2014	65, adult	29.2	x-ray	89.1 ^a 93.7 ^b	94.3 ^a 95.7 ^b
Kozanci et al, ¹³ 2014	83, 72% of patients were pediatric	100	x-ray	98	96
Current study, 2015	90, adult	41.9	X ray/CT ^c	100 for radius 89.5 for ulna	88.2 for radius 94.6 for ulna

^a Standard US examination.

^b US examination with water bath technique.

^c Gold standard test was CT in 35.5% of patients.



Fig. 2. Lister tubercle mimicking cortical disruption with US examination.

examination has a better sensitivity than x-ray because of we utilized CT as a gold standard test in patients who had inconsistency between x-rays and POCUS examination. (3) US examination were performed by emergency physicians, not the radiologist.

We detected 78 fractures, x-ray missed 5 fracture, whereas POCUS examination missed 2 cases. The sensitivity of US examination for distal radius fractures was 100%. However, x-ray were more sensitive for detecting ulna fracture (94.7% vs 89.5%). We have 4 false positive results for radius fractures. Lister tubercle may be seen like a cortical disruption that were mimicking displaced fracture of radius on the longitudinal axis (Fig. 2). Therefore emergency physicians should be aware of potential false positive results with sonographic examination.

5. Limitations

We enrolled only adult patients with blunt trauma, therefore our results should not be generalized to pediatric patients and who presents with penetrating forearm trauma. We ordered CT in only 35% of study patients, because of it, gold standard diagnosis often made by x-ray. Some fracture may be missed because of POCUS examination and x-ray both may have false negative results.

6. Conclusion

US examination has excellent sensitivity for diagnosis of distal radius fracture. Emergency physicians should be performed POCUS examination as a diagnostic tool for patients with distal forearm trauma.

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