Diagnostic Accuracy of Ultrasonographic Examination in the Management of Shoulder Dislocation in the Emergency Department

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Study objective: Emergency physicians frequently encounter shoulder dislocation in their practice. The objective of this study is to assess the diagnostic accuracy of ultrasonography in detecting shoulder dislocation and confirming proper reduction in patients presenting to the emergency department (ED) with possible shoulder dislocation. We hypothesize that ultrasonography could be a reliable alternative for pre- and postradiographic evaluation of shoulder dislocation.

Methods: This was a prospective observational study. A convenience sample of patients suspected of having shoulder dislocation was enrolled in the study. Ultrasonography was performed before and after reduction procedure with a 7.5- to 10-MHz linear transducer. Shoulder dislocation was confirmed by taking radiographs in 3 routine views as a criterion standard. The operating characteristics of ultrasonography to detect dislocation in patients with possible shoulder dislocation and to confirm reduction in patients with definitive dislocation were calculated as the primary endpoints.

Results: Seventy-three patients were enrolled. The ultrasonography did not miss any dislocation. The results of ultrasonography and radiography were identical and the sensitivity of ultrasonography in detection of shoulder dislocation was 100% (95% confidence interval 93.4% to 100%). The sensitivity of ultrasonography for assessment of complete reduction of the shoulder joint reached 100% (95% confidence interval 93.2% to 100%) in our study as well.

Conclusion: We suggest that ultrasonography be performed in all patients who present to the ED with a clinical impression of shoulder dislocation on admission time. The results of this study provide promising preliminary support for the ability of ultrasonography to detect shoulder dislocation. However, further investigation is necessary to validate the results and assess the ability of ultrasonography in detecting fractures associated with dislocation. [Ann Emerg Med. 2013;62:170-175.]

Please see page 171 for the Editor's Capsule Summary of this article.

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0196-0644/$-see front matter
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http://dx.doi.org/10.1016/j.annemergmed.2013.01.022

INTRODUCTION

Background

It is common practice for patients with presumed shoulder dislocation to undergo pre- and postreduction radiographic examination.[1] Typically, prereduction radiographs are performed to confirm the dislocation and exclude fracture; however, postreduction radiographs are generally ordered to confirm the reduction and rule out any iatrogenic fractures.[2] Recently, the necessity of pre- and postreduction radiographs in shoulder dislocations has been challenged by several authors.[3,4] Several case reports and case series with small numbers of patients have suggested that ultrasonography might be a useful bedside diagnostic modality for evaluating shoulder dislocations.[5-7] We performed an observational prospective study with higher sample size to better evaluate accuracy of ultrasonography for evaluation of shoulder dislocation.

Importance

If ultrasonography is found to be accurate for the diagnosis of shoulder dislocation, it might obviate the need for radiographs and reduce the need for resedation by more rapid identification of unsuccessful reduction.

Goals of This Investigation

Our primary purpose was to ascertain the diagnostic accuracy of bedside ultrasonography for detection of shoulder dislocation and confirmation of reduction compared with pre- and postreduction radiographic evaluation in a sample of emergency department (ED) patients with suspected shoulder

Editor's Capsule Summary

What is already known on this topic

Anecdotal reports describe ultrasonographic imaging of patients with shoulder dislocations but provide little information on the sensitivity and specificity of ultrasonography for detecting dislocations and other important shoulder injuries.

What question this study addressed

Does bedside ultrasonography exhibit sufficiently high sensitivity and specificity to justify further investigation into the use of this technology for acute shoulder dislocations?

What this study adds to our knowledge

In this 73-patient study, ultrasonography maintained perfect sensitivity and specificity compared with a radiograph criterion standard.

How this is relevant to clinical practice

Most dislocations can be managed without radiologic imaging, but if validated in larger studies, bedside ultrasonography could offer an alternative means of assessing patients with suspected acute shoulder dislocations.

dislocation. In addition, we sought to test the accuracy of ultrasonography for the detection of fractures associated with dislocation.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study enrolling a convenience sample of patients with suspected shoulder dislocation, conducted from July 1, 2011, until February 1, 2012, when either of the 2 investigators was on clinical shift to perform the ultrasonography. The study was conducted in 2 academic EDs with a combined annual census of more than 100,000 ED visits.

Selection of Participants

Adult patients (aged ≥18 years) with presumed shoulder dislocation (according to the clinical impression of the emergency physician) were enrolled. Shoulder dislocation was confirmed by taking radiographs in 3 views as the criterion standard (anterior-posterior, lateral, scapular Y). Patients with multiple trauma or decreased level of consciousness, or those who were hemodynamically unstable or did not consent to undergo sonography were excluded. Written informed consent was obtained from all participants. The study was approved by the Tehran University of Medical Sciences Institutional Review Board.

Interventions

Each patient who claimed shoulder pain was referred to the attending or resident physician by triage nurses and was enrolled in the study if he or she had suspected shoulder dislocation. After history taking and physical examinations, our sonographer performed bedside ultrasonography while the patient waited for radiography and registered the result of ultrasonography before the radiograph. Then the patient was sent for prereduction radiographs. When the radiographs were ready and dislocation was confirmed, the emergency physicians tried to reduce the shoulder. Ultrasonography was performed simultaneously and after completion of the reduction procedure. After that, the patient was sent for postreduction radiographs. The sonographer was blinded to the results.

Radiographs were subsequently interpreted by a consultant attending radiologist, who was blinded to the ultrasonographic results. The radiographs served as the criterion standard. All sonograms were also later reviewed and interpreted by an attending radiologist. The latter radiologist was blinded to the radiography result. An atraumatic mechanism was defined as arm motion, reaching up, sleeping, and turning over in bed.

Methods of Measurement

Bedside sonographic examination was performed by one of the 2 investigators. The first investigator (an emergency physician attending) had more than 5 years' experience in emergency sonography and approximately 1 year in shoulder sonography. The second investigator (senior emergency medicine resident) underwent a brief course (1-hour lecture and 10 shoulder sonographic procedures supervised by the first investigator).

We used an ultrasonographic scanner (SonoAce X8; Samsung Medison, Seoul, Korea) equipped with a 7.5- to 10-MHz linear transducer with a 2-inch-wide field. We used anterior and lateral approaches. The probe positions are shown and explained in Figure 1. In a normal anatomy of the anterior view, the humeral head is located laterally to the coracoid process but inferiorly in dislocation (Figure 2*A* and *B*). In a normal anatomy of the lateral view, the humeral head is viewed just below the acromion process. However, when the shoulder is dislocated, the space between the acromion and the humeral head widens (Figure 2*C* and *D*). The other signs of dislocation include disappearance of the humeral head sign, the humeral head visualized below the coracoid process, and an empty glenoid fossa. The sonologists scanned the shoulder region to determine associated injury as well. This process was done in supine position and while the patient was observed to recover from sedation. Fracture of the greater tuberosity, lesser tuberosity, humeral head (reversed fractures of the Hill-Sachs deformity), posterior glenoid rim, disruption of the glenoid rim (Bankart lesion), humeral neck fractures, and fractures of the proximal humerus are considered associated with shoulder dislocation.

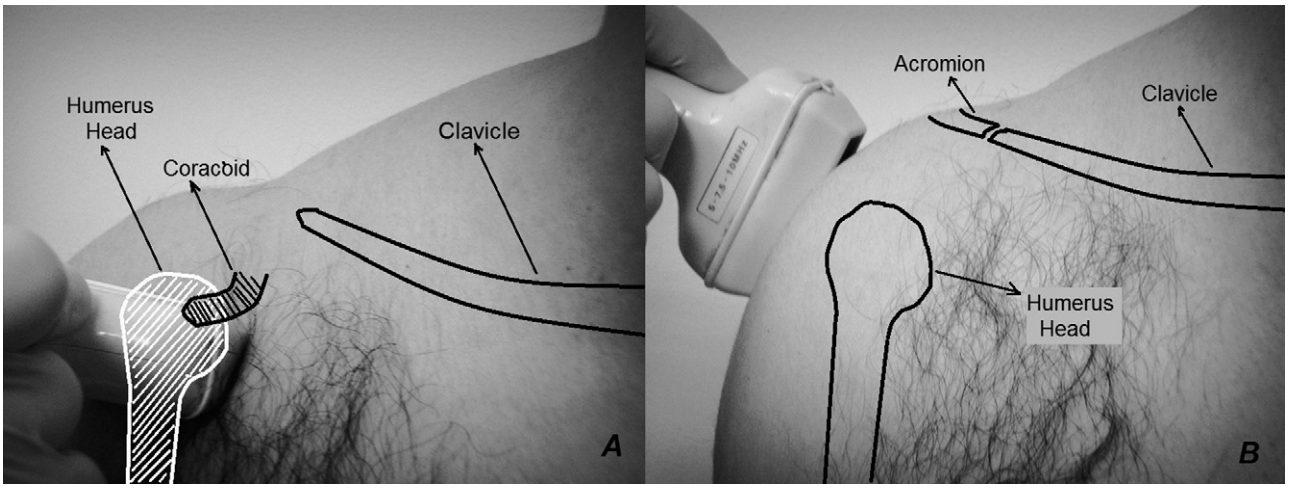

Figure 1. Probe placement and orientation. *A*, Anterior approach; the probe was placed transversely directly over the coracoid process. *B*, Lateral approach; the probe was placed longitudinally just below the acromion.

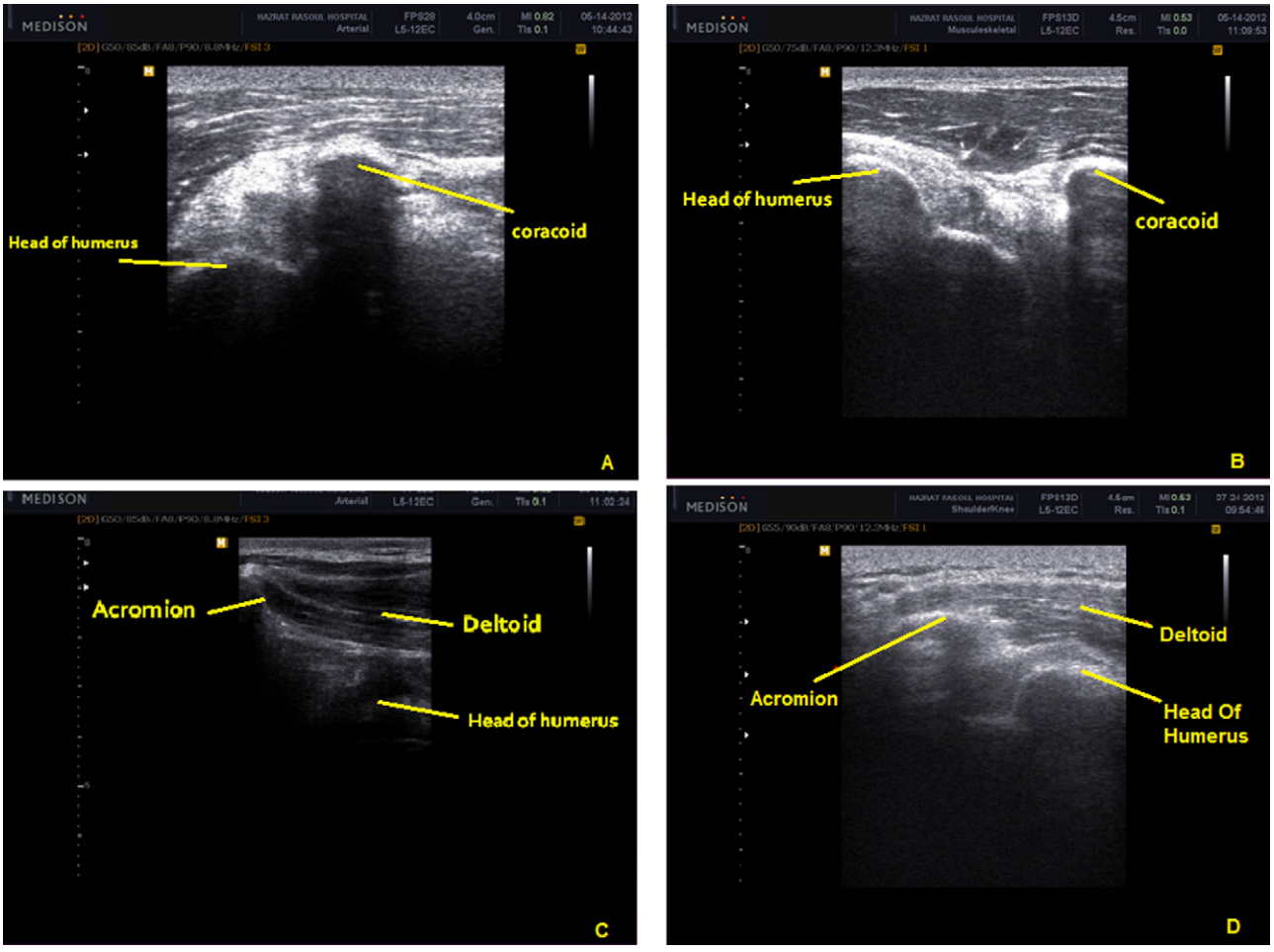

Figure 2. Ultrasonographic findings of anterior shoulder dislocation. *A*, Prereduction, anterior view (dislocation anatomy). *B*, Postreduction, anterior view (normal anatomy). *C*, Prereduction, lateral view (dislocation anatomy). *D*, Postreduction, lateral view (normal anatomy).

Outcome Measures

The primary outcomes were to determine the diagnostic accuracy of bedside ultrasonography in detecting shoulder dislocation and confirming proper shoulder reduction.

Primary Data Analysis

Data were entered into SPSS for Windows (version 16.0; SPSS, Inc., Chicago, IL) for analysis. Data are presented as mean (SD) for continuous variables. Frequencies are presented as percentages with 95% confidence intervals (CIs). We calculated sensitivity and specificity according to the standard formula and after generating 2×2 tables. A paired-sample *t* test was used to compare the time between admissions to ultrasonography or between admissions to when the radiographic image was available for the physician.

RESULTS

A total of 73 patients with suspected shoulder dislocation (according to history and physical examination) were enrolled in the study. Baseline characteristics of the study cohort are presented in Table 1. First, we performed ultrasonography and it did not show dislocation in 4 cases. Findings of ultrasonography were confirmed by subsequent radiographs. Both disclosed that the physical examination was falsely positive in 4 patients. Therefore, there was no false-positive case in relation to ultrasonography. None of the 69 dislocations were missed by ultrasonography and the results of sonography and radiography were identical (Table 2). Considering the 73 patients, the sensitivity and specificity of ultrasonography in detection of shoulder dislocation was 100% (95% CI 93.4% to 100%) and 100% (95% CI 39.5% to 100%).

We identified 11 fractures (16%; 95% CI 7.2% to 26.1%) on radiographs. Nine of the fractures occurred in patients who experienced trauma, and only 2 fractures (2 Hill-Sachs fractures) occurred in atraumatic cases. Similar to the results for nondislocated shoulders, ultrasonography was able to detect all 11 fractures.

The reduction procedures were successfully accomplished in 97.1% of patients. In 2 patients, the first try was unsuccessful. These dislocations were anterior type and resulted from direct trauma. After the reduction procedure, ultrasonography was repeated to assess the location of the humerus head and then the patients were sent to the radiology unit. We could visualize the complete reduction in 67 patients at the first attempt for reduction. The radiographs then confirmed the results of ultrasonography. In 2 of the patients for whom the first reduction attempt was not successful, the clinical examination failed to show the incomplete reduction, but ultrasonography revealed it. Then, considering the first attempt, the sensitivity and specificity of ultrasonography for assessment of complete reduction of the shoulder joint were 100% (95% CI 93.2% to 100%) and 100% (95% CI 19.7% to 100%).

The mean of time elapsed between triage and diagnosis of shoulder dislocation by ultrasonography was 4.4 minutes (95% CI 4.18 to 4.65 minutes), and the time elapsed until radiography was 16.49 minutes (95% CI 15.63 to 17.39 minutes). Ultrasonography was performed when patients were waiting for radiography. Comparing these 2 times revealed that the mean time for diagnosis

Table 1. Characteristics of patients and procedures.

Variable	Number (%)
Age, mean (SD), y	31.63 (15.88)
Sex (male)	63 (91.3)
Mechanism	
Traumatic	44 (63.8)
Fighting	11 (15.94)
Falling down	21 (30.43)
Sports	8 (11.6)
Other	4 (5.79)
Atraumatic	25 (36.2)
Arm motion	8 (11.59)
Sleeping	8 (11.59)
Lifting heavy objects	6 (8.69)
Other	3 (4.34)
Medical history	
None	65 (94.2)
Shoulder surgery	2 (2.9)
Arthroscopy	1 (1.45)
Shoulder joint fracture	1 (1.45)
Frequency of dislocation	2 (1–3)*
1	30 (43.5)
2	19 (27.5)
3	16 (23.2)
>3	4 (5.8)
Dislocation type	
Anterior	67 (97.1)
Subglenoid	40 (58)
Subcoracoid	22 (31.9)
Subclavicular	5 (7.2)
Posterior	2 (2.9)
Bilateral	0
Fracture-dislocation	11 (16)
Greater tuberosity	4
Hill-Sachs deformity	2
Bankart lesion	2
Humeral head	2
Glenoid	1
Drugs for PSA	
Fentanyl+thiopental	44 (63.8)
Fentanyl+thiopental+midazolam	11 (15.9)
Fentanyl+propofol	1 (1.45)
Fentanyl+midazolam	1 (1.45)
Fentanyl+etomidate	3 (4.3)
Fentanyl+local anesthesia	2 (2.9)
Local anesthesia (intra-articular)	7 (10.1)
Reduction technique	
External rotation	30 (43.5)
Milch	23 (33.3)
Traction-countertraction	14 (20.3)
Scapular manipulation technique	2 (2.9)
Sonologist	
Emergency medicine resident (PGY 3)	24 (34.8)
Emergency medicine attending	45 (65.2)

PSA, Procedural sedation and analgesia; *PGY*, postgraduate year.
*Data are presented as median and interquartile range.

Table 2. Performance of ultrasonography (test) for identifying shoulder dislocation in 73 patients and confirmation of shoulder reduction in 69 patients.

Ultrasonographic Findings	Shoulder Dislocation Detection			Shoulder Reduction Confirmation		
	Radiographic Results			Radiographic Results		
	Positive	Negative	Total	Positive	Negative	Total
Positive	69	0	69	67	0	67
Negative	0	4	4	0	2	2
Total	69	4	73	67	2	69

by ultrasonography was significantly shorter than for diagnosis by radiography (paired *t* test, $P<.001$).

As we mentioned in the "Materials and Methods," the radiographs and sonograms were interpreted by attending radiologists, and all diagnoses that were registered in the data sheets were confirmed by the attending radiologist.

LIMITATIONS

The sample size was relatively small; therefore, the results need to be validated by larger studies. The ultrasonography depends on operator expertise. Also the small numbers of posterior dislocations do not allow us to generalize our results to posterior dislocations. The study does not have enough power to make recommendation about the use of ultrasonography in identifying dislocation-associated fractures. Last, we did not measure intra- and interrater reliability.

DISCUSSION

Hendey[3] believed that prereduction radiographs should be obtained for patients with a direct blunt traumatic mechanism of injury; postreduction, for those found to have a fracture-dislocation. Shuster et al[8] observed that ordering prereduction radiographs increased the mean time for ED management by 29.6 minutes. They suggested that prereduction radiographs could be omitted when diagnosis of dislocation was certain, the patient was in pain, or radiography was not immediately available.

Postreduction radiographs are usually obtained after the patient has recovered from the procedure sedation. Therefore, if closed reduction fails, the patient might require readministration of the sedative or analgesic medication.[5,6] The recovery time from sedation might further delay the radiography and confirmation of the reduction. However, by using sonography to check for proper reduction, physicians could have multiple attempts at reducing the shoulder without the need for resedating the patient.[7]

Blakeley et al[6] demonstrated that bedside ultrasonography could correctly confirm successful reduction in 5 cases of anterior dislocation. Similarly, Halberg et al[7] presented 2 cases of anterior and posterior shoulder dislocation for which the success of the reduction process was confirmed correctly with ultrasonography. Posterior shoulder dislocations may easily be missed either by clinical examination or radiography. Yuen et al[5] reported 2 cases of acute posterior shoulder dislocation confirmed by bedside ultrasonographic scan. They concluded that bedside ultrasonography for diagnosis of posterior shoulder dislocation was accurate, noninvasive, repeatable, convenient, and without ionizing radiation.[5]

In the present study, ultrasonography was specific compared with radiography as the criterion standard in detecting 4 nondislocated shoulders. One explanation was that in traumatic patients who experience severe pain, the clinical examinations may be inaccurate. The patients may not want to move their shoulders and complain from severe pain. Painful shoulder and resistance against motion could simulate shoulder dislocation.

Despite the suggestions of some studies that postreduction radiographs be omitted, emergency physicians are not comfortable with that option. They are concerned about missing a fracture or missing failed reductions and potential medicolegal issues.[1,2] Blakeley et al[6] proposed that ultrasonography not replace radiography in suspected shoulder dislocations because they believed associated fractures are more easily observed on radiograph. They recommended that ultrasonography be used before and after reduction to confirm successful relocation of the joint to reduce the risk of repeated sedation. Yuen et al[5] said that prereduction radiograph should be conducted to rule out any fracture of the proximal humerus before any external rotation maneuver, but they believed that ultrasonography can possibly verify proper reduction of the shoulder at the bedside without any radiation risk. However, studies have revealed that ultrasonography may reduce the need for repeated sedation, expedite care (especially in EDs whose radiology unit is not close to where the shoulder reduction is performed), and reduce costs.[7] Another advantage of sonography would be reducing the number of radiographs and decreasing exposure to radiation. Ultrasonography could also allow physicians to perform simultaneous scanning when reduction is being performed.

In summary, we safely used ultrasonography for patients with a suspected shoulder dislocation, and no erroneous diagnosis was made. These results provide promising preliminary support for the ability of ultrasonography to detect shoulder dislocation, but further investigation is necessary both to confirm these results and to estimate with greater precision the ability of ultrasonography to detect fractures associated with dislocation. Ultrasonography may reduce the number of radiographs and time elapsed in the ED and allows physicians to spend sufficient time on more acute patients, especially in crowded EDs.

The authors acknowledge Shahriar Zehtabchi, MD, for his advice in study design and writing the article.

Supervising editor: William R. Mower, MD, PhD

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Author contributions: SA, MAZ, and DF conceived of and designed the study. HM, PH, and MA registered the study, communicated with the manager of hospitals, and arranged implementation. SA and HM were responsible for data collection. MA was responsible for quality control. MR and DF wrote the article. SA, MR, and DF were responsible for data analysis and finalizing the article. All authors contributed substantially to revision of article. DF takes responsibility for the paper as a whole.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist.

Publication dates: Received for publication May 11, 2012. Revisions received August 10, 2012, and January 13, 2013. Accepted for publication January 28, 2013. Available online March 13, 2013.

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