Accuracy of Point-of-Care-Ultrasonography in Confirming Shoulder Reduction in Emergency Departments

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Abstract

Aims
Accurate identification of the successful reduction of a dislocated shoulder could avoid additional episodes of procedural sedation and repeated performance of X-rays. The objective of this study was to assess the diagnostic accuracy of point-of-care-ultrasound (POCUS) in the confirmation of a successful joint reduction in patients with shoulder dislocation.

Methods
This was a single-centre, prospective observational study set in an urban academic ED in Ireland, with a convenience sample of adult patients with shoulder dislocation on X-ray. Ultrasound was performed on participants before and after joint reduction using a posterior approach technique. The operator's confidence levels were recorded after image acquisition.

Results
Thirty-three subjects were recruited. All dislocations were correctly identified on pre-reduction US, indicating a sensitivity of 100% (CI 89.42 – 100). Post-reduction US confirmed successful reduction in 30 subjects that were subsequently reported as such on X-Ray, giving it a specificity of 100% (CI 88.43 – 100). Failure to achieve reduction was correctly identified on US in three cases, resulting in post-reduction US Sensitivity of 100% (CI 29.24 – 100) and 100% accuracy (CI 89.42 – 100).

Conclusion
This study has shown that POCUS, with a posterior approach technique, has 100% sensitivity and specificity in confirming successful shoulder reduction in the ED.

Introduction

Shoulder dislocation is the most common joint dislocation presenting to the Emergency Departments (ED) worldwide[1, 2]. It affects approximately 2% of the population and has an incidence rate of 15 to 40 per 100,000 person-years[1, 3, 4]. The increasing utilization of point-of-care-ultrasound (POCUS) has prompted emergency physicians to consider the use of ultrasound in the management of shoulder dislocations. Multiple studies have demonstrated that ultrasonography (US) is highly sensitive and specific in diagnosing shoulder dislocation[5]. POCUS offers the ability to confirm joint position immediately after reduction[6-8]. Previous studies have shown that confidence in image acquisition and diagnosis can be achieved with basic training even in novice operators[7, 9].

The objective of this study was to assess the diagnostic accuracy of POCUS in the confirmation of successful joint reduction compared to standard radiography in patients presenting to the ED.

Patients with a dislocated shoulder typically present in pain and have significant decrease in the range of motion (ROM) of the affected limb. If the shoulder is dislocated anteriorly, the arm is usually held in abduction and external rotation, with a step-off deformity and a palpable gap below the acromion. The humeral head can often be felt antero-inferiorly to the glenoid. Posterior dislocations can be more subtle, with patients holding their arm in internal rotation and adduction. Often the reduction of a dislocated shoulder is clinically apparent by a 'clunk' or return of normal glenoid contour, accompanied by restoration of a normal ROM. When it is not, the patient may require further procedural sedation to facilitate another reduction attempt if the x-ray post reduction reveals persistence of the dislocation. Whilst generally safe and effective, procedural sedation in the ED is associated with prolongation of patient stays and the potential for side effects, particularly when administered in higher, repetitive doses[10-12]. It was hoped that this study would examine the clinical reliability of point of care ultrasound coupled with clinical correlation in confirming successful joint reduction immediately after the procedure thus avoiding the requirement for a second round of procedural sedation. Repeat x-ray should be used to further confirm successful reduction when the patient is alert and it is safe to do so. Operator confidence in the interpretation of the acquired images was also assessed in this study.

Methods

This was a single-centre, prospective study set in an urban academic ED in Ireland, with an estimated annual census of 52,000 patients. A convenience sample of patients was recruited between April 2018 and June 2020. The institutional ethics committee approved the study.

All ED patients over 16 years of age with shoulder dislocation on X-ray and who were capable of giving consent were eligible for inclusion. Patients with concurrent humeral fracture, unstable injury or a medical condition, which posed a significant risk to the patient at the time of attendance, were excluded.

Recruitment was performed if one of the six study investigators were on duty when eligible patients presented to the ED.

Shoulder dislocation was confirmed on standard shoulder X-Ray views taken in the ED radiography suite. Participants were then enrolled into the study, and pre-reduction ultrasound (US) was performed by the investigator. The patient then underwent a reduction procedure, after which a post-reduction US was performed. The investigator recorded their findings and their confidence in them prior to the second X-ray being obtained to confirm joint position. The level of confidence in correct image acquisition and interpretation was recorded by the operator as 'very confident', 'confident', 'not confident' or 'uncertain'.

The six study investigators received relevant reading materials and a focused 30-minute teaching session provided by the department of radiology. None of the investigators had previously used POCUS in the diagnosis of shoulder dislocation. Half of the investigators had a basic knowledge of US techniques at the beginning of the study, equivalent to the level 1 curriculum in the UK and Ireland, whilst the other half were experienced operators with years of experience in ED ultrasound.

A posterior approach with a linear transducer on the Mindray TE7 Ultrasound System was used as a standard imaging technique during the study. To obtain the view of the glenohumeral joint, the transducer was placed over the posterior region of the shoulder parallel to the scapular spine {fig.1}. It was then moved laterally, until a view of the glenoid and humeral head was obtained. The scapular spine and circular cortex of the humeral head served as landmarks during image acquisition. In a normal joint, the humeral head appears in-line with the glenoid, with both structures equidistant from the probe on the image (fig. 2). In an anterior dislocation the humeral head lies anterior relative to the glenoid i.e. further away from the probe (fig. 2). If the shoulder is dislocated posteriorly, the humeral head should be seen posterior to the glenoid and closer to the transducer. A traumatic haematoma can occasionally be present, seen as a dark area separating the glenoid and humeral head (fig. 2).

The primary outcome measure of interest was the diagnostic accuracy of POCUS in confirming glenohumeral realignment on post-reduction scans.

The secondary outcome was operator confidence in the interpretation of the US images obtained at the bedside.

The diagnostic accuracy was calculated as sensitivity and specificity by comparing POCUS findings to standard radiography. MedCalc online statistical software was used for analysis. Frequencies are presented as percentages with 95% Confidence Intervals (CI) and continuous variables as medians with interquartile ranges (IQR).

Results

Patients

Thirty-three subjects were recruited to the study, resulting in sixty-six (33 pre reduction and 33 post reduction) POCUS scans. The median age was 41 year (IQR 24 to 73) with a male to female ratio of 1.2 (18/15). Out of 33 patients, 31 had an anterior dislocation and 2 had a posterior dislocation.

Diagnostic Accuracy of Pocus

All dislocations were confirmed on pre-reduction US, indicating a sensitivity of 100% (CI 89.42 – 100) in pre-reduction US. Post-reduction US detected that 3 patients had persistent anterior dislocation after a reduction attempt, which was confirmed by a post-reduction XR in each case, resulting in 3 true positive scans and a Sensitivity of 100% in recognition of failed reduction (CI 29.24 – 100). Post-reduction US demonstrated a normal glenohumeral alignment, indicating a successful reduction in the remaining 30 subjects that was subsequently confirmed as such on X-ray, producing a specificity of 100% (CI 88.43 – 100) and an accuracy of 100% (CI 89.42 – 100). Imaging results are shown in *Table 1*.

Operators Confidence

Experienced POCUS operators performed scans in 60% (n=20) of patients. Operators rated themselves as 'confident' or 'very confident' in 84% (n=21) of pre-reduction and 96% (n=24) of post-reduction scans. In 16% (n=4) of pre-reduction scans operators were 'uncertain' in their findings, and a single 'not confident' rating was given to a post-reduction scan.

Table 1: Summary of the diagnostic findings from standard radiography and POCUS in the study subjects. *A total number of patients with corresponding diagnosis is shown for each imaging modality performed before and after the reduction attempt.*

US findings, n (%)	Pre-reduction scan	Post-reduction scan
Anterior dislocation	31 (94%)	3 (9%)
Posterior dislocation	2 (6%)	0
Normal joint alignment	0	30 (91%)
Total	33	33
XR diagnosis, n (%)	Pre-reduction image	Post-reduction image
Anterior dislocation	31 (94%)	3 (9%)
Posterior dislocation	2 (6%)	0
Normal joint alignment	0	30 (91%)
Total	33	33

Figure 1. Posterior US approach: *Transducer probe is placed along the edge of the scapular spine, and moved laterally to obtain the view of the glenoid and humeral head.*

Figure 2. Glenohumeral joint on US: *Image on the left demonstrates a normal joint: humeral head (A) articulates with the glenoid (B), both structures equidistant from the probe (top). Image on the right shows an anterior glenohumeral dislocation, where the humeral head is displaced away from the probe, and a hypoechoic dark area consistent with haematoma (arrows) is seen next to the glenoid (B).*
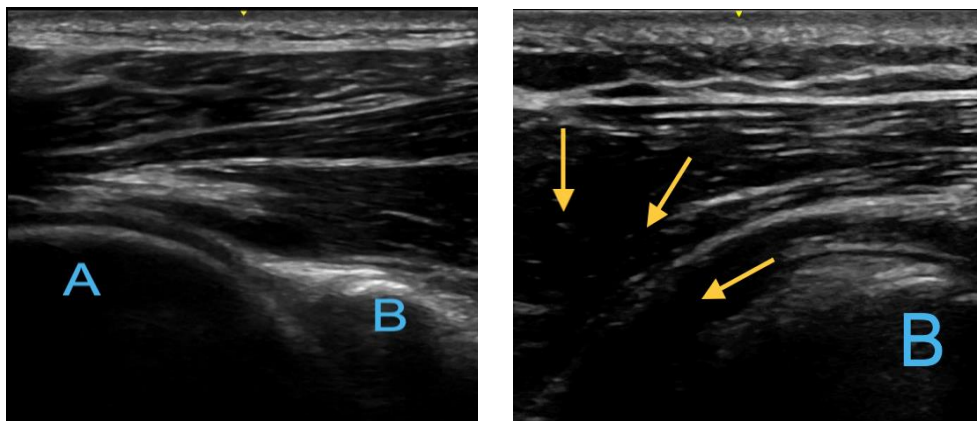
Discussion

Shoulder dislocation is a common condition that is managed by emergency physicians in Ireland and across the globe. The management depends on plain radiography for confirmation of the initial diagnosis of this condition and for confirmation of the successful treatment, after the reduction is performed. Increasing availability of POCUS technology creates an additional modality to confirm the success of the reduction in those patients where there is clinical concern as to whether or not joint reduction was achieved.

This study has shown that POCUS with a posterior approach technique has 100% sensitivity and specificity in detecting shoulder dislocation and in confirming successful joint reduction when compared to the gold standard of plain film radiography. These findings are in-line with the most recent American studies to assess the same technique, which also reported sensitivity and specificity of POCUS of 100% for identifying shoulder dislocations in ED[7, 9, 13]. A study from Iran on this topic has shown that the sensitivity of US in diagnosing shoulder dislocation was 100% with a specificity of 98.7% in confirming successful reduction[14]. All studies assessed the accuracy of US on post-reduction scans. Studies in other countries recruited larger numbers of patients in the ED setting and with different socio-demographic characteristics, but their results are similar to the results from this study, which adds to the applicability of the presented findings. Two recent systematic reviews on the topic have also concluded that the sensitivity and specificity of POCUS in this context is 100%[5, 15].

The confidence levels reported by our US performers were high overall, with 84% confident in their diagnosis on initial scan and 96% on post reduction images. The only 'not-confident' rating was given for a patient noted to have a high BMI, which can make the clinical appreciation of reduction more challenging and is known to increase the difficulty in interpreting soft tissue ultrasound [16]. Importantly, all 3 unsuccessful joint reductions were identified on US after the initial attempted reduction procedure. Although an increase in confidence levels can be related to a lack of blinding of the US operator to the reduction procedure, it also adds reliability to a core advantage of POCUS over x-ray i.e the ability to confirm the success of reduction at the patient's bedside, and in turn, to allow for another reduction attempt, if required. Four 'uncertain' ratings were reported by operators, with 3 of these related to performer experience (given by US operators with basic experience in the past) and the fourth was related to patient factors (high BMI). The only other study to assess sonographer confidence was by Secko et al, reporting a confidence levels of 9.1 and 9.4 on a 10 point scale for non-dislocated and dislocated cases respectively.

Potential limitations of this study include that we enrolled a convenience sample of patients, with recruitment possible only when one of the investigators was present on site. This has likely resulted in eligible patients not being recruited due to the lack of investigator availability. Only two patients with posterior dislocations were recruited, and while this number is higher than that reported in other studies, we couldn't draw specific conclusions on the accuracy of POCUS for posterior dislocation reduction. Subjects in this study were recruited based on the identification of shoulder dislocation on the initial x-ray. The US scan was then performed, and was repeated immediately after reduction. The investigator was not directly involved in the patient's care, but there was a lack of blinding to the initial diagnosis and the treatment process and this potentially could have introduced a degree of confirmation bias to the investigators. Another limitation is that recording of confidence levels was introduced early in the study, and while it was recorded for the majority of recruited patients, overall numbers do not allow us to correlate it reliably to the level of sonographer experience or type of dislocation.

In conclusion, the authors would always advise pre and post reduction shoulder x-rays for patients with dislocated shoulders, however this study demonstrates that the addition of point of care ultrasound can help to guide appropriate management. Point-of-care ultrasonography is an accurate and reliable method of diagnosing shoulder dislocations in the emergency department, with the additional advantage of confirming the success of the reduction procedure whilst the patient is still under the effects of procedural sedation thus allowing further attempts at reduction if necessary. POCUS is associated with a high degree of confidence in confirming shoulder joint reduction among emergency physicians performing the scan.

Declaration of Conflicts of Interest:
The authors have no conflicts of interest to declare.

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