Original Article

JHSMR Journal of Health Science and Medical Research

Prevalence and Factors Associated with Abnormal Ultrasonographic Findings of Hemiplegic and Non-Hemiplegic Shoulders in Patients after Stroke

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Received 5 June 2024 ● Revised 5 August 2024 ● Accepted 6 August 2024 ● Published online 11 February 2025

Abstract:

Objective: This study aimed to explore ultrasound (US) imaging in hemiplegic and non-hemiplegic shoulders in patients after stroke and to study factors associated with hemiplegic shoulder pain (HSP) and abnormal US findings on the hemiplegic side.

Material and Methods: A cross-sectional study was conducted to explore shoulder US imaging in hemiplegic and non-hemiplegic shoulders in a total of 60 patients after stroke and to study factors associated with HSP and abnormal US findings in the hemiplegic side of stroke patients who attended an outpatient rehabilitation clinic.

Results: Sixty patients after stroke were enrolled in the study (40 men and 20 women). Their mean age was 58.7 years. The prevalence of shoulder pain was 63.3% (38/60). Among those with shoulder pain, 81.6% (31/38) reported pain on the hemiplegic side. Fifty-five patients (91.7%) had shoulder US abnormalities on the hemiplegic side whereas 45 patients (75.0%) had shoulder US abnormalities on the non-hemiplegic side. The three most common shoulder US abnormalities on the hemiplegic side were biceps peritendon effusion (66.7%), supraspinatus tendinosis (45.0 %), and positive dynamic supraspinatus impingement (26.7%). The three most common shoulder US abnormalities on the non-hemiplegic were supraspinatus tendinosis (36.7%), biceps peritendon effusion (33.3%), and subdeltoid-subacromial bursitis (18.3%).

Conclusion: Shoulder pain and US abnormalities were prevalent in patients with hemiplegic stroke. Biceps peritendon effusion was the most common abnormality in shoulder US imaging on the hemiplegic side.

Keywords: hemiplegic shoulder pain, prevalence, risk factors, stroke, ultrasonography

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J Health Sci Med Res 2025;43(4):e20251151
doi: 10.31584/jhsmr.20251151
www.jhsmr.org

Introduction

Stroke refers to syndromes that affect the blood vessels in the brain that cause of temporary or permanent brain damage. These lead to neurological deficits, which are a leading cause of death and disability worldwide[1]. Weakness of the upper limbs induces shoulder problems such as shoulder subluxation, shoulder pain, shoulder stiffness, and shoulder hand syndrome[2]. Shoulder pain is one of the most common musculoskeletal complications after stroke[3]. Previous studies reported the prevalence of hemiplegic shoulder pain (HSP) in the range of 24% to 85%[4-9]. The pathogenesis of HSP is not well established[7], but multifactorial causes such as impairments in motor control, changes in peripheral and central nervous system activity, such as central pain sensitization, together with soft tissue injuries may play a role either separately or simultaneously[10]. Although conflicting results between studies exist, factors which were commonly found to be associated with HSP are diabetes, shoulder stiffness, poor Brunnstrom motor recovery stage, age, spasticity, sensory disturbance, shoulder subluxation, and left-sided hemiparesis[5,7,9,11-14].

To diagnose shoulder pain, history, physical examination, and various provocative tests are used. Dromerick et al. found that only 37% of patients with hemiplegic reported shoulder pain while physical symptoms such as biceps peritendon tenderness, supraspinatus tenderness, and positive Neer sign were found in up to 54% of patients[6]. Adey-Wakeling et al. found that the number of self-reported cases of HSP was lower than the detection of abnormal shoulder range of motion by examination[4].

Common shoulder investigation methods are plain film, Computerized Tomography (CT) scan, Magnetic Resonance Imaging (MRI), and ultrasound (US). US is a noninvasive medical approach which is less expensive and less time consuming than MRI or arthroscopy[15,16]. US can detect soft tissue lesions such as tendinopathy, synovitis, tenosynovitis, effusion, and bursitis, and it has the advantage of allowing dynamic examination of the shoulder. US is recommended as the primary diagnostic method in the screening of shoulder pain because it has good diagnostic accuracy and it is almost equally as effective as MRI in detecting soft tissue lesions such as partial tears of the rotator cuff tendon[16,17]. Ultrasonographic techniques have the potential to provide objective measurements of common shoulder pathologies after stroke[18-19]. The prevalence of abnormal shoulder US imaging in patients after stroke was previously reported to be 67-81%[14,15]. Common US findings of HSP are biceps peritendon effusion, subacromial-subdeltoid bursitis, and rotator cuff tendinopathy[14,15,18,19].

As far as we know, there were no previously published studies that investigated the US of both hemiplegic and non-hemiplegic shoulders combined with physical examinations and provocative tests in patients after stroke. We hypothesized that the prevalence of hemiplegic shoulder pain is higher than that of non-hemiplegic shoulder pain and that the most common shoulder US abnormalities differ between hemiplegic and non-hemiplegic shoulders due to varying pathologies. The aims of this study were to explore US imaging in hemiplegic and non-hemiplegic shoulders in patients after stroke and to study factors associated with HSP and abnormal US findings on the hemiplegic side.

Material and Methods

Study design and setting

This cross-sectional study was conducted in the outpatient rehabilitation clinic of Srinagarind Hospital from September 2020 to August 2022.

Participants

Inclusion criteria were: age of at least 18 years, a history of either ischemic or hemorrhagic stroke of duration greater than three months, the ability to cooperate, and the ability to sit for more than 30 minutes. Exclusion criteria were a history of bilateral hemiparesis, history of shoulder pain or injury to either shoulder prior to the clinical onset of stroke, and a history of prior shoulder surgery on either side.

Ethics approval

This study was approved by the Khon Kaen University Ethics Committee for Human Research (Ref. HE631471). Each participant provided written, informed consent prior to participation.

Procedures

All patients underwent clinical assessment and US examination of both shoulders. Stroke-associated data, including duration, type, side of weakness, level of dependence in activities of daily living, spasticity, and numbness of upper extremities, were evaluated. In case of shoulder pain, the pain site, duration, and severity were evaluated. Bilateral shoulder physical examinations were done to explore the point of maximal tenderness, passive range of motion, and muscle strength. The Brunnstrom stages of motor recovery, pinprick sensation, spasticity and shoulder subluxation were evaluated on the hemiplegic side. The provocative tests of both shoulders consisted of the Empty Can Test, Yergason's Test, resisted internal rotation, resisted external rotation, Neer Impingement Sign, and O'Brien's Active Compression Test for the acromioclavicular joint[20,21].

US of both shoulders was performed by a specialist in rehabilitation medicine with more than ten years of experience in the musculoskeletal US. The US specialist was blind to the patient's baseline characteristics and physical examination data. Shoulder US was examined in a standard procedure with a portable ultrasound system (GE Logiq-e, GE Healthcare, Wisconsin, USA), using a 9-14 Hz linear transducer[22]. The definitions of ultrasonographic pathology were established based on international guidelines of The Outcomes Measures in Rheumatology (OMERACT 7) and The European Society of Musculoskeletal Radiology (ESSR)[23,24].

Sample size estimation

We estimated the sample size using the standard formula for prevalence studies, $n=\frac{Z^2 P(1-P)}{d^2}$, where P is the expected prevalence of 0.8125 based on a previous study[25], Z is the test statistic corresponding to a 95% confidence interval and d is the required precision of 0.1. This gave a sample size estimate of n=60 participants.

Outcome measures

The primary outcome was the proportion of abnormal US findings in both the hemiplegic and non-hemiplegic sides. Ultrasound abnormalities and characteristics found in the biceps tendon, supraspinatus tendon, subdeltoid-subacromial bursa, subscapularis tendon, infraspinatus tendon, acromioclavicular joint, and glenohumeral joint were documented. The secondary outcome was the proportion of patients with hemiplegic shoulder pain (HSP), where HSP was defined as the patient reporting pain confined to the shoulder and/or C5 dermatome of the contralesional side with onset after stroke and present during rest, or during active or passive motion[25]. We also determined whether several factors age, sex, diabetes, side and type of stroke, stroke duration, activities in daily living (ADL) dependency, Brunnstrom stage, shoulder subluxation, spasticity, limited shoulder abduction, impaired pinprick sensation, presence of at least one positive shoulder provocation test and supraspinatus or biceps tendon pathology by US were associated with HSP or abnormal US findings in the hemiplegic shoulder.

Statistical analysis

Continuous data were presented as mean and standard deviation (S.D.) when the data were normally distributed. Median and interquartile range (IQR) were presented when the data were not normally distributed. McNemar's test was used to compare the proportion of US abnormalities between the hemiplegic and non-hemiplegic sides. A chi-squared or Fisher's exact test was performed to determine the association between the factors defined above and HSP and between these factors and shoulder US abnormalities. Any significant factors (p-value≤0.25) from univariate analysis were included in the multiple logistic regression model[26-27]. The predictive model was constructed using backward elimination[28]. Statistical analysis was done using Stata (Stata Statistical Software: Release 10, TX: StataCorp LLC.)

Results

Of the 60 patients enrolled in this study, 40 (66.7%) were male. The age of the patients was 58.7 years±10.3 years (mean±S.D.). The duration of stroke was 25.7 months±29.7 months. Ischemic stroke was the most common type (63.3%), and most patients had a left-sided weakness (63.3%). More than half of the patients had hemiplegic shoulder subluxation (57%) (Table 1).

Most patients (63.3%, 38/60) had shoulder pain. Among those with shoulder pain, 81.6% (31/38) reported pain on the hemiplegic side, 2.6% (1/38) on the non-hemiplegic side, and 15.8% (6/38) on both sides. The median duration of hemiplegic shoulder pain was 12 weeks and non-hemiplegic shoulder pain 10 weeks. The most common point of pain was the anterior shoulder (18.3%) and the point of maximal tenderness was also the anterior area (13%). The three most common abnormal shoulder provocative tests on the hemiplegic side were Neer impingement sign (35.0%), empty can test (11.7%), and pain on resisted internal rotation and external rotation (6.7% each) (Table 2).

The most common US abnormalities in the hemiplegic shoulder were biceps peritendon effusion (66.7%, Figure 1), supraspinatus tendinosis (45.0%), and positive dynamic supraspinatus impingement (26.7%). Participants who had full rupture of the supraspinatus tendon or severe shoulder subluxation could not be tested for dynamic supraspinatus impingement. The most common US abnormalities in the non-hemiplegic shoulder were supraspinatus tendinosis (36.7%, Figure 2), biceps peritendon effusion (33.3%),

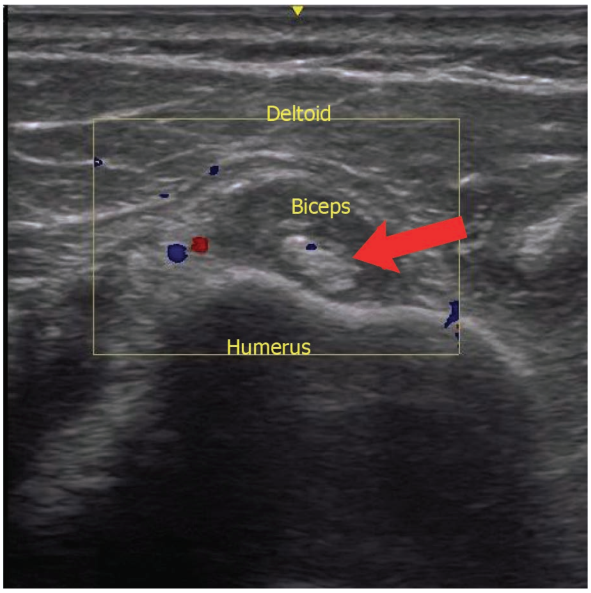

Figure 1 Illustration of biceps peritendon effusion with probe positioned in the short axis

and subdeltoid-subacromial bursitis (18.3%). Compared to the non-hemiplegic shoulder, the hemiplegic shoulder had significantly more cases of biceps peritendon effusion (p-value<0.001) (Table 3).

Thirty-five of 37 patients (94.6%) with hemiplegic shoulder pain had US abnormality in at least one of the structures examined. In addition, 87.0% (20/23) of patients with no HSP had US abnormalities. Five of seven (71.4%) patients after stroke with non-hemiplegic shoulder pain had US abnormality. Furthermore, US abnormalities were found in 40/53 (75.5%) of patients with asymptomatic non-hemiplegic shoulder pain.

Table 1 Baseline characteristics of the participants (n=60)

Variables	n (%), or mean±S.D.
Gender, Men	40 (66.7)
Age (years)	58.7±10.3
BMI (kg/m^2)	23.9±3.0
Underlying disease	
Diabetes mellitus	15 (25.0)
Hypertension	35 (58.3)
Dyslipidemia	17 (28.3)
Type of stroke	
Ischemic	38 (63.3)
Hemorrhagic	22 (36.7)
Duration of stroke (months) median (p25-p75)	14 (5-36)
Hemiplegic side	
Right	22 (36.7)
Left	38 (63.3)
Spasticity of upper extremity	43 (71.7)
Numbness of upper extremity	23 (38.3)
Activities of daily living	
Independent	30 (50.0)
Partially dependent	29 (48.3)
Totally dependent	1 (1.7)
Brunnstrom stage of motor recovery (hand)	3.0±1.4
Stage 1	8 (13.3)
Stage 2	17 (28.3)
Stage 3	19 (31.7)
Stage 4	3 (5.0)
Stage 5	10 (16.7)
Stage 6	3 (5.0)
Brunnstrom stage of motor recovery (arm)	3.1±1.4
Stage 1	5 (8.3)
Stage 2	18 (30.0)
Stage 3	18 (30.0)
Stage 4	6 (10.0)
Stage 5	10 (16.7)
Stage 6	3 (5.0)
Hemiplegic shoulder subluxation	34 (56.7)
Shoulder pain	38 (63.3)
hemiplegic side	31 (81.6)
non-hemiplegic side	1 (2.6)
both sides	6 (15.8)

BMI=body mass index, S.D.=standard deviation, n=number of participants

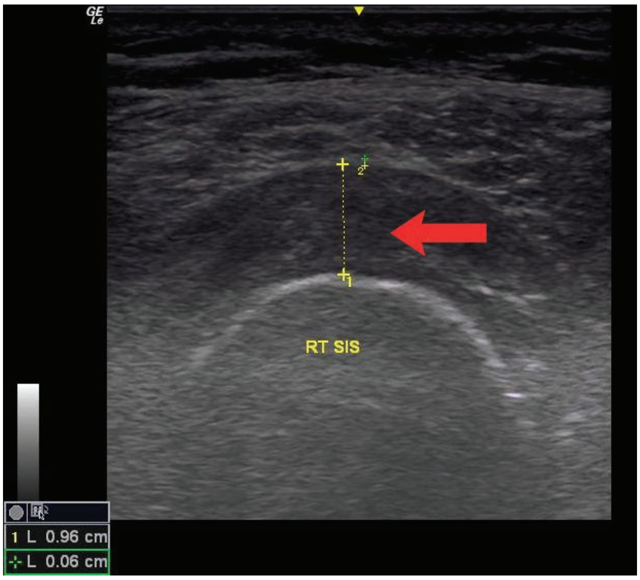

Figure 2 Illustration of supraspinatus tendinosis with probe positioned in the short axis

Table 2 Pain characteristics and clinical examination of the shoulders

Variables	Hemiplegic side	Non hemiplegic side
Duration of shoulder pain (weeks), median (IQR)	12 (4, 24)	10 (3.3, 17)
Severity of shoulder pain during ADL (NRS), mean±S.D.	2.7±3.2	0.4±1.5
Severity of shoulder pain during rest (NRS), mean±S.D.	1.3±2.3	0.1±0.5
Area of tenderness, n (%)		
Anterior	11 (18.3)	2 (3.3)
Posterior	5 (8.3)	1 (1.7)
Medial	1 (1.7)	0 (0.0)
Lateral	10 (16.7)	0 (0.0)
Point of maximal tenderness, n (%)		
Anterior	8 (13.3)	1 (1.7)
Posterior	5 (8.3)	0 (0.0)
Medial	0 (0.0)	1 (1.7)
Lateral	5 (8.3)	1 (1.7)
Passive range of motion (degrees), mean±S.D.		
Flexion	154.0±29.8	172.8±26.8
Extension	51.2±15.0	57.8±8.2
Abduction	145.1±38.9	178.7±7.9
Internal rotation	65.9±23.6	82.1±16.8
External rotation	73.8±23.6	85.2±17.2
Shoulder provocative tests, n (%)		
Empty can test	7 (11.7)	1 (1.7)
Yergason's test	1 (1.7)	0 (0.0)
Resisted internal rotation	4 (6.7)	1 (1.7)
Resisted external rotation	4 (6.7)	0 (0.0)
Neer Impingement Sign	21 (35.0)	2 (3.3)
O'Brien active compression test for acromioclavicular joint	1 (1.7)	2 (3.3)

IQR=interquartile range, ADL=activities in daily living, NRS=numeric rating scale, S.D.=standard deviation, n=number of participants

Table 3 Characteristics of ultrasonography results

Characteristics	Hemiplegic side, n (%)	Non hemiplegic side, n (%)	p-value
Biceps long head tendon			
Effusion	40 (66.7)	20 (33.3)	<0.001
Supraspinatus tendon abnormality	32 (53.3)	30 (50.0)	0.85
Tendinosis	27 (45.0)	22 (36.7)	
Partial rupture	1 (1.7)	1 (1.7)	
Full rupture	2 (3.3)	1 (1.7)	
Calcification	2 (3.3)	7 (11.7)	
Dynamic supraspinatus impingement			
Positive	16 (26.7)	8 (13.3)	0.12
Not testable	3 (5.0)	1 (1.7)	
Subdeltoid-subacromial bursa			
Bursitis	15 (25.0)	11 (18.3)	0.45
Subscapularis tendon abnormality*	3 (5.0)	5 (8.3)	0.73
Calcification	3 (5.0)	1 (1.7)	
Tendinosis	0 (0.0)	3 (5.0)	
Partial rupture	0 (0.0)	1 (1.7)	
Infraspinatus tendon abnormality*	3 (5.0)	5 (8.3)	0.73
Partial rupture	2 (3.3)	3 (5.0)	
Calcification	1 (1.7)	0 (0.0)	
Tendinosis	0 (0.0)	2 (3.3)	
Acromioclavicular joint abnormality*	2 (3.3)	0 (0.0)	0.25
Synovial hypertrophy	0 (0.0)	0 (0.0)	
Effusion	2 (3.3)	0 (0.0)	
Glenohumeral joint abnormality*			
Calcification	1 (1.7)	4 (6.7)	0.25

*Fisher's exact test, n=number of participants

Regarding factors associated with HSP, there were modest degrees of evidence that dependence or partial dependence in ADL, shoulder subluxation, and limited shoulder abduction of <90 degrees were associated with HSP (p-value=0.063, 0.10 and 0.055, respectively). Patients with HSP were more likely to have a stoke in less than 6 months (p-value=0.038), have at least one positive shoulder provocative test (p-value=0.028) and show supraspinatus tendon pathology by the US (p-value=0.034). Age, sex, type of stroke, poor Brunnstrom stage of arm motor recovery (less than 3), spasticity, and side of hemiparesis were not associated with HSP. Multivariable analysis showed that shoulder subluxation adjusted odds ratio (OR_{adj})=3.6 [95% CI: 1.1-12.0] and stroke duration <6 months (OR_{adj}=6.1 [95% CI: 1.3-27.3]) were predictive factors for HSP (Table 4).

HSP, age, limited shoulder abduction of <90 degrees, poor Brunnstrom stage of arm motor recovery (<3), spasticity, impaired sensation, or at least one positive shoulder provocative test were not significantly associated with abnormal US findings. Additionally, univariate analysis revealed that only dependence or partial dependence in activities of daily living (ADL) showed a p-value of less than 0.25. Consequently, we did not proceed with the multivariable logistic regression analysis (Table 5).

Table 4 Factors associated with hemiplegic shoulder pain and predictive factors for hemiplegic shoulder pain

Factors	HSP (n=37), n (%)	No HSP (n=23), n (%)	p-value	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age ≥60 years	17 (45.9)	14 (60.9)	0.26	0.5 (0.2–1.6)	0.26		
Women	13 (35.1)	7 (30.4)	0.71	1.2 (0.4–3.8)	0.71		
Diabetes mellitus	8 (21.6)	7 (30.4)	0.44	0.6 (0.2–2.1)	0.45		
Left-sided weakness	24 (64.9)	14 (60.9)	0.76	1.2 (0.4–3.4)	0.76		
Ischemic stroke	25 (67.6)	13 (56.5)	0.39	0.6 (0.2 –1.8)	0.39		
Stroke duration < 6 months	14 (37.8)	3 (13.0)	0.038	4.1 (1.0-16.2)	0.047	6.1 (1.3–27.3)	0.019
Dependent/Partially dependent in ADL	22 (59.5)	8 (34.8)	0.063	2.75 (0.9–8.1)	0.066		
Brunnstrom stage arm <3	27 (73.0)	14 (60.9)	0.33	0.6 (0.2–1.7)	0.33		
Motor power of deltoid MRC <3	23 (62.2)	11 (47.8)	0.28	1.8 (0.6–5.1)	0.28		
Shoulder subluxation	24 (64.9)	10 (43.5)	0.10	2.4 (0.8–7.0)	0.11	3.6 (1.1–12.0)	0.035
Spasticity*	27 (73.0)	19 (82.6)	0.53	1.8 (0.5–6.5)	0.39		
Limited shoulder abduction <90 degrees	11 (29.7)	2 (8.7)	0.055	4.4 (0.9–22.3)	0.070		
Impaired pinprick sensation	18 (48.6)	13 (56.5)	0.55	0.7 (0.3–2.1)	0.55		
At least 1 positive shoulder provocative test	28 (75.7)	11 (47.8)	0.028	3.3 (1.1–10.3)	0.031		
Supraspinatous tendon pathology by US	24 (64.9)	8 (34.8)	0.034	3.2 (1.1–9.7)	0.037		
Biceps tendon pathology by US	25 (67.6)	15 (65.2)	0.85	1.1 (0.4–3.3)	0.85		

*Fisher's exact test, HSP=hemiplegic shoulder pain, ADL=activities in daily living, US=Ultrasound, CI=confidence interval, MRC=Medical Research Council, OR=odds ratio, n=number of participant

Table 5 Factors associated with abnormal US findings in the hemiplegic shoulder

Factors	Abnormal US findings (n=55), n (%)	Normal US findings (n=5), n (%)	p-value	Crude OR (95% CI)	p-value
Age ≥60 years	28 (50.9)	3 (60.0)	1.00	0.7 (0.1– 4.5)	0.70
Women	18 (32.7)	2 (40.0)	1.00	0.7 (0.1–4.8)	0.74
Diabetes mellitus	13 (23.6)	2 (40.0)	0.59	0.5 (0.1–3.1)	0.43
Left-sided weakness	34 (61.8)	4 (80.0)	0.64	0.4 (0.0–3.9)	0.43
Ischemic stroke	36 (65.5)	2 (40.0)	0.35	0.4 (0.1–2.3)	0.28
Stroke duration <6 months*	38 (69.1)	5 (100.0)	0.31	5.0 (0.3–95.5)	0.29
Dependent/partially dependent in ADL	29 (52.7)	1 (20.0)	0.35	4.5 (0.5–42.5)	0.19
Shoulder pain	35 (63.6)	2 (40.0)	0.36	2.6 (0.4–17.1)	0.31
Brunnstrom stage arm <3	37 (67.3)	4 (80.0)	1.00	1.9 (0.2–18.7)	0.56
Motor power of deltoid MRC <3	31 (56.4)	3 (60.0)	1.00	0.9 (0.1–5.6)	0.88
Shoulder subluxation	30 (54.5)	4 (80.0)	0.38	0.3 (0.0–2.9)	0.30
Spasticity*	48 (87.3)	5 (100.0)	0.33	3.8 (0.2–73.9)	0.37
Limited shoulder abduction <90 degrees*	13 (23.6)	0 (0)	0.58	3.5 (0.2–67.4)	0.41
Impaired Pinprick sensation	28 (50.9)	3 (60.0)	1.00	0.7 (0.1–4.5)	0.70
At least 1 positive shoulder provocative test	36 (65.5)	3 (60.0)	1.00	1.3 (0.2–8.2)	0.81

All analysis was done with Fisher's exact test, *=analysis was done with chi square test and logistic regression analysis, DL=activities in daily living, US=Ultrasound, 95% CI=confidence interval, MRC=Medical Research Council

Discussion

Our study aimed to explore US imaging in hemiplegic and non-hemiplegic shoulders in patients after stroke and to study factors associated with hemiplegic shoulder pain (HSP) and abnormal US findings on the hemiplegic side. We found the prevalence of HSP was 63.3% and of non-hemiplegic shoulder pain 11.7%. Similar to previous studies, we found that the anterior shoulder was the most commonly reported location of pain. Tenderness on palpation was also found mostly in the anterior region and the most commonly found abnormal provocative test was the Neer Impingement Test[29].

We found modest degrees of evidence that reduced shoulder passive ROM in abduction and the need for assistance in ADL were associated with HSP. However, we did not observe statistical evidence of associations with poor motor function, poor motor recovery determined by Brunnstrom stage of the arm being <3, or an absence of upper limb motor function and HSP[4,12,14,30]. Additionally, similar to previous studies, we found that supraspinatus tendon pathology identified by US was significantly associated with HSP in patients with chronic stroke[30]. It was found that supraspinatus tendinosis or tendon tear was associated with HSP in the subacute and chronic stages[30]. In our study, in contrast to some previous studies, we did not find any association between left-sided weakness, sensory impairment or spasticity and HSP[7,11,13,31]. Multivariable analysis showed that shoulder subluxation and a duration of stroke <6 months were significant predictive factors of HSP, which is in line with previous studies[32–34]. The shorter duration after stroke and HSP may be explained by the documented usual occurrence of HSP 2-3 months after the onset of stroke[35]. In addition, shoulder subluxation may occur at an early stage after a stroke. Designing rehabilitation programs that aim to prevent shoulder subluxation is essential to mitigate the occurrence of HSP.

Abnormal shoulder US imaging was higher on the hemiplegic side (91.7%) compared with the non-hemiplegic side (75.0%). The percentage of abnormal US findings in our study was consistent with previous studies which found abnormal US in the hemiplegic-sided shoulder of 81.3% to 100% although the percentage of abnormal US findings in the non-affected side in our study (75.0%) was somewhat higher than in previously published articles (20.7%–55.6%)[8,36]. The two most common US abnormalities of the hemiplegic shoulder found in this study were biceps peritendon effusion (66.7%) and supraspinatus tendinosis (45.0%) which is in accordance with previous studies[36,37]. The presence of biceps peritendon effusion on the hemiplegic side was significantly higher compared to the non-hemiplegic side (p-value<0.001). Our results agreed with previous studies that the hemiplegic shoulder had a significantly higher number of structural abnormalities determined by the US compared to the non-hemiplegic shoulder[8,31]. The finding of biceps peritendon effusion is not specific but may point to shoulder pathology. Biceps peritendon effusion was more common in older patients or patients with shoulder pathology such as adhesive capsulitis, subacromial impingement, subdeltoid bursitis, rotator cuff tear, biceps tendinitis, and calcific tendinitis[38]. Additionally, since both the biceps and supraspinatus tendons are considered vertical stabilizers of the glenohumeral joint, the muscles around the shoulder become weaker after stroke, stretching of the joint capsule and the musculotendinous structures occur, and this may be the source of pain and abnormal US findings[6]. We found that a quarter (25%) of patients had subdeltoid-subacromial bursitis. This was lower than in the study of Lin et al. which found that 73.1% of patients with stroke HSP had subacromial subdeltoid bursitis[39] but was in line with multiple previous studies which found that subacromial subdeltoid bursitis was in the range of 21.0% to 43.8%[7,40].

We found no significant association between sex, duration after stroke, the presence of HSP, spasticity, impaired sensory function, stage of motor recovery and US abnormality, which is similar to previous findings[36,40]. Additionally, the results of the positive shoulder provocative test were not associated with the US results. The shoulder provocative test for the diagnosis of shoulder problems may have low diagnostic value for detecting abnormalities in the hemiplegic shoulder and this points to physical examination alone not leading to accurate diagnosis. US is one option to determine the cause of shoulder pain and it is useful for detecting pre-symptomatic pathologies. A recent systematic review and meta-analysis found that US-guided shoulder interventions, such as suprascapular nerve blocks, botulinum toxin injections, and corticosteroid injections, play a role in relieving HSP[41]. In medical practice, US imaging, together with clinical assessment, should be considered to accurately determine the causes of shoulder pain so that proper treatment can be planned accordingly.

Our study had some limitations. Firstly, a single center study limits its generalizability. Secondly, the cross-sectional design limits the determination of the temporal relationship between stroke and the development of US abnormalities, i.e., whether patients had shoulder pathology prior to stroke or whether patients with abnormal US findings will subsequently develop shoulder pain. Future prospective longitudinal studies should be considered. Thirdly, we could not confirm the diagnosis of adhesive capsulitis by physical examination alone since patients after stroke may have limited ROM due to spasticity or soft tissue around the shoulder joint contracture, and not just because of adhesive capsulitis. The abnormalities detected were solely diagnosed from the US which may have lower sensitivity or limitations in the diagnosis of some specific conditions such as adhesive capsulitis. Fourthly, the shoulder provocative tests have limitations when performed on the hemiplegic side due to neurological deficits, especially in the lower Brunnstrom stage, which can affect the interpretation of our results. Finally, it should be noted that an abnormal US finding is not a definitive diagnosis for shoulder pain in each patient. The final diagnosis should be individualized to the patient's clinical and overall US findings.

Conclusion

Shoulder US abnormalities in patients with hemiplegic stroke were prevalent. Biceps peritendon effusion was the most common abnormal shoulder US finding on the hemiplegic side.

Funding sources

This study received funding from the Faculty of Medicine, Khon Kaen University (Grant number IN64134).

Conflict of interest

The authors declare that they have no conflict of interest.

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