Bedside ultrasound evaluation of tendon injuries☆

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Abstract

Objective: The primary purpose of this study was to investigate the overall accuracy of bedside extremity tendon ultrasound performed by emergency physicians in the emergency department. We also sought to investigate whether or not bedside tendon ultrasonography can be used to expedite the diagnosis and discharge planning in patients with suspected tendon injuries.

Methods: This was a prospective study conducted at 2 academic level 1 trauma centers. Thirty-four patients were enrolled and underwent a comprehensive physical examination of the injured extremity, followed by a bedside ultrasound evaluation to look for tendon disruption. Results of the tendon ultrasound were compared against the findings seen during wound exploration in the emergency department, wound exploration in the operating room, or results from an extremity magnetic resonance imaging (MRI).

Results: There were 6 finger injuries, 11 hand injuries, 6 arm injuries, 6 forearm injuries, and 5 lower extremity injuries. Of the 34 total patients, 4 patients had partial tendon injuries, 9 suffered from 100% tendon laceration or rupture, and 21 had no tendon injury noted on exploration or MRI. Bedside ultrasound had a sensitivity, specificity, and accuracy of 100%, 95%, and 97%, respectively. Physical examination had a sensitivity, specificity, and accuracy of 100%, 76%, and 85%, respectively. Average time to bedside ultrasound was 46.3 minutes compared with 138.6 minutes for wound irrigation and exploration, MRI, or surgery consultation.

Conclusion: Bedside ultrasound is more sensitive and specific than physical examination for detecting tendon lacerations, and takes less time to perform than traditional wound exploration techniques or MRI.

Keywords: Tendon lacerations; Ultrasound; Emergency department; Diagnosis; Discharge planning.

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1. Introduction

Subspecialists have used musculoskeletal ultrasound during the assessment and diagnosis of extremity tendon lacerations for decades [1,2]. Ultrasound can diagnose full and partial tendon disruptions in a quick and noninvasive manner with sensitivities and specificities approaching 100% [1-6]. Although a careful history and physical examination will usually reveal whether tendon injury or disruption has occurred, normal function can still be seen with partial tendon lacerations. In addition, practitioners may not be able to perform an adequate physical examination of the injured extremity because of patient pain, lack of patient effort or cooperation, or other associated factors (eg, presence of a foreign body or fractures, neurologic injury, patient intoxication). For this reason, many emergency physicians (EPs) are learning how to use focused musculoskeletal ultrasonography to aid in the diagnosis and management of patients with a suspected tendon injury.
To date, very little has been published concerning the utility and accuracy of point-of-care musculoskeletal ultrasonography in the emergency department (ED). We sought to determine the overall accuracy of bedside extremity tendon ultrasound, and whether or not it can be used to expedite the diagnosis and discharge planning in patients with suspected tendon injuries in the ED.

2. Methods

2.1. Setting

This study took place at 2 academic level 1 trauma centers. Orlando Regional Medical Center was the primary site (annual ED census of 90,000). Maricopa Medical Center was the secondary site (annual ED census of 70,000). Both emergency medicine residents and attending emergency medicine physicians participated in the study.

2.2. Study design

This was a prospective study involving 2 level 1 trauma centers. Over the course of 3 years, emergency attending physicians and emergency medicine residents sought to identify patients with a suspected open or closed tendon injury to enroll into the study. Patients who met enrollment criteria first underwent a comprehensive physical examination of the injured extremity, followed by a bedside ultrasound. Following the physical examination, the practitioner was asked to note if the patient had a full tear, partial tear, or no tear in the tendon(s) based on the physical examination findings. After performing the bedside ultrasound, the practitioner was asked to estimate the degree of tendon injury: 0% to 25%, 25% to 50%, 50% to 75%, 75% to 99%, or 100% disruption (Fig. 1). Results of the bedside ultrasound were compared against definitive data acquired by one of the following diagnostic evaluations: (1) wound exploration in the ED, (2) wound exploration in the operating room, or (3) extremity magnetic resonance imaging (MRI) as dictated by the patient’s clinical condition.

The research protocol was approved by the human investigation committee and institutional review board of both institutions before commencement of the study.

2.3. Selection of participants

Patients were eligible for study enrollment if they were at least 16 years of age, were hemodynamically stable, were able to provide informed consent, and had no preexisting tendon injury to the injured extremity. Patients were excluded from the study if they were hemodynamically unstable, if they required emergent management for other coexisting conditions, if they were younger than 16 years, if they were unable to provide informed consent, or if they had significant tissue injury or active bleeding that prevented sonographic evaluation of the injured extremity.

2.4. Methods of measurement

At both institutions, emergency attending physicians and emergency medicine residents were trained to perform bedside tendon ultrasonography in a 2-hour hands-on ultrasound course led by an ultrasound fellowship–trained EP. Instructions were given on how to use adjuncts such as water immersion or acoustic stand-off pads to maximize tendon visualization during bedside scanning (Fig. 2). All emergency medicine personnel were educated about which standardized ultrasound views to obtain and the specific data to collect on each patient enrolled.

2.5. Data collection and processing

Data regarding injury location; degree of tendon injury on physical examination; extent of tendon injury by ultrasound; degree of tendon injury on wound exploration; time of initial patient encounter; time to diagnosis by ultrasound; and time to diagnosis based on wound exploration, MRI, or consultation were collected and recorded onto a standardized data collection sheet. This information was then saved to a password-protected Excel spreadsheet devoid of any patient identifiers.

2.6. Primary data analysis

Data were entered into a logistical regression model to identify statistical significance. All statistical analyses were performed using the statistical program SPSS version 15.
(SPSS, Chicago, IL). Statistical significance was defined as a 

\( P \) value of .05 or less.

3. Results

Thirty-four patients were enrolled in this study. There were 6 finger injuries, 11 hand injuries, 6 forearm injuries, 6 arm injuries, and 5 lower extremity injuries. Based on MRI or direct wound exploration, 4 patients had partial tendon injuries, 9 patients had complete tendon injury, and 21 patients had no evidence of tendon injury noted. Bedside ultrasound was able to accurately diagnose the extent of tendon injury in 33 of the 34 total cases (sensitivity, 100%; specificity, 95%). In comparison, physical examination accurately diagnosed 29 of the 34 total cases (sensitivity, 100%; specificity, 76%) (Table 1). On average, time to diagnosis and disposition based on bedside ultrasound findings was 46.3 minutes. In contrast, overall time to wound exploration, MRI, or consultation was 138.6 minutes (Table 2). Of the 34 patients enrolled, none had incomplete data collected or were lost to follow-up.

4. Discussion

Ultrasonography is a relatively inexpensive, noninvasive tool that allows rapid, real-time imaging of the musculoskeletal system with sensitivities and specificities approaching 100% [1-4]. It can be used at the bedside to augment the physical examination findings and provide useful data that can be used to expedite diagnosis and disposition. In patients who are unable to cooperate with a comprehensive physical examination, bedside ultrasound can be used to determine if discrepancies in strength are secondary to actual tendon disruption or simply due to lack of patient effort or pain.

This prospective study demonstrates that EPs with minimal ultrasound training can accurately diagnose tendon injuries with bedside ultrasound. Following a 2-hour training session, the EPs in our study were able to accurately identify the extent of tendon injury in 97% of the patients evaluated (33 of 34 patients). In contrast, physical examination was only able to correctly identify the extent of tendon disruption in 86% of enrolled patients (\( P = .221 \)).

Of the 34 patients evaluated, one case was misdiagnosed with a partial tendon disruption on bedside ultrasound. The

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Table 1  Performance of bedside ultrasound evaluation of tendon lacerations as compared with physical examination findings

<table>
<thead>
<tr>
<th>Criterion standard</th>
<th>No injury Count</th>
<th>Injury Count</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound</td>
<td>No injury</td>
<td>20</td>
<td>0</td>
<td>(13/13) 100%</td>
<td>(20/21) 95%</td>
<td>(33/34) 97%</td>
</tr>
<tr>
<td></td>
<td>Injury</td>
<td>1</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical examination</td>
<td>No injury</td>
<td>16</td>
<td>0</td>
<td>(13/13) 100%</td>
<td>(16/21) 76%</td>
<td>(29/34) 85%</td>
</tr>
<tr>
<td></td>
<td>Injury</td>
<td>5</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significance is defined as \( P < .05 \).
As ultrasound has become more widely available, many practitioners are using it to help with the evaluation and diagnosis of a suspected tendon injury. For suspected partial tendon injuries, ultrasound has been used successfully to look for "soft" signs of partial damage (swelling around the tendon fibers, fiber discontinuation, irregularity of the tendon surface, and hypoechogenicities within the tendon bed) [8,9]. With the additional data gleaned from an ultrasound evaluation, partial tendon lacerations that may have been missed on physical examination can be diagnosed accurately in the acute phase. Early diagnosis and treatment of these partial tendon lacerations can prevent complete rupture and the need for future surgical repair [5].

In addition to exceptionally high sensitivity, specificity, and accuracy, bedside ultrasound has the distinct advantage of providing a rapid diagnosis. In this study, average time to disposition based on bedside evaluation for tendon injury was 46.3 minutes. If patients were noted to have a tendon laceration on bedside scan, resources were immediately mobilized for requisite wound irrigation and splinting; and decisions were made for either immediate repair or outpatient consultation per practice patterns unique to each consulting surgeon and facility. Knowing the diagnosis early enabled more efficient disposition for the patient. In contrast, if patients had to wait for a comprehensive wound irrigation and exploration, MRI, or surgical consultation to make the diagnosis, they waited for an average of 138.6 minutes for their disposition. Without the additional data provided by bedside ultrasound, patients spent an additional 92.3 minutes in the ED.

Data from the bedside ultrasound not only enhanced time to diagnosis and disposition but also provided helpful information that was used to aid in tendon repair. In a few cases, ultrasound evaluation of the injury site helped delineate the location of the ends of the disrupted tendon, therefore minimizing the amount of local tissue damage sustained from blind exploration attempts during the repair. In cases where an associated foreign body was suspected, bedside ultrasound was also used to help localize the foreign body for removal at the bedside or in the operating room.

### 4.1. Limitations

This study had some limitations, including a small sample size and the nonrandomized acquisition of data in our cohort of patients. Furthermore, all bedside scans were performed by EPs and residents who practice and train at institutions with vast bedside ultrasound experience. Ultrasound results and findings are going to be operator dependent, so future studies will need to be done to address its utility and application in more diverse practice settings where practitioners have varying levels of ultrasound experience and expertise.

None of the patients enrolled in the study had large, impaled foreign bodies or significant crush injury that could potentially limit the use of bedside scanning. We hypothesize that patients presenting with such injury patterns would

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Emergency department disposition times based on the amount of time required to conduct an ultrasound examination, undergo an exploration, obtain a surgical consultation, and obtain an MRI of the injured extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (min)</td>
<td>Median (min)</td>
</tr>
<tr>
<td>Time to ultrasound</td>
<td>46.29</td>
</tr>
<tr>
<td>Time to wound exploration, surgical consultation, or MRI</td>
<td>138.6</td>
</tr>
<tr>
<td>Time to wound exploration</td>
<td>90.36</td>
</tr>
<tr>
<td>Time to surgical consultation</td>
<td>174.16</td>
</tr>
<tr>
<td>Time to MRI</td>
<td>246</td>
</tr>
</tbody>
</table>

All patients underwent ultrasonography of the injured extremity. Significance is defined as \( P < .05 \).
likely bypass comprehensive ED exploration and, instead, undergo a full exploration, irrigation, and repair in the operating room. Furthermore, it should be noted that both institutions possessed the same brand of ultrasound machines (SonoSite, Inc, Bothell, WA) with similar transducer options and scanning capabilities. It is plausible that the results from our study may not be generalizable to practice settings with less sophisticated ultrasound equipment. Subtle tendon injuries may be missed if high-frequency transducers are not available or if lateral and axial resolution is not optimized.

The management of significant tendon injuries was similar in both study institutions. For most large tendon disruptions (hand, forearm, arm, patella, Achilles, etc), a surgical consultation was obtained; and the timing and method of repair were determined based on the type of tendon injured, the extent of the laceration, and the surgeon’s availability for immediate operative or bedside repair. In practices where all suspected tendon injuries receive immediate operative management or in places where all tendon injuries get splinted for outpatient referral, estimating the extent of tendon injury may not be as important as simply making the diagnosis of a tendon rupture. In that type of practice, bedside ultrasound can still be used to provide additional data that improve diagnostic accuracy and expedite patient care.

5. Conclusion

Emergency physicians trained in basic tendon ultrasonography can use ultrasound at the bedside to rapidly and accurately evaluate potential tendon lacerations. Bedside ultrasound is more sensitive and specific than physical examination alone for detecting tendon lacerations and takes less time to perform than traditional wound exploration techniques or MRI. Data obtained from bedside ultrasonography can be used to improve diagnostic accuracy and enhance and expedite patient care [10,11].

References