Painful poststroke shoulder: Comparison of magnetic resonance imaging and high frequency ultrasonography

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Abstract Background: The use of high frequency ultrasound has been increased in the diagnosis of musculoskeletal abnormalities.
Aim: To detect the structural abnormalities in patient with poststroke painful shoulder as a first objective, and the second objective to assess the diagnostic accuracy of US in detecting these abnormalities.
Patients and methods: The study included 106 patients (62 men; mean age, 57 ± 13 years) with shoulder pain after 1st attack of stroke, the patients examined separately by two radiologists, within three months of stroke development with ultrasound and MRI which was done in the same day or as maximum as three days after US examination, the images were reviewed for any abnormalities in rotator cuff, biceps tears, tendinopathies and atrophy, subacromial bursa fluid, and acromioclavicular capsular hypertrophy. MRI results were considered as gold slandered. Sensitivity, specificity,
1. Introduction

Stroke is a medical emergency that can cause permanent neurological damage (1). Shoulder pain is a common complication after stroke (2), about one third of all stroke survivors experience shoulder pain during their recovery time (3) this pain interferes with rehabilitation and patients ability to attain their maximal motor function (2). The exact etiology of poststroke shoulder pain remains unknown (3) and, most commonly many factors were involved (4).

High frequency ultrasonography established its role in the demonstration of different pathologies of the shoulder girdle complex that are difficult to identify by clinical examination (2). The diagnostic value of MRI had been proved widely in diagnosing of shoulder pathologies and MRI was found to be the most useful modality for establishment of the etiology of pain in the shoulder (5).

1.1. Patient and methods

One hundred and six patients complaining of 1st flare of shoulder pain after 1st attack of stroke were enrolled in this study. A clinical diagnosis of stroke had been made in all patients on the basis of the criteria of the World Health Organization (i.e., signs of focal disturbance of cerebral function that lasted longer than 24 h and had no apparent origin other than vascular) (WHO, 2001) (6).

The diagnosis of stroke was confirmed by the findings of either brain CT or MRI.

Inclusion criteria included patients with hemiplegia after the first stroke attack who developed shoulder pain within 3 months of stroke onset and they are clinically fit to participate in the study and they have no contraindication to MRI.

Exclusion criteria included Patients with previous stroke, severe cognitive impairment, cardio-respiratory instability, history of previous steroid injection in the diseased shoulder, previous trauma or chronic inflammatory arthritis.

2. Methods

2.1. Clinical examination

All patients were examined by single independent neurologist and rheumatologist.

Shoulder pain was quantified with the Brief Pain Inventory Questions 12 (BPI 12), which asks patients to rate their shoulder pain in the last 7-d on an 11-point numeric ration scale of 0–10, where “0” indicates “no pain” and “10” indicates “pain as worse as the patient can tolerate” (7,8).

Upper limb motor function was by assessed using Brunnstrom recovery stages (9,10). The lowest stage (flaccid stage and no voluntary movement) was stage I and highest stage (isolated joint movement) was stage VI.

US examination was done 1st for all patients followed by MRI by another radiologist on separate cession who was unaware about US findings, with an interval on the same day or within maximum of three days according to clinical condition of the patients.

2.2. US examination

All patients were examined using TOSHIBA (Xario, SSA-660A and Toshiba nemio XG, Toshiba medical system corporation, Tokyo, Japan) using a (6–11) MHz linear phased array transducer. US examination was performed according to the techniques described by Mack et al. (11) and Middleton (12) The patient sits on a rotating chair with the shoulder exposed; this help easy access to both anterior and posterior aspects of the shoulder and for the required positional changes. The thickness and the homogeneity of the fibrillar pattern of the tendon were evaluated. Transverse and longitudinal planes from the biceps tendon groove, rotator cuff, and subacromial-subdeltoid bursa were scanned.

2.3. MRI examination

All shoulder MR scans were obtained on a 1.5-Tesla unit (Intera, Philips Medical Systems) using a surface array-shoulder coil. Patients were supine with the examined shoulder horizontal on the MRI table and the arm by their side in a neutral position.

The MRI scanning protocol included the following: oblique coronal, oblique sagittal, and axial fat-suppressed proton density-weighted sequences (TR/TE, 1500/25; field of view, 120 mm; 4-mm-thick slices with 0.4-mm gap and 320 × 512 matrix; 4 excitations); and coronal and sagittal T2-weighted fast spin-echo sequences (1800/100) and coronal and axial T1-weighted fast spin-echo sequence (400/20); field of view,
100 mm; 4 mm-thick slices with 0.4-mm intersection gap and 354 × 512 matrix; 4 excitations). The total scanning time was lasted from 20 to 25 min.

All US and MRI images were reviewed for any abnormalities based on standard radiological criteria already established in the literature (13–22).

2.4. Image analysis

The findings obtained for each patient were analyzed and compared, MRI was considered as the gold standard for this study as surgical and endoscopic intervention was difficult to perform for such group of the patients. Sensitivity, specificity, positive and negative predictive values of the US was compared to that of MRI (Table 4). Also kappa coefficient was measured to indicate binary agreement of the two methods (Table 1).

Rehabilitation program and treatment were scheduled for the patients depending on final diagnosis observed in MRI and the success of treatment followed up after 6 month depending on improvement of patient symptoms and relieve of pain.

3. Results

This prospective study included 106 patients (62 men and 44 women, with age range from 40 to 78 years with mean age 57 ± 13 years. Table 2 shows the demographic data of the patients.

MRI examination of the patients revealed normal examination in 24 patients and abnormal finding in 82 patients, the most detected finding was glenohumeral joint effusion followed by subdeltoid and subacromial bursitis, then rotator cuff partial tear.

Normal examination was seen in 24 patients with MRI, while US revealed normal examination in only 21 patients, (three cases discrepancy were two diagnosed by US as partial thickness tear of rotator cuff and one case of glenohumeral effusion), kappa value was good (0.92). Patients with normal examination and suffering of shoulder pain were diagnosed to have central poststroke pain.

Rotator cuff abnormalities including, full thickness tear (Fig. 1A–C) were found in 10 cases by US while MRI diagnosed 11 cases (US missed the diagnosis in one case of small tear beneath the acromion), partial thickness tear of the tendon (Fig. 2A and B) was reported in 21 shoulders by MRI and in 17 shoulders by US and atrophy of one or more muscle of the rotator cuff was diagnosed in 11 cases by US and in 14 cases by MRI, agreement between the two methods regarding Rotator cuff tendon abnormalities was good for both full thickness tear (0.80) and partial tear (0.89), and was considered poor for muscular atrophy (Table 3).

Biceps tendon effusion (Fig. 3A–D) was found in 15 cases by US and in 17 by MRI (two cases showed minimal effusion in the peri-insertional area of the tendon), while biceps tendon tendonitis (Fig. 4A and B) was observed in 17 cases by US and 18 cases by MRI (case diagnosed as only effusion at the tendon sheath by US). The agreement of the two imaging modalities regarding biceps tendon effusion and tendonitis was 0.85 and 0.89 and was considered as very good agreement (Table 3).

Subacromial and subdeltoid (Fig. 5A–C) bursal effusion was diagnosed in 27 shoulders by MRI and in 23 shoulders by US, while effusion of the GH joint was recorded in 37 shoulders by MRI and in 31 shoulders by US, the agreement between both modalities for both finding was good (Table 3), the sensitivity, specificity, PVP and NPV of US in relation to MRI of each finding was calculated (Table 4).

4. Discussion

Shoulder pain is a frequent complication after stroke and may develop from a variety of factors (2). The exact cause of pain in the shoulder is often difficult to identify; thus, there has been an ongoing search for more accurate non-invasive methods of identification of the etiology of such pain (25).

In the past 10 years ultrasound and MRI have been introduced into the clinical practice of diagnosing shoulder problems, especially in soft tissue manifestations (24).

Although comparative study between US and MRI in diagnosing various shoulder diseases in other patients group than stroke survivors was done before Naredo (5), while Shah et al. (26) reported that his study constitutes the first MRI based description of the painful shoulder among chronic stroke survivors also Lee et al. (27,28) described two studies on US examination of post hemiplegic shoulders pain. This study was considered the first comparative study between US and MRI involve such critical group of poststroke survivor.

Several clinical diagnoses have been proposed as causes of hemiplegic shoulder pain syndrome, including rotator cuff tendonitis or tears, subacromial bursitis, bicipital tendonitis; diffuse shoulder pain or adhesive capsulitis, brachial
neuralgias, sympathetically mediated pain, and referred pain (29).

Shah et al. (26) reported in his MRI based study that post-stroke survivors demonstrated a higher incidence of tendon tears, tendinopathy, muscle atrophy, subacromial fluid collection, and acromioclavicular capsular hypertrophy.

Lee et al. (27,28) in his two studies using ultrasound reported a higher prevalence of rotator cuff tendinitis and joint

Fig. 1  Complete rotator cuff tear: (A) high frequency long-axis ultrasound of the shoulder reveals anechoic region within the rotator cuff tendon, which extends through the full thickness of the tendon which is typical of full thickness tear (B and C): Coronal MRI T1WI and fat suppression reveals complete tear of the rotator cuff tendon, the defect is replaced by fluid signal.

Fig. 2  Rotator cuff partial tear: (A) high frequency long-axis ultrasound scan of the shoulder reveals partial tear of the rotator cuff tendon in the form of hypoechoic triangular area within the peripheral portion of the tendon substance. (B) Findings on corresponding oblique-coronal T1WI reveals high signal intensity lesion in the rotator cuff substance.
effusion in the hemiplegic shoulder and in his recent study (28), he described a higher prevalence of subacromial–subdeltoid bursal effusion in stroke patients with shoulder pain. In our study in agreement with all previous series both US and MRI findings in examined patients were biceps tendon effusion and tendonitis, GH joint effusion, SA and SD bursal effusion, rotator cuff tendon pathology.

Gamble et al. (30) and Tavora et al. (31) stated that adhesive capsulitis was found significantly more frequently among the hemiplegic patients than in general population, however in Lee et al. study (28) no cases of adhesive capsulitis founded among study population. In our series no cases of adhesive capsulitis were found, this may be due to short time of the study, the mean time of adhesive capsulitis onset in hemiplegic patients is 3 months.

Rotator cuff pathology has been described by many authors as an etiology of poststroke shoulder pain (32). In the present series, rotator cuff tear represent 30%, this incidence is consistent with the 40%, 34% and 30% reported by Najensen et al. (33), Shah et al. (26) and Nepomuceno and

<table>
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<th>Findings</th>
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<th>GH effusion</th>
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<td>P/T</td>
<td>Atrophy</td>
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FT/T = full thickness tear, PT/T = partial thickness tear, SA = subacromial, SD = subdeltoid, GH = glenohumeral.

Fig. 3  Biceps tendon effusion: (A and B) axial and long-axis ultrasound of the shoulder reveals hypoechoic fluid surrounding the biceps tendon (asterisks). (C and D) Coronal T2WI and axial fat-suppression MRI reveals high fluid signal surrounding the biceps tendon.
Miller (34) respectively, but it was higher than 0% and 22% reported by Pong et al. (35), Rizk et al. (36) and Lo et al., (37) respectively, this difference may be attributed to small number of patients included in this lower incidence studies ((34,30,32) patients in (35–37), respectively).

Middleton et al. (38) and Dinnes et al. (39) stated that either MRI or sonography could be used for equal detection of full-thickness rotator cuff tears. Brenneke and Morgan (40) showed that ultrasonography was accurate as MRI for predicting the full-thickness tears but less so for moderate

Fig. 4  Biceps tendinitis: (A) long-axis high frequency ultrasound reveals fusiform swelling of the biceps tendon (asterisks) with hypoechoic texture surrounded by minimal clear fluid in its dependent part. (B) Coronal T1WI MRI reveals high signal intensity within the long head of biceps tendon substance.

Fig. 5  Subdeltoid bursa: (A) longitudinal high frequency ultrasound of deltoiud muscle reveals subdeltoid hypoechoic bursal fluid collection (asterisk). (B and C) Coronal oblique T2WI and axial T1WI of the shoulder reveal subdeltoid bursal fluid signal intensity.
and small tears, in our study US and MRI was similarly accurate in detection of complete rotator cuff tears, however for partial tear the US appears less accurate than MRI.

de Jesus et al. (41) reported that there is no statistically significant difference between the sensitivities and specificities of MRI versus ultrasound in diagnosing either full- or partial-thickness tears.

Sensitivity and specificity of US for the diagnosis of rotator cuff injuries in poststroke patients were reported to vary from 76% to 94%, and from 57% to 100%, for partial and complete tear, respectively (42–45), the lower level is reported in old study and this was attributed to investigator bias or poor-quality equipment (46). Recent studies represent a sensitivity of 100%, and a specificity of 85% for full thickness tear and about 93% sensitivity and 94% specificity for the partial-thickness tears, (47,48).

Also Naredo et al. (5) calculated the sensitivity, specificity, PPV and NPV of US in relation to MRI for the diagnosis of complete rotator cuff tears 88.9%, 100% PPV 100% and NPV 90%, and partial rotator cuff injuries was 92.3%, 91.3%, PPV 85.7% and NPV 94.5%, respectively. In our study we found that sensitivity, specificity, PPV and NPV for US in relation to MRI was 90.9, 98.6, 90.9, 98.6 and 80.0, 97.5, 90.9 and 94.1 for complete and partial rotator cuff tear, respectively.

In this study the prevalence of rotator cuff atrophy was found in 13% of the patients, this figure is lower than that described by Shah et al. (26) who present a prevalence ranging between 20% and 23%, but in agreement with Távora et al. (31), he presented a prevalence of 15%, and stated that rotator cuff atrophy were not related to severity of shoulder pain.

We found that MRI is more accurate than US in detection of atrophy this result is in agree with Strobel et al. (49), he stated that US is moderately accurate in the diagnosis of rotator cuff atrophy, although the MRI remains the standard of reference for assessment.

Pong et al. (35) found an incidence of 39% for bicipital effusion and 17.3 for tendenosis in his US study on poststroke patients. Middelton et al. (14) stated that Sonography provided information about the tendon and tendon sheath of the biceps with incidence of 19% of his patients and he added that US was more valuable than did arthrography for diagnosis of biceps tendon effusion or tendinitis.

In our study biceps tendon effusion present in 16% and tendinitis in 17% of patients, US was nearly as accurate as MRI in diagnosis of biceps tendon effusion and tendinitis with sensitivity and specificity reaching up to 82.4 and 98.9 for effusion and 88.9 and 98.9 for tendinitis and also with excellent agreement with Kappa coefficient.

Another clinical condition that has to be considered in patients with shoulder pain is subacromial bursa fluid which was seen in 26% of cases in the study of Shah et al. (26) and occurs mostly in stage of greater motor strength may be at increased risk for repetitive movement trauma leading to subacromial bursitis.

Also Lee et al. (28) stated that effusion within the SA–SD bursa was the most common abnormality depicted on ultrasonography and he presented a higher incidence of 39%.

In our study 25% of the patients had subacromial and subdeltoid bursal effusion in MRI and 21% in US. The differences between the studies may be due to the differences in patient selection, studies that reported low prevalence rates with the largest sample sizes included all stroke survivors regardless of pain, whereas the present study included only those with pain.

In agreement with Kayser et al., (50) study, subacromial bursitis represent sensitivity of 79%; and specificity of 98% and in our study the sensitivity and specificity were 81% and 98%, respectively.

Our study was prospective but there was some limitations as that the other unaffected shoulder was not examined, there was no matched control comparison of poststroke survivors without shoulder pain as well as no surgical data available as referral gold standard.

On the basis of our results we found that US and MRI examination of the shoulders of stroke survivors patients were nearly consistent and complementary at the same time, and also MRI was more accurate than US. However the shows between both technique depend on the availability and the skills of the operator, adding that there are some advantage for US have to be taken in consideration as that it is less costly, and less time-consuming, suitable as screening test for obese patients, patients have contraindication to MRI examination, allergy to contrast medium, or claus-trophobic, furthermore it can be done at bed side in critical patients.

5. Conclusion

Although MRI remains the imaging reference standard for a wide range of musculoskeletal disorders, musculoskeletal ultrasonography is an important complementary, and in some cases it can replace the MRI.

References


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