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Original article

Bedside ultrasonography for verification of shoulder reduction: A long way to go

Koorosh Ahmadi^{a,1}, Amir Masoud Hashemian^{b,1}, Kaveh Sineh-Sephehr^b, Monavvar Afzal-Aghaee^b, Saba Jafarpour^{c,d}, Vafa Rahimi-Movaghar^{c,e,f,*}

^a Emergency Department, Alborz University of Medical Sciences, Karaj, Iran

^b Emergency Department, Mashhad University of Medical Sciences, Mashhad, Iran

^c Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran

^d Department of Neurology, Boston Children's Hospital, Harvard Medical School, Boston, MA, USA

^e Department of Neurosurgery, Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran

^f Research Centre for Neural Repair, University of Tehran, Tehran, Iran

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ABSTRACT

Purpose: Shoulder dislocation is a common joint dislocation managed by the emergency physicians in the emergency departments. Pre- and post-reduction radiographic examinations have long been the standard practice to confirm the presence of dislocation and the successful reduction. However, shoulder ultrasonography has recently been proposed as an alternative to the radiographic examination. This study aimed to assess the accuracy of ultrasonography in evaluating proper reduction of the dislocated joint.

Methods: This was a prospective observational study. All patients with confirmed anterior shoulder dislocation were examined by both ultrasonography and radiography after the attempt for reduction of the dislocated joint. The examiners were blinded to the result of the other imaging modality. Results of the two methods were then compared.

Results: Overall, 108 patients with confirmed anterior shoulder dislocation were enrolled in the study. Ninety-one (84.3%) of the patients were males. Mean age of the participants was (30.11 ± 11.41) years. The majority of the patients had a recurrent dislocation. Bedside ultrasonography showed a sensitivity of 53.8% (95% CI: 29.1%–76.8%) and a specificity of 100% (95% CI: 96.1%–100%) in detecting inadequate reductions. The results of ultrasonography had a statistically significant agreement with the results of radiography (Kappa = 0.672, $p < 0.001$).

Conclusion: The results suggest that the sensitivity of post-reduction ultrasound is not sufficient for it to serve as a substitute for radiography.

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Introduction

Emergency physicians frequently encounter patients with a shoulder joint dislocation. The shoulder is the most frequently dislocated major joint.¹ Anterior glenohumeral dislocations account for more than 50% of all joint dislocations.² Reduction is

attempted in the emergency department (ED), often under conscious sedation. As a common practice, pre- and post-reduction radiographic examinations are performed to ensure the presence of dislocation, to exclude fractures, and to confirm a successful reduction. However, the necessity of routinely obtaining these radiographs from all patients with dislocation has been challenged.^{2–4}

Ultrasonography is being increasingly used in the EDs as a diagnostic tool. It has been proposed as an alternative to the radiography in evaluating shoulder joint dislocation^{1,5,6} considering its benefits in detecting shoulder pathologies.^{7,8} In the evaluation of proper reduction of a dislocated shoulder joint after performing the reduction maneuvers, bedside ultrasonography has the advantages of timely usage and can preclude the need for re-sedation in cases

* Corresponding author. Tel.: +98 915 3422682, +98 216 6757010; fax: +98 216 6757009.

E-mail addresses: v_rahimi@sina.tums.ac.ir, v_rahimi@yahoo.com (V. Rahimi-Movaghar).

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¹ These authors had equal contribution to the project.

of an inadequate reduction. This in turn can result in a decrease in the cost and the length of patient's stay in the ED. Therefore, bedside ultrasonography can be a good choice as long as it is accurate.

To our knowledge, very few papers that chiefly comprise case reports and small case series have addressed the use of bedside ultrasonography in evaluating the adequacy of the reduction.^{1,5,6,9} There is an obvious gap in the literature for larger validation studies. We performed a prospective observational study to evaluate the accuracy of the bedside ultrasonography in detecting unsuccessful reductions and to examine whether this diagnostic modality can be safely recommended as a reliable indicator of the post-reduction persistent dislocation.

Materials and methods

This prospective observational study was performed between March 2012 and March 2014 at a university-affiliated trauma center ED where the two principal investigators were on duty as attending emergency physicians. We enrolled all patients with suspected shoulder dislocation presented to the ED in the two-year study interval.

Patients whose anterior shoulder dislocation was further confirmed by the standard radiologic examination were included in the study. A true anteroposterior (true AP) shoulder radiograph was taken as the standard criterion to confirm the anterior shoulder dislocation. In order to have a more homogenous sample, patients with a body mass index (BMI) of 35 or higher were excluded from our study. Other exclusion criteria were: time interval of more than 12 h since the occurrence of the dislocation, multiple trauma or concomitant fractures. Posterior glenohumeral dislocations were also excluded because standard radiography is not accurate enough to show this type of dislocation,¹⁰ and according to our hospital's protocol, the suspected posterior dislocations should be managed by an orthopedic surgeon and reduced in the operation room not the emergency department.

An experienced attending emergency physician interpreted the initial radiographs and confirmed the dislocations. Subsequently, either of the two principal investigators tried to reduce the joint by performing scapula manipulation or traction-counter-traction maneuvers while procedural sedation was applied and cardiovascular monitoring was being performed in all cases. Then, the two principal investigators who had several years of experience in bedside emergency sonography and had received training courses of shoulder ultrasonography in the radiology department performed the ultrasonography of the shoulder. Presence of humeral head in the glenoid fossa was examined to confirm the proper

reduction. We used an ultrasound system (Honda Electronics Co., Ltd., Japan, 2100) with a 7-MHz linear probe. Both anterior and lateral approaches were used while the patient was laid in the supine position. A persistent dislocation was assigned as a positive finding.

After the result of the ultrasonography was documented, a post-reduction radiograph was obtained and interpreted by the independent attending physician who had confirmed the dislocations at the first stage. He was blinded to the results of the bedside ultrasonography performed by the principal investigator. Therefore, the interpretation of the radiographs and the sonographic examinations were performed independently and in a double-blind manner. At the end, the two sets of results were collected and then entered into a spreadsheet for later analysis. [Figs. 1 and 2](#) demonstrate the radiographic and ultrasonographic views of the shoulder joint before and after the reduction.

Statistical analysis was performed using SPSS for Windows (version 14.0, SPSS, Inc. Chicago, IL). Data was presented using descriptive statistics. Student's *t* and Chi-square tests were used to compare the results of ultrasonography and radiography, and sensitivity and specificity were calculated according to the standard formulas. Kappa agreement coefficient for the two diagnostic modalities was also calculated. Non-parametric tests were considered in case the variables did not obey the normal distribution. *p* values of 0.05 or less were regarded as statistically significant.

The study was approved by the ethics committee of the corresponding medical university. Written informed consent was obtained from all participants.

Results

Overall, 108 patients with confirmed anterior shoulder dislocation were enrolled in the study. Ninety-one (84.3%) of the patients were males. Mean age of the participants was (30.11 ± 11.41) years with a minimum age of 18 and a maximum of 75 years. The majority (80.6%) had a prior dislocation. Patients who were suffering the first episode of the shoulder dislocation were significantly younger. There was no significant difference between males and females in terms of dislocation recurrence ([Table 1](#)).

Cross tabulation was used in order to compare the findings of ultrasonography with the results of radiography ([Table 2](#)). Ultrasonography had a sensitivity of 53.8% (95% CI: 29.1%–76.8%) in detecting persistent dislocations. All cases that were assigned by the ultrasonography as positive were further confirmed by the radiography to be an unsuccessful reduction. Thus, ultrasonography was 100% specific (95% CI: 96.1%–100%) in detecting persistent dislocations.

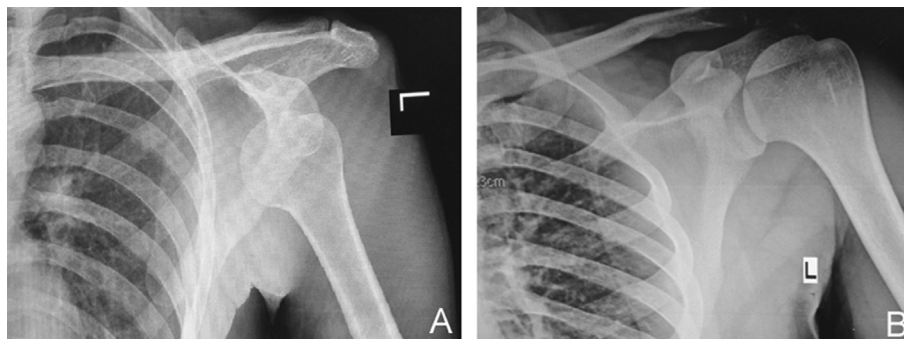


Fig. 1. Radiographic evaluation of the dislocated shoulder joint, anteroposterior view (A). Post-reduction radiograph shows the head of humerus relocated into the glenoid fossa (B).

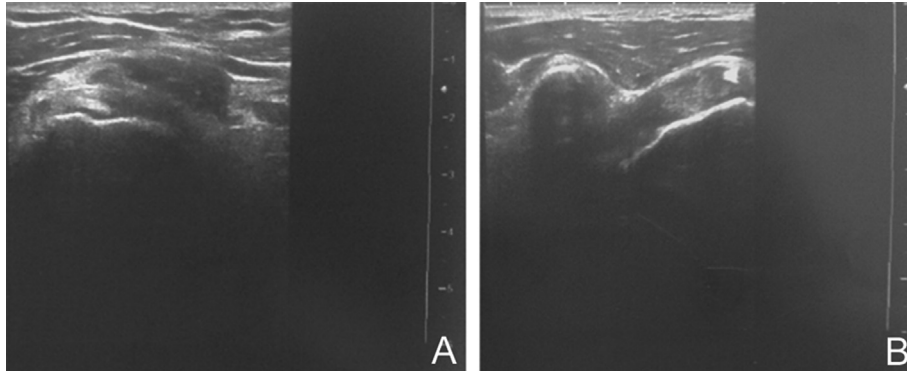


Fig. 2. Ultrasonographic view of the shoulder joint (anterior approach). The head of humerus is visualized in its normal lateral position to the coracoid process (A: pre-reduction, B: post-reduction).

Table 1
The association of age and sex with the dislocation recurrence.

		1st Episode	Recurrence	Total
Sex	Male	18 (19.8%)*	73 (80.2%)*	91 (100%)
	Female	3 (17.6%)*	14 (82.4%)*	17 (100%)
	Total	21	87	108
Age		24.0 ± 12.1	31.6 ± 10.8	30.1 ± 11.4

*Numbers in the parenthesis indicate the percentage of cases within the same sex group. Fischer's exact test = 0.041, $p = 0.005$.

Agreement between the findings of ultrasonography and the radiologic results was examined using Kappa coefficient as the measure of agreement. A Kappa value of 0.672 was obtained, which was statistically significant ($p < 0.001$).

Discussion

The notion of routinely obtaining pre- and post-reduction radiographs from all patients has been questioned.^{2–4} Earlier studies that challenged this notion suggested that in the majority of cases, physicians are able to accurately determine the joint position according to clinical clues.^{2–4,11} Hendey⁴ proposed a clinical decision rule for selective radiography based on the mechanism of injury, history of previous dislocations, and the physician's clinical confidence of the dislocation or relocation. The proposed algorithm showed the potential of considerably reducing the utilization of radiography without missing any persistent dislocation. However, the physicians preferred to take a more conservative approach with regard to omitting the radiographs chiefly due to medicolegal concerns.¹² Fear of litigation leads physicians to prefer a documented evidence for their decision, rather than merely a subjective clinical guess.

Table 2
Performance of ultrasonography in detecting persistent dislocation.

Ultrasonography ^a	Radiography ^a		Total
	Positive	Negative	
Positive	7	0	7
Negative	6	95	101
Total	13	95	108

^a A positive test indicates a persistent dislocation.

There are two main sources of worry that leads to obtaining a post-reduction radiograph. The first is iatrogenic fracture caused by the reduction maneuvers, which is hardly a concern since it very rarely occurs especially with modern less traumatic reduction techniques.^{4,11} The second concern is persistence of the dislocation despite the reduction attempt. Rate of persistent dislocation after the first reduction attempt varies among different studies, and ranges from 0.6%³–3.1%.¹¹ In cases of an unsuccessful reduction, because the medications used for procedural sedation are short-acting agents and their effects wane before the results of radiography are obtained, re-administration of the sedative medication is commonly required to perform a second attempt at reduction.

Based on the aforementioned rationale, the use of bedside ultrasonography has been proposed for confirming the adequate reduction when a procedural sedation is used. Halberg et al¹ reported two cases of anterior and posterior shoulder dislocations in which relocation was successfully confirmed by bedside ultrasonography before the patients recovered from sedation. Meanwhile, Yuen et al⁶ also reported that their team had a two-year experience in utilizing bedside ultrasound for diagnosing anterior shoulder dislocation and confirming the complete reduction. In a series of 5 patients with anterior dislocation, bedside ultrasonography was found by Blakeley et al⁵ to be accurate in verifying the adequacy of reduction. In two separate case reports by Beck & Chilstrom¹³ and Mackenzie & Liebmann,¹⁰ point-of-care ultrasound was shown to be worthwhile in the rapid assessment and management of suspected posterior shoulder dislocation.

Abbasi et al⁹ reported a prospective observational study on a convenience sample of patients with suspected shoulder dislocation. The aim was to determine the accuracy of bedside ultrasonography in detecting the dislocation and confirming the relocation. According to this study, ultrasound was 100% sensitive

and specific in the detection of shoulder dislocation, pre- and post-reduction.

Our study found a much lower sensitivity in the detection of persistent dislocation after a reduction attempt. In 6 out of 13 cases, ultrasonography suggested that a successful reduction was accomplished while radiography revealed persistence of the dislocation. In other words, persistent dislocation was missed by ultrasonography in nearly half of the cases (46.2%, 95% CI: 23.2%–70.9%). This is an unacceptably high rate, and suggests that we cannot safely rely on the results of bedside ultrasonography for detecting patients in whom the first attempt at reduction is not successful and a second attempt is required.

We found the specificity of ultrasonography to be perfect. So there may be some benefit in a positive test because it indicates that the reduction is not successful and another attempt should be made. However, a negative test cannot be used to confirm a successful reduction.

There is a discrepancy between our results and the results obtained by Abbasi et al,⁹ despite the fact that the sample size and characteristics, equipment, technique, and experience of the shoulder ultrasonographers are comparable in both studies. The only methodological difference lies in involving expert radiologists in verifying the interpretation of X-ray and sonographic imaging in Abbasi's study,⁹ which is not feasible in our study. On the other hand, assuming "unsuccessful reduction" as the positive result of the test, the lower limit of the 95% confidence interval for the calculated sensitivity in the Abbasi's study would be as low as 34.2%, which is aligned with the low sensitivity obtained in our study.

It is important to note that a persistent dislocation is relatively rare, and to reliably exclude a rare event we need larger sample sizes to let the rare event show itself. In validation studies, sample size requirements depend on several factors including the hypothesized values of sensitivity and specificity, the desired degree of precision at a specified confidence level, and the estimated prevalence of the studied condition in the target population.¹⁴ For instance, given the anticipated sensitivity of 90% and a precision of 10%, i.e. a sensitivity range of 80%–100%, for a 95% confidence level, a sample size of around 700 will be required.¹⁵ Neither our study nor Abbasi's study⁹ utilized sample sizes of this scale. Despite the low number of persistent dislocations in our study, only about half of them were detected by the ultrasonography. Thus, even in the absence of larger studies it can be concluded that this test is not good enough in fulfilling the proposed goal.

Our study has several limitations. First of all, the results of ultrasonography can vary extensively depending on the experience of the operator. As a result, the accuracy of findings cannot be extrapolated to other situations. Another limitation of our study is that due to some technical problems we used a single radiographic view, i.e. true AP instead of the three standard AP, lateral, and scapular Y views. In addition, the emergency physicians' interpretations of the imaging were not confirmed by an expert radiologist. Therefore, one can argue that the number of true inadequate reductions might have been under-calculated. In this case, the actual sensitivity would be even lower than what we have obtained. However, since we just included the anterior dislocation, the true AP could be sufficient for detecting inadequate reductions. Furthermore, the emergency physicians were proficient in the field of shoulder imaging as they had specific trainings and experiences under supervision of expert radiologists. Thus, this should not be a significant concern. Finally, the clinical clues to the complete or unsuccessful reduction were not addressed. We can look at this issue from another perspective. Physician's clinical certainty of the joint's position and clues such as surface anatomy and shoulder contour, neurovascular signs, and the feeling of a "clunk" during the

reduction procedure has been proposed by the previous investigators as diagnostic factors that can reduce the need to obtain unnecessary radiographs. Some authors have even gone a step further by suggesting that imaging should be reserved for the cases that physical examination is inconclusive; otherwise, it would indicate a "hyposkillia" or "subluxation of clinical skills".¹⁶

In our study, ultrasound had inadequate sensitivity for the detection of persistent dislocation. We suggest that the accuracy of a combination of ultrasonography and the physician's clinical suspicion should be compared with the clinical findings alone and/or selective radiographic examinations. This is a fruitful area for further investigations. It is recommended to explore utilization of the bedside ultrasonography as a supplement to the clinical clues in order to increase the sensitivity of the diagnostic approach. Considering the advantages of the bedside ultrasonography over radiography which includes a reduced stay, cost and radiation exposure, and bearing in mind the apprehension of litigation that leads the physicians to prefer the use of additional confirmatory tests, we believe that development of a valid clinical decision rule comprised by both the physical examination and the bedside ultrasonography would cover both ends of the spectrum of concerns.

In conclusion, post-reduction ultrasound is not sensitive enough to serve as a substitute for radiography in detecting persistent dislocations.

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