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Point-of-care wrist ultrasonography in trauma patients with ulnar-sided pain and instability

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ABSTRACT

Objective: We evaluated the effectiveness of point-of-care wrist ultrasonography compared with 3T-magnetic resonance imaging (MRI) for diagnosing triangular fibrocartilage complex (TFCC) injuries in trauma patients with ulnar-sided pain and instability. Moreover, we assessed the inter-observer variability between an emergency physician and a musculoskeletal radiology fellow.

Material and methods: A prospective cross-sectional study was conducted in an emergency department; patients with ulnar-sided sprain and instability were recruited. An emergency physician and a musculoskeletal radiology fellow independently evaluated the TFC, meniscal homologue, volar and dorsal distal radioulnar ligaments, and extensor carpi ulnaris using point-of-care ultrasonography. Findings were classified as normal, partial rupture, or complete rupture. Wrist 3T-MRI was used as the reference standard. We compared the diagnostic values for point-of-care ultrasonography obtained by both reviewers using DeLong's test. Intra-class correlation coefficients (ICCs) were calculated for agreement between each reviewer and the reference standard, and directly between the two reviewers.

Results: Sixty-five patients were enrolled. Point-of-care wrist ultrasonography showed acceptable sensitivity (97.2–99.1%), specificity (96.8–97.3%), and accuracy (96.9–97.9%); these diagnostic performance values did not differ significantly between reviewers ($p = 0.58$–0.98). Agreement between each reviewer and the reference standard was excellent (emergency physician, ICC = 0.964; musculoskeletal radiology fellow, ICC = 0.976), as was the inter-observer agreement (ICC = 0.968).

Conclusion: Point-of-care wrist ultrasonography is as precise as MRI for detecting TFCC injuries, and can be used for immediate diagnosis and further preoperative imaging. Moreover, it may shorten the interval from emergency department admission to surgical intervention while reducing costs.

1. Introduction

Wrist pain with a history of trauma is a common presentation in emergency departments (EDs). The routine diagnostic workup for acute wrist trauma consists of a physical examination, usually with radiography. This diagnostic strategy likely identifies the majority of fractures and dislocations, but provides very little information regarding injuries to the triangular fibrocartilage complex (TFCC) [1].

The TFCC is important for the stabilization of the distal radial-ulnar and ulnocarpal joints. It is composed of a triangular fibrocartilage (TFC, the articular disk), meniscus homologue, volar and dorsal radioulnar ligaments, extensor carpi ulnaris (ECU) tendon sheath, and ulnocarpal ligaments. It is the main stabilizer of the ulnar-sided wrist and the distal radioulnar joint (DRUJ), and plays an important role in maintaining the stability of the ulnocarpal joint while allowing the stable motion of the DRUJ during rotation of the forearm [2-5]. Injury to one or more of the TFCC components may cause ulnar-sided wrist pain and may lead to wrist instability.

Conventionally, wrist injuries with negative radiography results are usually diagnosed as acute wrist sprains, which are defined by the International Wrist Investigator Workshop as a partial ligament tear [6], often without identifying the actual injured ligament. Moreover, the dimensions of the affected ligaments may sometimes change with or without the loss of its structural integrity [6]. Although perforation of the TFC or meniscal homologue may require surgical intervention in most ED settings, these patients are treated conservatively with the "protection, rest, ice, compression, and elevation" [7] and are discharged without receiving a consultation from an orthopedic surgeon. Although the prognosis is usually good, some patients suffer from prolonged pain and reduced wrist function [7], likely owing to missed diagnoses of a more serious pathology [8].

To date, the use of point-of-care wrist ultrasonography in the ED has been restricted to fractures and dislocations [9-14]. To the best of our

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knowledge, no published study has assessed the usefulness of point-of-care wrist ultrasonography in trauma patients with suspected TFCC injuries. We hypothesized that the multi-step evaluation currently used (ED management with subsequent orthopedic outpatient clinic assessment, magnetic resonance imaging (MRI), and admission if required) can be shortened to ED assessment followed by immediate admission, if required, by using point-of-care wrist ultrasonography in the ED.

The aims of this study were to evaluate the effectiveness of point-of-care wrist ultrasonography for diagnosing TFCC injuries in trauma patients with negative X-rays, to compare ultrasonography and MRI as diagnostic modalities, and to compare inter-observer variability between an emergency physician and a musculoskeletal radiology fellow.

2. Material and methods

2.1. Study design, setting, and population

This prospective study was approved by our institutional review board; written informed consent was obtained from all participants. The study was conducted in an academic ED with an annual census of 76,000 patients. We enrolled consecutive patients who presented with traumatic wrist injuries during times when this study's sonologists (an emergency physician and a musculoskeletal radiology fellow) and research assistant were present in the ED (Mondays to Fridays, 8:00 a.m. to 6:00 p.m.) between January 1, 2017 and October 31, 2017. Inclusion criteria were: (1) physically active adults aged 18–40 years with ulnar-sided wrist pain and a positive instability test, (2) a recent history of wrist trauma, and (3) wrist MRI performed within one month for preoperative evaluation after the ED visit. Physical examination for instability was evaluated using the ulnocarpal stress test, fovea sign, and DRUJ instability tests. We excluded the following patients: (1) those with fractures detected on plain radiography or computed tomography images, (2) those with subluxation or dislocation requiring reduction, (3) those who underwent previous wrist surgery, and (4) those who did not consent to participate in the study.

A research assistant collected data from the patients' electronic medical records. These data comprised demographic characteristics, clinical course and cost (from the ED visit to the preoperative wrist MRI examination), interpretation of the point-of-care ultrasound image performed by the emergency physician (as recorded in each patient's chart) and of the final report by the musculoskeletal fellow (recorded in the Picture Archiving and Communication System [PACS]), and the senior board-certified musculoskeletal radiologist's final MRI report. The radiologist was blinded to the findings of the point-of-care wrist ultrasonography.

2.2. Ultrasonography training

The study sonologist, a board-certified emergency physician at the time of recruitment, was a novice who was assigned to the musculoskeletal section of the radiology department at our institution for a one-week period. The emergency physician was trained by a senior musculoskeletal radiologist with 10 years of experience in performing wrist evaluation ultrasonography, including the TFC, meniscal homologue, volar and dorsal distal radioulnar ligaments, and ECU. The ultrasonography equipment (LogiQ E9, GE Healthcare, Milwaukee, WI) used for training in the radiology department was the same as that used in the ED.

2.3. Ultrasound image evaluation

Point-of-care wrist ultrasonography was first performed by the emergency physician immediately after the triage assessment using the above-mentioned scanner with a 12 MHz linear transducer. The scanning protocol used was based on the guidelines of the European Society of Musculoskeletal Radiology [15] and Taljanovic et al. [16]. The scanner settings were as follows: depth range, 4 cm; transmit focal depth, 3 cm; gain, 80 dB; dynamic range, 60 dB; time gain compensation sliders, central position; lateral gain compensation, neutral position; and mechanical index, 0.2. Ultrasound gel was layered onto the probe, which was then placed in the prone-positioned wrist longitudinally over three targeted structures: the TFC, meniscal homologue, and ECU. The probe was then placed in the prone-positioned or supine-positioned wrist transversely over three targeted structures: the TFC and the volar and dorsal distal radioulnar ligaments. The emergency physician classified these structures as normal, having a partial rupture, or having a complete rupture.

Immediately thereafter, and while the patient was still in the ED, a second point-of-care wrist ultrasonography was performed by the musculoskeletal radiology fellow, who was blinded to the clinical information (except for the wrist trauma history), any previously captured images, and the interpretation of the initial point-of-care wrist ultrasound image performed by the emergency physician. The fellow also classified the characteristics of the five structures as (1) normal, (2) partial rupture, or (3) complete rupture.

2.4. MRI acquisition and reference standard

Wrist MRI was performed using the 3T system (Achieva; Philips Healthcare; Best, Netherlands) with an 8-channel wrist coil (SENSE Wrist Coil, Philips Healthcare; Best, Netherlands). Axial proton-density fat-suppressed (repetition time [TR]/echo time [TE], 2500/25; matrix, 252×252; field of view, 140 mm^2), axial T2-weighted (TR/TE, 4500/60; matrix, 132×128; field of view, 150 mm^2), coronal T1-weighted (TR/TE, 500/20; matrix, 240×240; field of view, 150 mm^2), coronal and sagittal proton-density fat-suppressed (TR/TE, 2400/20; matrix, 252×252; field of view, 150 mm^2) sequences were performed. The slice thickness was 1.5 mm with a 1 mm interslice gap. All images were digitally obtained from the PACS.

The final radiology reports of the wrist MRI, as interpreted by a senior musculoskeletal radiologist, were considered the reference standards. The senior musculoskeletal radiologist was aware of the patients' clinical symptoms and laboratory findings, and also classified the characteristics of the five structures as normal appearance, partial rupture, or complete rupture.

2.5. Statistical analysis

Positive results for each structure examined during point-of-care wrist ultrasonography are expressed as frequencies and proportions, both overall and stratified by final diagnosis. Continuous variables are described in terms of the mean ± standard deviation. There were no missing data for the primary analysis, and no indeterminate findings on either the point-of-care wrist ultrasonography or MRI examination. We calculated sensitivities, specificities, and accuracies with 95% confidence intervals (CIs) to assess the performance of the test for diagnosing tears (complete or partial rupture vs. normal) in the five structures examined. Structures were examined separately and as a composite; the results were compared between reviewers using DeLong's test. Intra-class correlation coefficients (ICCs) with 95% CIs were calculated to determine the agreement between the two study sonologists and between each sonologist and the reference standard. ICCs of 0–0.20 indicated poor agreement, 0.21–0.40 indicated fair agreement, 0.41–0.60 indicated moderate agreement, 0.61–0.80 indicted good agreement, and 0.81–1.00 indicated excellent agreement [17]. Data were analyzed using the SPSS software (version 15.0; SPSS, Chicago, Ill). p-Values <0.05 were considered statistically significant.

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