Effects of Electrical Stimulation to Long Head of Biceps in Glenohumeral Subluxation after Stroke

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Glenohumeral subluxation is the common complication occurs in 17% to 81% of post-stroke hemiplegia and its reduction has been considered as an important goal. The electrical stimulation of posterior deltoid and supraspinatus muscles can reduce subluxation by many studies, but the role of biceps which is an anterior, inferior and superior stabiliser of the shoulder has not been studied much. The aim of this study was to determine the effect of electrical stimulation to long head of biceps in reduction of glenohumeral subluxation after stroke. Twenty-eight stroke patients were recruited into this hospital-based comparative study from June 2016 to June 2018 and randomly assigned to group I (electrical stimulation to supraspinatus and posterior deltoid) and group II (electrical stimulation to supraspinatus, posterior deltoid and long head of biceps) along with routine physiotherapy for 5 weeks. All patients were assessed for shoulder subluxation by X-ray, pain and shoulder active range of motion at the start of study, weekly during treatment and at the end of treatment duration for five weeks. The group II had more significant improvement in visual analogue pain score, active shoulder abduction, external rotation range of motion and vertical acromion-humeral distance in X-ray. Electrical stimulation to biceps along with the supraspinatus and posterior deltoid can more effectively reduce shoulder subluxation than without stimulation of biceps.

Keywords: Electrical stimulation, Shoulder subluxation, Stroke, Long head of biceps muscle, Posterior deltoid

INTRODUCTION

In stroke patients, weakness of shoulder muscles and the gravitational pull on the humerus cause shoulder subluxation by reducing the strength of the shoulder joint capsule. The shoulder subluxation is one of the most common musculoskeletal complications of stroke patients.[1] The glenohumeral subluxation (GHS) causes supraspinatus and long head of biceps muscles pain by stretching down the periarticular tissues of shoulder joint in stroke.[2] The treatments for glenohumeral subluxation are proper positioning, sling, range of motion exercise, sling, strapping, electrical stimulation (ES) and drug treatment. The ES is the application of electric current to the skin, or directly into muscle that stimulates motor nerves and muscle fibres resulting in improved contractility and greater muscle bulk. The treatment can be used to improved muscle strength, joint misalignment, muscle tone, sensory deficit and self-reported pain intensity.[3] Stroke patients can get inferior shoulder subluxation but most are anterior-inferior shoulder subluxation. The vertical stabilisers are supraspinatus and posterior deltoid muscles and the anterior, inferior and superior stabiliser muscles are long head of biceps. The effectiveness of shoulder subluxation reduction is more in ES to long

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DOI: https://doi.org/10.34299/mhsrj.009105

head of biceps along with supraspinatus and posterior deltoid than to supraspinatus and posterior deltoid.[2] Stroke patients were treated with ES to supraspinatus and posterior deltoid for 8 weeks and founded that ES to supraspinatus and posterior deltoid can prevent shoulder subluxation.[5]

In Myanmar, routine physiotherapy for shoulder subluxation after stroke is positioning, sling, shoulder range of motion (ROM) exercises and ES to supraspinatus and posterior deltoid and there is no previous study on effect of ES to long head of biceps in glenohumeral subluxation after stroke. This study was therefore interested in comparing the effect of ES to long head of biceps, supraspinatus and posterior deltoid muscles against stimulation of supraspinatus and posterior deltoid in glenohumeral subluxation after stroke.

MATERIAL AND METHODS

The study was a hospital-based comparative study. All stroke patients with glenohumeral subluxation, came to outpatient clinics of Physical Medicine and Rehabilitation Department and, General and Neurology Medicine Department at No (1) Defense Services General Hospital (1000-bedded) were studied from June 2016 to June 2018 (total-24 months). A total number of 28 stroke patients were involved in this study. Patients were assigned to two groups; 62 14 patients in group (I) and 14 patients in group (II). Inclusion criteria were post-stroke patients during six months duration, age from 20 years to 80 years, patients with upper limb motor deficit, shoulder subluxation patients with (positive sulcus sign and load and shift test) correlated with radiography and stroke patients with no other risk conditions such as tumors, cardiac failure, skin irritation, vascular diseases, seriously ill patients. Exclusion criteria were patients with electronic implant such as cardiac pacemaker, patients with previous use of electrical stimulation for their subluxated shoulder, patients who were not tolerated to pain during ES, female patients with pregnancy and patients with shoulder pathology such as fracture and deformity.

All the cases were selected by researcher according to above inclusion and exclusion criteria. Each medically stable patient was screened by thorough history taking and clinical examination including positive sulcus sign, load and shift test correlated by X-ray. Then, informed consent was taken and all patients were randomly divided into two groups, group (I) (ES to supraspinatus and posterior deltoid in addition to their conventional physiotherapy) and group (II) (ES to supraspinatus, posterior deltoid and long head of biceps in addition to their conventional physiotherapy).

Treatment procedures

In group (I) patients, ES were given to supraspinatus, posterior deltoid in addition to their conventional physiotherapy. In group (II) patients, ES was given to supraspinatus, posterior deltoid and long head of biceps in addition to their conventional physiotherapy. The patients were placed in sitting position, shoulder and elbow held slightly abducted, and flexed. The electrodes were placed on the supraspinous fossa and the posterior aspect of the upper arm to stimulate the supraspinatus and posterior deltoid muscles, respectively. The electrode was placed on motor point to stimulate long head of biceps. Motor point of long head of biceps is located at about 2/3 of the vertical length from the coracoid process and about 1/5 of the half of the horizontal length from the vertical reference line. The vertical length of the upper arm is defined as the length of the line connecting coracoid process and midpoint of the elbow crease along with the horizontal length as the length of the elbow crease.[6]

All patients were treated with electrical stimulation by the following technique: ES device-Neuroflux ME 115, 2005. Stimulation wave-form was asymmetrical biphasic interrupted direct current, 30 Hz frequency, 300 μs pulse width, 15 seconds duty cycle on, which incorporated a ramp-up time 3 seconds and ramp down time 3 seconds, and 15 seconds off. The duration started at 30 minutes in week 1, 45 minutes in week 2 and 3, 60 minutes in week 4 and 5 once a day, five days per week until five weeks.[7]

Conventional physiotherapy

All patients received conventional physiotherapy (proper positioning and shoulder range of motion exercise therapy). The proper position for the upper limb is towards abduction, external rotation and flexion of the shoulder. The patient was advised to perform this position in his or her daily activity. In this study, all patients performed active-assisted shoulder flexion and extension, external and internal rotation, adduction and abduction exercise under observation of assigned physiotherapist, at a frequency of 15 repetitions of two sets for five weeks to improve the motor control over the shoulder muscles.

Clinical assessment

All patients were clinically assessed by researcher (a) at the start of study (0 week), (b) weekly during treatment and (c) at the end of treatment duration (5 weeks) by the following clinical parameters: (a) Pain score by visual analogue pain scale (VAS) (b) Active shoulder range of motion by using goniometer.

Radiological assessment

Plain X-ray shoulder radiograph was taken with antero-posterior view on the affected and normal shoulder and seen by Direct View CR system in radiology department. The vertical distance was calculated by measuring the distance between the acromion process and the head of the humerus with assigned radiologist. Shoulder subluxation was confirmed by subtracting vertical distance of un-affected shoulder from the affected shoulder in millimeter.[8]

Data management and analysis

Data were collected and the completed data were entered in the proforma and analysed with Statistical Package for Social Science (SPSS) software version 23. Frequencies and percentages of baseline characteristics of patients were analyzed by descriptive analysis and comparative data between the groups were analyzed by independent t-test method.

Ethical considerations

This study was done according to the ethical guideline set by Council of International Organization of Medical Science, 2002 and hospital manual guideline. Ethical approval was obtained from the Ethical Approved Committee, Defense Services Medical Academy, Academic Board (25/4/2016).

RESULTS

A total of 30 patients, were enrolled for this study and two withdrew prior to fulfilling the interventions of this study due to their social problems. Therefore, the analysis was based on the data from 28 patients, 14 in the group (I) and 14 in the group (II). There were no significant differences between the two groups with their age, sex, duration of stroke onset, hemiplegic side and muscle tone (Table 1).

Table 1. Demographic and baseline clinical characteristics

Patients' characteristics	Group I (n=14)	Group II (n=14)
Age	50.64±8.59	49.5±11.64
Gender	13 males 1 female	13 males 1 female
Duration of stroke	13 patients <12 weeks 1 patient >12 weeks	14 patients <2 weeks
Side of hemiplegia	8 right 6 left	8 right 6 left
Affected side muscle tone	5 flaccid 9 spastic	6 flaccid 8 spastic

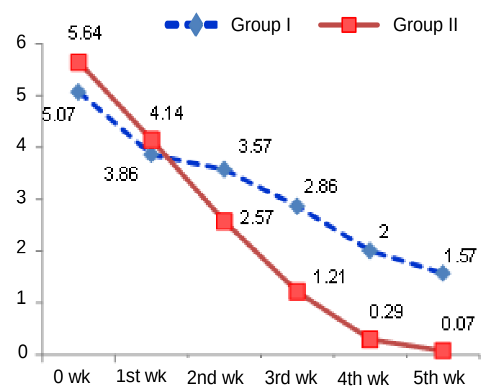

Fig.1. Comparison of mean values of 10 cm visual analogue pain score (VAS)

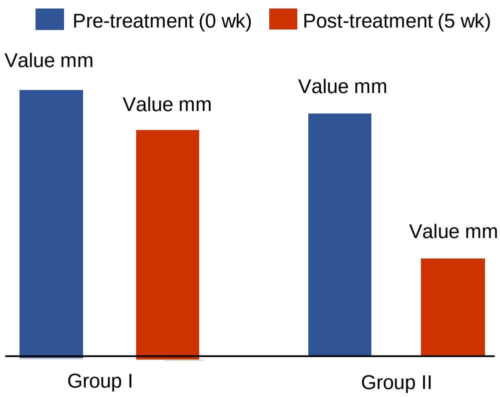

Fig. 2. Comparison of vertical distance reduction in shoulder subluxation X-ray mean values

Table 2. Pre- and post-intervention outcome measures

Outcome measures	Group I (n=14)	Group II (n=14)
VAS pain score mean value	Pre:1.43 ±1.65 Post:0.50 ±0.85*	Pre:1.36 ±1.69 Post 0.14 ±0.36*
Shoulder flexion ROM mean value (degrees)	Pre:25.00 ±23.03 Post:35.00 ±18.29	Pre:13.93 ±14.56 Post:36.79 ±13.38
Shoulder extension ROM mean value (degrees)	Pre:11.07 ±10.41 Post:18.21 ±11.36	Pre:8.57 ±9.07 Post:20.71 ±7.81
Shoulder internal rotation ROM mean value (degrees)	Pre:9.29 ±8.05 Post:15.00 ±5.54	Pre:7.14 ±6.71 Post:7.86 ±5.44
Shoulder external rotation ROM mean value (degrees)	Pre:7.14 ±6.11 Post:1.07 ±4.87*	Pre:4.29 ±4.74 Post:16.79 ±5.40*
Shoulder abduction ROM mean value (degrees)	Pre:25.36 ±23.07 Post:36.43 ±17.91*	Pre:16.79 ±16.47 Post:51.43 ±9.49*
Shoulder subluxation X ray mean value (mm)	Pre: 17.09 ±1.26 Post: 16.48 ±1.38*	Pre:16.73 ±1.35 Post:14.49 ±1.58*

The results are described as mean±standard deviation. VAS=visual analogue pain score, ROM=range of motion

Visual analogue pain score was significantly improved in group (II) than that in group (I) (Fig. 1). There were no significant differences between groups in shoulder flexion, extension and internal rotation range of motions improvement after weekly assessments. But at the end of treatment, group (II) demonstrated greater external rotation and abduction range of motions improvement than group (I). The mean reduction of shoulder subluxation distance on radiological assessment after five-week intervention revealed that group (II) had more improvement than group (I) (Fig. 2 & Table 2).

DISCUSSION

The interventions of this study were conventional physiotherapy and electrical stimulation (ES) to supraspinatus, posterior deltoid for group (I) patients and electrical stimulation to supraspinatus, posterior deltoid and long head of biceps for group (II). After 5 weeks intervention, the overall results of this study showed that group (II) had greater improvement than group (I).

Age distribution of patients

The incidence of stroke by age distribution varies in different studies. The mean age of the patients was 50.64 for 14 group (I) patients and 49.50 for 14 group (II) patients. The functional stroke outcome may partly be related to comorbid diseases, initial disability and advanced age.[9] But there were three patients older than 65 years; 1 patient in group (I) and 2 in group (II).

Gender distributions of patients

There was 1.9% men and 2.2% women who had stroke syndrome at age of 40-59 years.[14] But, at the age of 60-79 years, 6.1% men and 5.2% women of their population had stroke syndrome. The incidence of stroke is 50% higher among men compared with women of all races between ages 65 and 74, but gender difference is much less thereafter.[13] In Myanmar, males are 63% and females are 37% among 60 stroke patients.[5] In this study, the gender distribution of patients was 92.9% male and 7.1% female in both studied groups. There was marked male preponderance in this study rather than others, potentially due to population of this study who were from military field.

Distribution of patients by duration of stroke

There were 77% of patients with less than three weeks post-stroke duration and 23%

had more than three weeks duration. Most patients, 95% of stroke survivors reached their best neurologic level within 11 weeks of onset and severe strokes reached their best neurologic level in 15 weeks on average.[9]

In this study, five patients in group (I) and six patients in group (II) had duration of stroke within (0-4) weeks while seven patients and one patient of both groups were within 4-8 weeks and 8-12 weeks, respectively. Only one patient in group (I) had post-stroke duration of 15 weeks.

Distribution of patients by side of hemiplegia

The hemiplegic side distribution as 59% left and 41% right in their 107 patients with stroke4 while these figures were, respectively, 48% left and 52% right in the 75 patients with stroke[12] and 53% and 47% in the 60 patients with stroke in one study of Myanmar.[5] The distribution was 43% left-sided stroke patients with shoulder subluxation and 57% right-sided stroke patients in our 28 subjects of this study. This may be probably due to small sample size and because of the study area which was based upon one hospital.

Distribution of patients by muscle tone of affected side

The shoulder subluxation is associated with flaccid muscle tone[12]. If the affected extremity is not adequately supported during flaccid stage, subluxations will result[3]. Most of the patients (65%) had flaccid muscle tone on affected side5. But quite different distribution of muscle tone was found in this study, 61% had spastic muscle tone and 39% had flaccid muscle tone on affected sides, and therefore, more spastic patients were involved.

Comparison of VAS pain score

According to results, 67% of our subluxation patients had shoulder pain and mean pain scores reduced weekly in both groups and this may be explained by three mechanisms. The electrical stimulation leads to increased blood circulation to the muscles and there by removes the metabolic waste products and noxious substances.[15] Electrical stimulation stimulates thick myelinated fibres and inhibits transport of pain to the brain via thin non-myelinated fibres by gate mechanism theory.[16] ES might have stimulated the central nervous system to produce endogenous opiates resulting in pain suppression.[17]

There was significant mean pain score difference between the groups after three weeks of treatment period (p value=0.002) and no significant mean difference was founded during early two weeks treatment. This suggests that additional electrical stimulation to long head of biceps, has advantage over stimulation of supraspinatus and posterior deltoid in treating hemiplegic shoulder pain of stroke patients with GHS. But, in treating hemiplegic shoulder pain, patients can be received advantage of ES to long head of Biceps technique after three weeks of treatment period.

Comparison of shoulder active range of motion (ROM) degree

The electrical stimulation to long head of biceps group had more ROM improvement than supraspinatus and deltoid group mostly in passive pain-free external rotation and active abduction[2]. This study also has more improvement of external rotation and abduction range of motion in group II than group I. There was no statistically significant difference of shoulder active flexion, extension, internal rotation ROM between two groups. This may be due to biomechanical properties of long head of biceps muscle and, because of more remarkable, more significant improvement of pain and other ROM improvement in group II. The limitation of external rotation of the hemiplegic shoulder was the factor which most correlated with hemiplegic shoulder pain.[18] In this study, more significant external rotation ROM improvement in group II may be due to more significant pain reduction of group II patients and so, similar hypothesis was found.

The increased abduction ROM in group (II) may be due to dynamic stabilization function of long head of biceps which stabilizing the fulcrum by centering the humeral head in glenoid fossa, dynamic joint compression force of biceps and allowing more efficient arm elevation. This stabilisation also reduces the superior and inferior translation of humeral head, thereby enhancing active abduction. The long head of biceps dynamically stabilises the shoulder joint and allowing humeral head to rotate externally permitting greater degree of abduction.[2]

Comparison of vertical distance reduction in GHS X-ray

The effects of electrical stimulation to long head of biceps compared with supraspinatus and posterior deltoid, in 24 acute stroke patients. Shoulder subluxation reduced after five weeks of therapy in both groups but it reduced more in biceps group. The ES to supraspinatus and deltoid group's reduction of subluxation was 3.21 mm and biceps group's reduction was 6.55mm.[2] The biceps have more effect in shoulder stabilizsation in all direction in an unstable shoulder.[10, 11]

It was found that group (I) had 0.61 mm reduction of subluxation and group (II) had 230 2.24 mm after five weeks therapy. There was statistically significant difference between these two groups' vertical acromio-humeral distance reduction after 5 weeks therapy (p-value=0.002). The better reduction in shoulder subluxation in group (II) may be positively attributed to the additional electrical stimulation given to long head of biceps, which are anterior, inferior and superior stabilizer of gleno-humeral joint.

Limitations of this study

Major limitations were lack of specific measurement score for functional activities, synergy pattern and recovery staging for affected side upper limb. There were no follow up in this study after 5 weeks of treatment to know the sustainability of treatment effects and sample size of this study was small.

Conclusion

The results of this study suggest that the additional electrical stimulation to long head of biceps has a definite advantage over stimulation of supraspinatus and posterior deltoid in treating glenohumeral subluxation after stroke. All participants reported a sense of wellbeing to notice the reduction of shoulder pain and resultant shoulder movements. We recommend future studies on different spastic and flaccid groups of shoulder subluxation, narrowing of age differences, chronic stroke, different intensity, long-term sustainability of electrical stimulation effect on shoulder subluxation, electrical stimulation of other shoulder stabilizer muscles, correlation of functional activities.

Competing interests

The authors declare that they have no competing interests.

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