

# Musculoskeletal ultrasonographic findings of the affected and unaffected shoulders in hemiplegic patients

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## Background

There are many sonographic changes in affected and unaffected shoulders in patients with established hemiplegia.

## Aim

The aim of this study was to evaluate the sonographic findings of hemiplegic shoulder in patients after acute stroke and the detection of the correlation between the physical or sonographic findings and early-onset hemiplegic shoulder pain.

## Patients and methods

Shoulders of 30 patients with cerebrovascular stroke (six male and 24 female patients), 18 with right-sided and 12 with left-sided established hemiplegia, were tested. Wasting and weakness of the deltoid were recorded in the involved side. Musculoskeletal ultrasonography examination of both affected and unaffected shoulders of all patients was carried out. Two physicians classified the severity of the injury on a six-point rating scale, and Brunnström motor recovery stages and Brief Pain Inventory score were assessed.

## Results

Biceps tendon calcification, tendinosis, and tear (73.3, 76.6, and 13.3%, respectively), deltoid calcification and tendinosis (33.3 and 33.3%, respectively), supraspinatus calcification and tear (53.3 and 26.7%, respectively), and the subacromial–subdeltoid bursitis (43.75%) were the most frequent abnormalities in the affected painful shoulder. No significant relationship ( $P = 0.1$ ) was found between the US grades of the painful hemiplegic shoulder and the Brunnström motor recovery stages. Ultrasonographic grades of the unaffected shoulder correlated with the stroke duration ( $P = 0.001$ ). The ultrasonographic rating scores of hemiplegic shoulders correlated with age, duration of stroke, shoulder pain duration, limitation of shoulder movement, the Brief Pain Inventory score and degree of spasticity ( $P = 0.04, 0.03, 0.001, 0.03, 0.046,$  and  $0.001$ , respectively).

## Conclusion

Hemiplegic stroke results in injury to the affected shoulder and the shoulder on the unaffected side. Musculoskeletal ultrasonography is an essential method in the evaluation of poststroke painful hemiplegic shoulder. However, the US grades did not correlate with the stages of motor recovery.

## Keywords:

Ashworth scale, Brunnström motor recovery, hemiplegic shoulder pain, Medical Research Council scoring system, spasticity

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## Introduction

Radiological methods are the most appropriate tools in the evaluation of shoulder pain, particularly when examining bony structures and when joint subluxation is suspected. Computed tomography scans depict detailed images of bone and, when combined with arthrography, show intra-articular pathology [1]. Rotator cuff tears are commonly diagnosed by means of shoulder arthroscopy. Sonography and MRI were found to be noninvasive methods used to diagnose rotator cuff pathology [2]. MRI is superior to other diagnostic methods in diagnosing soft tissue lesions, as well as bone marrow lesions [1,3]. However, MRI is relatively expensive, time-consuming, and inappropriate for the examination of both shoulders at

once, which is particularly important when evaluating hemiplegic stroke patients due to their limited range of motion (ROM) and their need for comfortable positioning in the scanner [2].

Ultrasonography is a useful diagnostic tool for the assessment of rotator cuff and nonrotator cuff disorders of the shoulder [4,5]. Ultrasonography is a noninvasive and inexpensive imaging modality that does not expose patients to radiation, and this

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method allows for the evaluation of structural status of the tissue, as well as the examination of dynamic movement of the affected area. Thus, ultrasonography is an imaging tool that allows for both anatomical and functional assessments of hemiplegic patients [2,6].

Painful shoulder is a common complication following hemiplegic stroke. This pain may interfere with functional improvement, the patient's quality of life, and it may impede the process of rehabilitation [7]. The clinical management of hemiplegic shoulder pain (HSP) usually involves the administration of oral analgesics, intra-articular injections, and therapeutic exercises [2,8]. Further understanding of rotator cuff tendon impairment in stroke patients may help clinicians in assigning more complete therapeutic plans to hemiplegic patients [2]. Following a stroke, immobility and weakness often force patients to compensate for the affected body parts by using the unaffected parts in their daily activities [9].

Stroke resulting in hemiplegia would result in damage to not only the tendons in the affected shoulders but also to those on the unaffected sides, due to compensatory overuse. Shoulder pain in the unaffected shoulder side most commonly is not a complaint from patients because of the greater impact of the hemiplegically affected shoulder problems. In addition, these patients may not be able to describe their pain because of aphasia or other forms of cognitive dysfunction, which commonly follow stroke [10].

In this study, we performed ultrasonography to observe structural and functional changes in the tendons of both the affected and unaffected shoulders of hemiplegic stroke patients.

The purposes of this study were to examine sonographic imaging ratings of both affected and unaffected shoulders, as well as to explore the relationships between sonographic imaging data and a number of clinical variables in hemiplegic stroke patients.

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## Patients and methods

The nature of the study was explained to the patients and their relatives and an oral consent was taken from the patients or their relatives. Shoulders of 30 patients with cerebrovascular stroke [six male (20%) and 24 female patients (80%)], 18 with right-sided (60%) and 12 with left-sided (40%) established hemiplegia, were tested.

The inclusion criteria were as follows: first stroke resulting in unilateral hemiplegia and no history of

shoulder pain in the 6 months before the stroke. The exclusion criteria were as follows: a history of rotator cuff injuries; frozen shoulder; shoulder surgery; cognitive impairment that impeded communication; and neuromuscular disorders resulting in a weakened shoulder.

Handedness, duration of injury, ROM of the shoulder joints, level of spasticity in the hemiplegic upper extremities, history of use of antispastic agents, level of functional activity of the shoulders, and the nature of the stroke experienced were evaluated. The level of spasticity in the affected upper extremities was measured using the modified Ashworth scale. Muscle power of the shoulder girdle was examined in each direction when performing the motions of flexion, extension, adduction, and abduction using the Medical Research Council scoring system. These muscle power scores were then summed to give a composite muscle power score: grade 5, muscle contracts normally against full resistance; grade 4, muscle strength is reduced but muscle contraction can still move joint against resistance; grade 3, muscle strength is further reduced such that the joint can be moved only against gravity with the examiner's resistance completely removed; grade 2, muscle can move only if the resistance of gravity is removed; grade 1, only a trace or flicker of movement is seen or felt in the muscle, or fasciculations are observed in the muscle; and grade 0, no movement is observed [10].

Levels of functional activity of the patient were classified as follows: grade 0, bedridden state; grade 1, has the ability to roll to one's side; grade 2, sits independently; grade 3, stands independently; grade 4, walks with assistance; and grade 5, walks without assistance [10].

The Brunnström motor recovery (BMR) stages, glenohumeral subluxation, passive ROM of the hemiplegic shoulder, and shoulder pain were also evaluated for all patients.

The BMR stages in the upper extremity are as follows: stage I, flaccid limbs without any voluntary movement; stage II, spasticity with weak flexor synergy; stage III, voluntary movement of the limbs, but the action is still within a flexor synergy pattern; stage IV, selective activation of muscles outside the flexor synergy; stage V, decrease in muscle spasticity and selective muscle activation, which is mostly selective and independent of limb flexor synergy; and stage VI, well-coordinated movements [11].

The five-point Ashworth scale: 0 = no increase in muscle tone; 1 = slight increase in muscle tone, manifested by a

catch at the end ROM; 2 = marked increase in muscle tone through most ROM such that the affected limb is easily movable; 3 = considerable increase in muscle tone but difficult passive movement of the affected limb; and 4 = rigid affected limb. Spasticity was identified if the Ashworth scale was greater than or equal to a score of 1 [12].

The nature of the study was explained to all patients included in the study and their caregivers.

### Ultrasonography and imaging analysis

Each ultrasonographic examination was performed by two operators with 3 years of experience in musculoskeletal sonography who were unaware of the clinical details of the patients when interpretations were performed. Sonography was performed using a 12–18 MHz high-resolution electronic linear-array transducer, P300 Siemens (Erlagen, Germany). The ultrasonographic evaluation included the subacromial–subdeltoid (SA–SD) bursa and the rotator cuffs, which are routinely imaged in both short-axis and long-axis planes.

All patients underwent shoulder sonography in a seated position in a wheelchair. Both shoulders were examined in all patients using the scanning techniques described in other studies following the Eular guidelines [2,13,14].

The investigated tendons of the shoulder were scanned in both longitudinal and transverse planes according to the techniques described by Mack *et al.* [15] and Middleton [16]. The accessed soft tissues for hemiplegic shoulder included the long head of the biceps brachii tendon, subscapularis tendon, supraspinatus tendon, infraspinatus tendon, and the SA–SD bursa complex. Effusion in the biceps tendon sheath appears as anechoic area with grey scale US, partially or completely surrounding the long head of the biceps tendon in the transverse or longitudinal plane [16]. Bicipital tenosynovitis was interpreted by the thickened hypoechoic or anechoic change around the biceps tendon using increasing power Doppler flow on the sonography. Biceps tendinitis was defined as thickening of and a decreased echogenicity in the tendon [16]. We diagnosed a full-thickness tear of the tendon if the following sonographic findings were found: absence of the rotator cuff, naked tuberosity, focal nonvisualization of the cuff, discontinuity or a hypoechoic cleft in the cuff, herniation of the deltoid muscle or SA–SD bursa in the cuff, or compression of the tendon [17]. Two sonographic criteria for a partial-thickness tear of the tendon were mixed hypoechoic and hyperechoic changes in the critical

zone of the tendon, or a hypoechoic lesion within the tendon with either bursal or articular extension in both imaging planes [18]. Tendinitis of the rotator cuff was identified when a hypoechoic change and a thicker tendon (>2 mm) was observed compared with the contralateral side [17]. SA–SD bursitis was diagnosed when effusion accumulated in the bursa with more than 2 mm thickness and increased power Doppler imaging in the bursa were also found.

To define the relationships between ultrasonographic findings and the clinical variables assessed, ultrasonographic imaging data were reclassified into six grades on the basis of the presence of a rotator cuff tear and fluid collection in the SA–SD bursa or the wall of the shoulder. This rating system has received support from previously published studies [2,19,20]. On this rating scale, a grade of 0 represents no abnormal finding around the rotator cuff; a grade of 1 represents tendinosis of the intratendinous hypoechoic areas with a loss of fibrillar echoes, reflecting a disorganized structure of the collagen bundles of the supraspinatus tendon [7,20]; a grade of 2 represents a SA–SD bursa thickness of 1.5–2.0 mm; a grade of 3 reflects a SA–SD bursa thickness over 2 mm [15]; a grade of 4 indicates a partial or full-thickness tear of the supraspinatus tendon; and a grade of 5 suggests multiple ruptures of the tendons of the rotator cuff [2,10]. If there were more than two abnormal ultrasonographic ratings for any case, the case was classified on the basis of the most severe rating score (6 points score from 0–5) [2,10].

### Statistical analysis

Statistical analysis was performed with SPSS statistical software, version 16 (SPSS Inc., Chicago, Illinois, USA). The range, mean, and SD were calculated for interval and ordinary variables. Correlation between the study variables was determined with Pearson's correlation for parametric variables. The level of statistical significance was set at *P* value level less than 0.05.

## Results

Characteristics of the patients included in the study are represented in Table 1.

Figure 1 represents the grades of musculoskeletal ultrasonography (MSUS) scaling score of the affected shoulders.

Shoulder joint subluxation was found in all patients. The following MSUS findings were seen in the paralyzed shoulder of 26 patients (86.6%): shoulder joint effusion in eight patients (26.7%), biceps tendon calcification in 22 patients (73.3%), bicipital

tendinosis in 23 patients (76.6%), bicipital tear in four patients (13.3%), biceps thickness of 5–10.4 ( $7.3 \pm 1.9$ ), deltoid calcification in 10 patients (33.3%), deltoid tendinosis in 10 patients (33.3%), partial deltoid tear in 10 patients (33.3%), complete deltoid tear in two patients (6.7%), supraspinatus calcification in 16 patients (53.3%), supraspinatus tear

in eight patients (26.7%), supraspinatus thickness of 6–16.4 ( $9.4 \pm 2.9$ ), and SA–SD bursitis in 13 patients (43.75%) (Table 2 and Fig. 2).

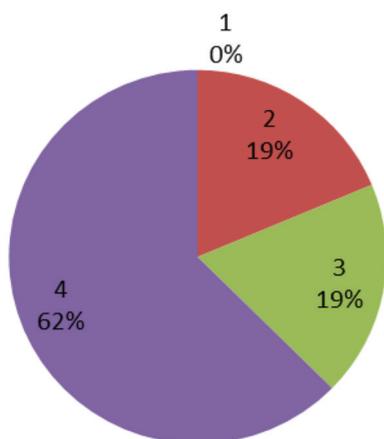
**Table 1 Patient characteristics**

Items	Patients ( <i>n</i> = 30)
<b>Age</b>	
Range	26–62
Mean $\pm$ SD	51.5 $\pm$ 11.2
<b>Disease duration</b>	
Range	0.5–18
Mean $\pm$ SD	2.9 $\pm$ 4.5
<b>Sex [<i>n</i> (%)]</b>	
Male	6 (20)
Female	28 (80)
<b>Hemiplegic side [<i>n</i> (%)]</b>	
Right	18 (60)
Left	12 (40)
<b>Painful shoulders [<i>n</i> (%)]</b>	
Present	26 (87.6)
<b>Limitation of movement [<i>n</i> (%)]</b>	
Limitedly active	12 (40)
Frozen	18 (60)
<b>Shoulder injection [<i>n</i> (%)]</b>	
Present	10 (33.3)
<b>Grade of upper extremity spasticity (affected shoulder)</b>	
Range (median)	0–3 (1)
<b>Composite muscle power scores of affected shoulder</b>	
Range (median)	0–14 (7)
<b>BMR [<i>n</i> (%)]</b>	
Low (stage I, II, III)	16 (53.3)
High (stage IV, V, VI)	14 (46.7)
<b>Spasticity</b>	
Range (median)	1–4 (3)

The following MSUS findings were seen in the contralateral shoulder of 12 patients (86.6%): shoulder joint effusion in one patient (3.3%), biceps tendon calcification in two patients (6.7%), bicipital tendinosis in 10 patients (33.3%), bicipital tear in one patient (3.3%), deltoid calcification in three patients (10%), deltoid tendinosis in one patient (3.3%), deltoid tear in two patients (6.7%), supraspinatus calcification in three patients (3.3%), supraspinatus tear in eight patients (26.7%), and the SA–SD bursitis in nine patients (30%).

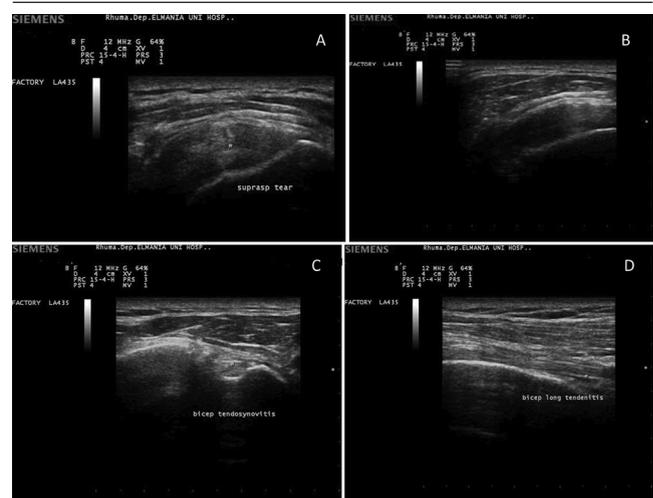
No significant correlation ( $r = 0.07$ ,  $P = 0.114$ ) was found between the US grades of the painful hemiplegic shoulder and the BMR stages. Ultrasonographic grades of the unaffected shoulder significantly correlated with the stroke duration in months ( $r = 0.46$ ,  $P = 0.001$ ). The ultrasonographic rating scores of hemiplegic shoulders were correlated with age ( $r = 0.33$ ,  $P = 0.04$ ), duration of stroke ( $r = 0.39$ ,  $P = 0.03$ ), shoulder pain duration ( $r = 0.44$ ,  $P = 0.001$ ), limitation of shoulder movement ( $r = 0.36$ ,  $P = 0.03$ ), the Brief Pain Inventory score ( $r = 0.30$ ,  $P = 0.046$ ), and degree of spasticity ( $r = -0.47$ ,  $P = 0.001$ ) (Table 3). However, ultrasonographic ratings of both affected and unaffected shoulders were not related to the level of functioning or to the composite muscle power score for the shoulder girdle.

**Figure 1**



Grades of musculoskeletal ultrasonography (MSUS) scaling score.

**Figure 2**



(a) B mode of the supraspinatus tendon in the longitudinal axis showing supraspinatus tear, (b) B mode of the supraspinatus tendon in longitudinal scan showing thickened supraspinatus with hyperechoic areas and subacromial–subdeltoid (SA–SD) bursitis, (c) B mode of biceps tendon in transverse scan showing bicipital tenosynovitis, (d) B mode of the biceps tendon in longitudinal scan showing tendinitis.

**Table 2 Ultrasonographic findings in the studied patients in the affected shoulder**

Item	n (%)	Mean±SD
Shoulder joint effusion	8 (26.7)	
Biceps tendon calcification	22 (73.3)	
Bicipital tendinosis	23 (76.6)	
Bicipital tear	4 (13.3)	
Deltoid calcification	10 (33.3)	
Deltoid tendinosis	10 (33.3)	
Deltoid tear		
Partial	10 (33.3)	
Complete	2 (6.7)	
Supraspinatus calcification	16 (53.3)	
Supraspinatus tear	8 (26.7)	
SA–SD bursitis	13 (43.75)	
	Range	Mean ± SD
Biceps thickness	5–10.4	7.3 ± 1.9
Supraspinatus thickness	6–16.4	9.4 ± 2.9

SA–SD, subacromial–subdeltoid.

**Table 3 Correlation between ultrasound rating scales and clinical parameters**

Item	URS
Age	
<i>r</i>	0.33
<i>P</i>	0.04
Duration of stroke	
<i>r</i>	0.39
<i>P</i>	0.03
Shoulder pain duration	
<i>r</i>	0.44
<i>P</i>	0.001
Limitation of the shoulder	
<i>r</i>	0.36
<i>P</i>	0.03
Brief Pain Inventory score	
<i>r</i>	0.30
<i>P</i>	0.046
Degree of spasticity	
<i>r</i>	-0.47
<i>P</i>	0.001

URS, ultrasound rating scale; *P* < 0.05, significant.

## Discussion

The prevalence of HSP following stroke ranges from 20 to 84% of patients. Shoulder pain hinders motor recovery of the affected upper limb and recovery of function for the performance of daily activities in the upper extremities [3,7,21,22]. Shoulder pain following stroke has many causes, such as rotator cuff disease, adhesive capsulitis of the shoulder joint, shoulder joint subluxation, spasticity in the upper extremities, changes in pain sensitivity, complex regional pain syndrome, and centralized poststroke pain. After hemiplegic stroke, abnormal neuromuscular features induce compensatory adaptations, which may influence the structures and functions of the unaffected and affected extremities in hemiplegics [10].

In this study, shoulders of 30 patients with cerebrovascular stroke [six male (20%) and 24 female patients (80%)], 18 with right-sided (60%) and 12 with left-sided (40%) established hemiplegia, were tested clinically and using MSUS.

As regards the ultrasonographic findings in the current study, our results are in agreement with the results of Huang *et al.* [23], who showed that the stroke patients had significantly restricted shoulder rotation, increased spasticity, shoulder subluxation, increased HSP, higher visual analogue scale score, and increased abnormal sonographic findings (85%) of hemiplegic shoulders after an acute stroke. They showed that the shoulder sonography noted showed a higher frequency of structural abnormalities of the long head of the biceps tendon (24/57; 42%), supraspinatus tendon (20/57; 35%), and SA–SD bursa (20/57; 35%).

Aras *et al.* [24] reported in their study that the abnormalities of shoulder sonography were found on the long head of the biceps tendon (64.8%) and supraspinatus tendon (64.8%). Lee *et al.* [25] reported in a study conducted on 84 patients (median age, 61 years) that abnormal sonographic findings were observed in 62.2% of hemiplegic shoulders and 20.7% of nonhemiplegic shoulders. The main abnormalities in hemiplegic shoulders were effusion (39%) of the biceps tendon and tendinopathy (17.3%) of the supraspinatus and the biceps tendons, which were significantly more than that in nonhemiplegic shoulders. Those two studies found similar results and both revealed a high prevalence of effusion or tendinopathy in biceps and supraspinatus tendons of hemiplegic shoulders.

In our study we found that there was no significant correlation between the US grades of the painful hemiplegic shoulder and the BMR stages.

However, Aras *et al.* [24] found a higher prevalence of HSP in 48 of 64 patients (75%) at a low BMR stage compared with that in six of 19 patients (31.6%) at a high BMR stage. This may be due to the small number of patients in our study; in addition, we found no significant difference as regards the prevalence of shoulder pain in patients, with 14 of 16 patients (87.5%) having low BMR stage, compared with 12 of 14 patients (85.7%) patients having high BMR stage.

In our study, the ultrasonographic rating scores of hemiplegic shoulders were correlated with age, duration of stroke, shoulder pain duration, limitation of shoulder movement, the Brief Pain Inventory score, and degree of spasticity. However, ultrasonographic ratings of both affected and unaffected shoulders were not correlated to the level of functioning, or to the composite muscle power score for the shoulder girdle.

This is in agreement with the findings of Cho *et al.* [10], who found that ultrasonographic rating scores of affected shoulders were positively correlated with patient age and negatively correlated with the level of spasticity in the hemiplegic upper extremities, whereas the unaffected shoulder was not statistically significantly correlated with age. Van Ouwenaller *et al.* [26] also reported an association between HSP and spasticity.

From these findings, it can be suggested that elderly individuals' rotator cuff tendons may be more prone to injury than those of younger individuals, due to progressive degeneration in aged tendons occurring before stroke. Patients are more prone to postmorbid rotator cuff injuries with increasing age due to greater magnitudes of weaknesses caused by stroke, and enhanced muscle tone in the upper extremities following stroke may have a protective role against injury of the rotator cuff tendons.

However, Roy *et al.* [27] and Cheng *et al.* [28] did not find a relationship between HSP and shoulder spasticity in recent-stroke patients.

The different results among these studies may be attributed to the different methods of assessment for spasticity and the difference in durations from stroke onset.

In our study, the ultrasonographic grades of the unaffected shoulder were significantly correlated with the stroke duration.

This is in agreement with the findings of Cho *et al.* [10], who found that ultrasonographic rating scale scores for unaffected shoulders were positively correlated with the duration of injury.

These findings may be attributed to the fact that hemiplegics have a tendency to use their unaffected shoulders before achieving adequate motor recovery in their affected sides, which results in prolonged overuse of the unaffected shoulder. Moreover, immediately following stroke, the affected side tends to be hypotonic and in a lowered or 'slouched' state compared with the relatively hypertonic and elevated state of the unaffected side. The slouching of the affected side leads to an imbalanced hemiplegic body posture, which can induce rotator cuff tendon injury.

## Conclusion

Hemiplegic stroke results in injury to not only the affected shoulder but also to the shoulder on the unaffected side. Ultrasonography is an essential method

in the evaluation of poststroke painful hemiplegic shoulder. However, the US grades were not correlated with the stages of motor recovery. Avoiding overuse of the unaffected shoulder will be helpful in the prevention of shoulder injuries following hemiplegic stroke.

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## Conflicts of interest

There are no conflicts of interest.

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