



Original Contribution

Accuracy of bedside ultrasonography for the diagnosis of finger fractures



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ABSTRACT

Objective: Diagnosis of bone fractures by ultrasonography is becoming increasingly popular in emergency medicine practice. We aimed to determine the diagnostic sensitivity and specificity of point-of-care ultrasonography (PoCUS) compared with plain radiographs in proximal and middle phalanx fractures.

Methods: Between August 2012 and July 2013, adult patients presenting to our emergency department with a possible (by clinical evaluation) proximal or middle phalanx fracture of finger were invited to participate in this prospective cohort study. From those granting consent to participate, anteroposterior and lateral radiographs were obtained. PoCUS was then performed by emergency physicians blinded to the radiograph results. The criterion standard test for diagnosis was radiograph interpretation by an orthopedic surgeon blinded to the ultrasonographic findings.

Results: During the study period, 212 patients with an injury to the proximal or middle phalanx presented to the emergency department. Of these, 93 patients met exclusion criteria; thus, data were analyzed from the remaining 119 patients. Fracture prevalence was 24.3%. Diagnostic sensitivity of PoCUS was 79.3% (95% confidence interval [CI], 59.7%–91.2%), specificity was 90% (95% CI, 81.4%–95.0%), positive predictive value was 71.8% (95% CI, 53.0%–85.6%), negative predictive value was 93.1% (95% CI, 85.0%–97.1%), positive likelihood ratio was 7.93 (95% CI, 4.15–15), and negative likelihood ratio was 0.23 (95% CI, 0.11–0.47).

Conclusion: Emergency physician-performed PoCUS was moderately sensitive and specific for diagnosing proximal and middle phalanx fractures.

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1. Introduction

The hands are one of the most functional organs in human body; therefore, appropriate management of phalanx injuries is an important part of emergency medicine practice. Finger fractures are one of the most commonly overlooked fractures in emergency departments (EDs) [1,2]. Recently, ultrasonography has been reported to have a high sensitivity for the fracture identification, but the use of ultrasonography for the diagnosis of fractures of phalanges (hand) has not been extensively studied [3–6]. We decided to perform the present study to prospectively evaluate the diagnostic sensitivity and specificity of point-of-care ultrasonography (PoCUS) in patients with possible proximal and middle phalanx fractures.

2. Methods

The study design was approved by our teaching hospital's ethics committee. This prospective cohort study was conducted between August 2012 and July 2013 in an urban tertiary ED that has approximately 200 000 visits annually. Our institution is the reference hospital in our region and has a 4-year emergency medicine education program. First of all, sonographers performed examination on 5 patients with radiographically confirmed phalanx fracture with an experienced sonographer to corroborate the examination technique and the appearance of the fracture. Then, all patients admitted to the ED with the complaint of finger trauma were reported to 1 of the 5 operators by the emergency residents performing the examination. PoCUS was performed on all patients by 1 of the 5 sonographers. On days when more than 1 sonographer was present, the operator performing the least number of applications was preferred.

Patients older than 14 years presenting within 1 week of finger trauma and who had tenderness on the proximal or middle phalanx were included into the study. Patients were excluded from the study if they had an open wound in the area of tenderness on the finger or if they presented at a time when no sonographer was present; patients

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without available radiography results and patients for whom the blindness of the operator was impaired were also excluded.

On those granting consent to participate, anteroposterior and lateral radiographs of the involved phalanges were obtained. Interpretation of the radiographs by an orthopedic surgeon (blinded to the ultrasonographic findings) was considered the criterion standard for fracture diagnosis. Sonographic examination was performed using a multifrequency (7.5–10 MHz) linear probe (Mindray M5 Color Diagnostic Ultrasound System, Shenzhen, China). Bone was examined from 4 sides (plantar, dorsal, medial, lateral) along its long and short axis for findings of fracture. The area having the most tenderness; edema; ecchymosis; and, if present, deformity was examined in more detail. Multifrequency linear probe was used at its highest frequency (10 MHz). Cortical disruption on ultrasonography was accepted as a fracture (Fig. 1). The sonographer was blinded to the radiograph findings.

Data were collected and analyzed using Microsoft Excel and Vassar Stats (<http://faculty.vassar.edu/lowry/VassarStats.html>). Nominal quantitative data are presented as the number of observations and percentage, whereas quantitative data that are not normally distributed are presented as median, interquartile range. Sensitivity, specificity, accuracy, positive likelihood ratio, negative likelihood ratio, negative predictive value, and positive predictive value were calculated.

3. Results

During the study period, 212 patients presented to our ED with a proximal or middle phalanx injury. Ninety-three patients were excluded for the following reasons: 69 came at an hour when a sonographer was not present, 17 had open wounds in the area of maximal tenderness, 3 had ultrasonographs performed in an unblinded fashion, 3 were evaluated when the radiograph was unavailable for technical reasons, and 1 was evaluated without a radiograph being taken. Of the remaining 119 patients, 73 (61.3%) were male, and the median age was 27 years old (interquartile range, 16–36). In 61 (51.3%) patients, the trauma was on the right hand. Details of the patients and their injuries are given in Table 1.

A phalanx fracture was diagnosed by the orthopedic specialist in 29 (24.3%) patients. PoCUS resulted in 6 false-negative and 9 false-positive results (details of each case are listed in Table 2). Nineteen of the fractures (65.5%) were located in the proximal and 10 (34.5%) were located in the middle phalanx. Most of the fractures missed with PoCUS were volar avulsion fractures of the middle phalanx, at the insertion of the superficialis flexor tendon. Our missed cases of proximal volar plate fracture were all avulsion fractures with small (<5 mm) fragments. All of these patients were managed conservatively.

Table 1

Characteristics of phalanx fractures identified on radiograph in 119 patients and corresponding numbers of false-negative and -positive ultrasonography examinations

	Tenderness, n (%)	Fracture, n (%)	False – US	False + US
5th finger	36 (30.3%)	18 (62.0%)	2	1
4th finger	26 (21.8%)	5 (17.5%)	1	1
3rd finger	22 (18.4%)	3 (10.3%)	2	2
2nd finger	10 (8.4%)	2 (6.8%)	1	1
1st finger	25 (21.1%)	1 (3.4%)	–	4
Total	119 (100%)	29 (100%)	6	9

The diagnostic characteristics of PoCUS for the diagnosis of proximal or middle phalanx fractures were as follows: sensitivity, 79.3% (95% confidence interval [CI], 59.7%–91.2%); specificity, 90% (95% CI, 81.4%–95%); positive predictive value, 71.8% (95% CI, 53%–85.6%); negative predictive value, 93.1% (95% CI, 85.0%–97.1%); positive likelihood ratio, 7.93 (95% CI, 4.15–15); and negative likelihood ratio, 0.23 (95% CI, 0.11–0.47).

4. Discussion

Phalanx fractures are often missed in emergency medicine practice because their radiographic findings may be subtle. More sensitive imaging modalities such as computed tomography and magnetic resonance imaging are often not available, are more costly, and involve exposure to higher levels of ionizing radiation. Although ultrasonography has been used to diagnosis bony fractures for at least a decade, a few number of studies on phalanx fractures exist in the literature [3]. We found the sensitivity and specificity of emergency physician-performed ultrasonography for detecting phalangeal fractures to be 79.3% and 90.0%, respectively.

In their prospective study of ultrasonography for the diagnosis of hand fractures, Tayal et al [6] detected fractures in 30 of 78 patients. Among these, 10 had phalanx fractures and 1 had concurrent phalanx and metacarpal fractures. Compared with plain radiographs, ultrasonography resulted in 1 false-positive and 1 false-negative result (1 distal tuft phalangeal fracture). In our previous study of emergency physician-performed PoCUS for the diagnosis of fifth metacarpal fractures, we found ultrasonography to be 93% sensitive and 83% specific [7]. Javadzadeh and colleagues [8] evaluated the diagnostic value of convenient ultrasonography and water bath technique in adult upper extremity injuries. They found that the sensitivity and specificity in diagnosing fractures of the phalanges with ultrasonography were 83.3% and 90.5%. However when water bath technique was used, the sensitivity and specificity increased to 94.4% and 95.2%, respectively. Neri and colleagues [9], using an 18-MHz linear transducer, found ultrasonography to be 91.5% sensitive and 96.8% specific for metacarpal and



Fig. 1. A, Fracture of the proximal phalanx of the fifth finger is seen on the radiograph (arrow). B, Ultrasonographic image in longitudinal plane (arrow indicates cortical disruption).

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