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Brief Report

The role of ultrasonography in the diagnosis of metacarpal fractures☆,☆☆

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ABSTRACT

Introduction: The aim of this study was to evaluate the efficiency of ultrasonography (USG) in identifying metacarpal bone fractures in patients admitted to the emergency department (ED) with hand injury.
Materials and methods: Patients who were admitted to a training and research hospital's ED during the study period with hand trauma and had suspected metacarpal fractures were included in the study. They were examined for metacarpal fracture by USG and x-ray. Hand radiographs reviewed by an emergency physician were considered to be the criterion standard diagnostic tool. Ultrasonography results were compared to x-ray results.
Results: Ninety-eight ultrasound examinations were performed on 96 adult patients who were enrolled in the study. The mean age of the patients was 30.1 ± 11.8 years; 79.2% of the patients were male. Right hand injury was observed in 69.4% of the cases. Forty metacarpal fractures were detected in 38 patients on x-ray. We found a sensitivity of 92.5% (95% confidence interval [CI], 78.5-98), a specificity of 98.28% (95% CI, 89.5-99.9), a positive predictive value of 97.37% (95% CI, 84.5-99.8), and a negative predictive value of 95% (95% CI, 85-98) for USG to detect metacarpal fractures when compared to x-ray imaging.
Conclusions: Under the light of these results, we suggest that USG may be an option for detecting metacarpal fractures and prevent unnecessary x-ray imaging examinations in patients presenting to the ED with hand trauma.

1. Introduction

Human hand, fulfilling the tasks of holding, grabbing, and sensing objects, has a very important place in human life. It is the most important part of upper extremity in terms of functions and tasks fulfilled, and it is a vital part of human body providing a direct interaction between a human being and its environment [1]. Various studies have reported that hand injuries constitute 16% to 29% of all emergency department (ED) admissions, and metacarpal fractures are detected in 30% to 40% of all hand fractures [2-4]. Among metacarpal fractures, fractures of the fifth metacarpal bone are the most common ones [5].

X-ray imaging is the standard imaging modality used in the hand trauma. Its advantages include its wide availability and easy accessibility. Despite these advantages, it has also some drawbacks such as involving ionizing radiation, unavailability outside hospital setting, and prolonging ED stay.

On ultrasonography (USG), bone tissue interface is observed as a hyperechogenic line with a posterior acoustic shadow due to its highly reflective property, and disruption of this line in linear fractures appears as angulation of pieces of fracture on ultrasonography [6]. As a result of these properties, USG has been increasingly used for making the diagnosis of fractures in the ED. Many studies have reported that USG was successfully used to diagnose fractures involving humerus, sternum, femur, clavicle, scaphoid, forearm, and ribs [7-10]. Some advantages of USG have increased its utilization in EDs, which include a short procedure time, a noninvasive and a nonionizing radiation involving nature, availability for use at nonhospital setting or bedside, repeatability, and a higher safety in children and pregnant patients [11].

In this study, we aimed to investigate the diagnostic utility of USG and plain radiograms in metacarpal fractures in patients presenting to ED with hand trauma.

2. Methods

After being approved by the local ethics committee, this study was conducted between January 1, 2015, and May 31, 2015, at the ED of a training and research hospital having an annual patient volume of approximately 140 000. It was designed as a single-center, prospective, single-blinded, controlled study. During the study period, 96 patients who presented to our hospital's ED with hand trauma and suspected to have metacarpal fracture were enrolled after giving written informed consent.

The inclusion criteria included being older than 18 years, presenting to our hospital's adult ED with hand trauma at the specified time frame, and giving consent for the participation in the study.

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The exclusion criteria included having suffered trauma 3 or more days before ED admission, having a former definitive diagnosis for which acute care had been provided, having additional life-threatening injuries, refusing to give consent to participate in the study, and having an open wound or infection risk in lesion site.

Patients who presented to our hospital's ED with hand trauma within the specified time frame and who met the inclusion criteria were primarily examined by a triage physician at the ED. Patients with suspected metacarpal fracture based on physical examination and patient history were referred to a single USG examiner, who was a senior emergency medicine resident who had completed his/her third year in residency and been trained and certified on "use of bedside ultrasonography at the ED." The resident training in ultrasound is a part of our standard curriculum; there was no special training for this study. Standard training in our department is 2 dedicated weekend courses for 32 hours of lectures and practice during the first 2 years of residency. The residents can then practice on real patients for as long as they work in the ED. (The residents work an average of 10 × 24 hour shifts per month.) Their skills for fracture assessment were not evaluated by any standard method. No expert-level interrater reliability was performed. Ultrasonographer was blinded to x-ray findings.

The patients were sonographically examined for 3 to 5 minutes to search for metacarpal fractures at the longitudinal and transverse planes with a USG device (UMT-200; Mindray, Hamburg, Germany) using a 7.5-MHz linear probe (Figure). Ultrasonographic images were recorded in a digital medium, and USG findings were recorded on the study form of each patient. All metacarpals were examined for each patient with maximum time spent on the areas of maximal tenderness.

Then, anteroposterior and oblique hand x-rays were obtained and interpreted by a single senior emergency medicine physician who was blind to USG findings. The x-rays interpreted by that physician were considered as the criterion standard diagnostic reference for metacarpal fractures and used to calculate the sensitivity and specificity of USG for the detection of metacarpal fractures. X-ray interpreters were blinded to USG results. There was no confirmation or comparison of emergency physician read by a radiologist.

Shapiro-Wilk test was used to test the normality of the distribution of the variable age, which had a nonnormal distribution and was thus expressed with the descriptive statistics of median (minimum-maximum) and mean ± SD. The variables sex, mechanism of trauma occurrence, and findings on physical examination were presented as number (n) and percentage. Pearson χ^2 test was used to determine if mechanism of occurrence varied by sex category. McNemar test was used to compare the results of USG and X-Ray imaging results. In addition to the sensitivity and specificity figures, positive predictive value and negative predictive value were also calculated for USG. IBM SPSS Statistics 21.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, version 21.0; IBM Corp, Armonk, NY) and MS Excel 2007 software packages were used for executing all statistical analyses. $P \leq .05$ was considered statistically significant.

3. Results

The study included 98 examinations performed in 96 patients. The mean age of the study population was 30.1 ± 11.8 years. Sixty-eight patients (69.4%) had right hand trauma, and 30 (30.6%) had left hand trauma. On physical examination, findings of the affected hand are shown in Table 1.

According to the results of the criterion standard x-ray imaging, 38 of 96 patients had fractures. Among these, 2 patients had 2 fractures. The total number of fractures identified by X-Ray was 40, of which 37 were also detected by USG. Ultrasonography yielded only 1 false-positive result in 58 patients who had no fracture on x-ray imaging.

In 37 patients detected to have a fracture by both techniques, fracture localizations were also the same in both techniques. The fractures on USG were most commonly located in the fifth metacarpal bone (n = 25; 65.8%) and at distal region (n = 22; 57.9%); similarly, fractures detected by x-ray were most commonly located in the fifth metacarpal bone (n = 27; 67.5%) and at a distal region (n = 25; 62.5%). The distribution of fractures by the involved metacarpal bones and their involved regions was shown in Table 2.

All 3 metacarpal fractures that could not be detected by USG were at a distal region of the fifth metacarpal bone, as indicated by x-ray imaging. In all 3 of those false-negative cases, the fractures were nondisplaced, noncomminuted, and not angled. In a single patient with a false-positive USG result, no fracture could be demonstrated by x-ray imaging, although a fracture was detected by USG at the proximal region of the fifth metacarpal bone.

X-ray imaging and USG techniques yielded statistically similar results (McNemar test, $P = .625$). For the detection of metacarpal fractures, USG had a sensitivity of 92.5% (95% confidence interval [CI], 78.5-98), a specificity of 98.28% (95% CI, 89.5-99.9), a positive predictive value of 97.37% (95% CI, 84.5-99.8), and a negative predictive value of 95% (95% CI, 85-98) (Table 3). Post hoc power analysis revealed a power of 0.47.

4. Discussion

Hand trauma constitutes an important proportion of ED presentations [12-14]. X-ray imaging is the conventional imaging method used

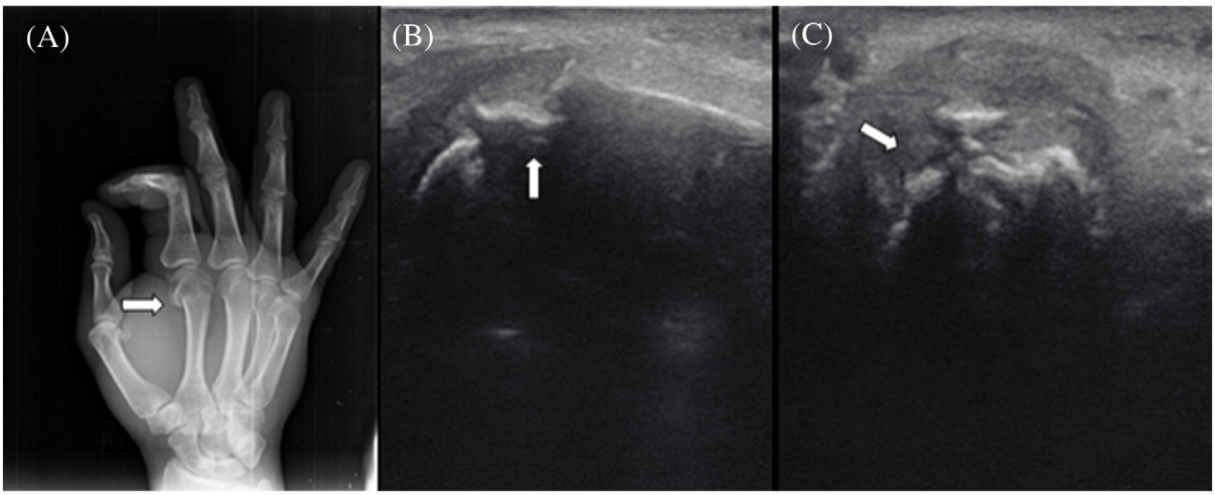

Figure. Oblique x-ray (A) and longitudinal (B) and transverse (C) and USG views of the first metacarpal fracture.