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Research Article

The Effects of Bedside Shoulder Exercises in Stroke Patients with Severely Impaired Upper Extremity Function

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Abstract

Background: Stroke is the leading cause of serious long-term disability in older adults, and more than 70% of individuals experience Upper Extremity (UE) paresis after stroke. The effect of bedside shoulder exercise in stroke patients with severely disabled has not been evaluated, so, we investigated the effects these kind of exercises in the ward for subacute stroke patients with severely impaired UE function.

Methods: Subacute stroke patients with severely impaired UE weakness who have a grade below poor for their motor power of the shoulder were enrolled in this pilot, case-control study. This study was conducted from May 2013 to October 2015 in Dong-A University Hospital, Busan-Ulsan Regional Cardiocerebrovascular center, republic of Korea. Experimental group performed bedside shoulder exercises for 3 weeks. During the exercises, a caregiver supported the subject's affected arm and assisted the subject in perform a precise exercise. An age-, stroke lesion-, and shoulder motor power-matched control group were enrolled. Manual Function Test (MFT), Fugl-Meyer Scale (FMS), manual muscle test and modified Ashworth scale were used to assess shoulder functions. Radiological findings of Glenohumeral Subluxation (GHS) were measured. All evaluations were measured before and after 3-week treatment.

Results: Forty-three patients in the experimental group and fifty patients in the control groups were enrolled. When compared with control group, experimental group showed significantly more improvement in the scores of MFT and FMS, and radiological findings of GHS. Bedside shoulder exercise showed more effective when a patient's shoulder motor power grade was poor and the patient's compliance was high.

Conclusion: Bedside shoulder exercise might be a helpful therapeutic option to enhance shoulder function in stroke patients with severely impaired UE. This protocol is simple, and feasible in clinical settings.

Introduction

Stroke is the leading cause of serious long-term disability in older adults, and more than 70% of individuals experience Upper Extremity (UE) paresis after stroke [1]. A strong relationship has been found between UE function and the ability to perform activities of daily living and social activities [2,3]. The more severe the UE paralysis, the greater the Glenohumeral Subluxation (GHS) frequency will be [4]. GHS is a common problem in paretic UE and may be associated with poorer functional outcomes [5].

A literature review of early rehabilitation treatments for paretic upper extremities clearly indicated that increased treatment intensity using repetitive, task-oriented methods improves motor and functional recovery compared to facilitative approaches [6,7]. Increased therapeutic activity also leads to better post-stroke outcomes. Recently, an intensive rehabilitation program (3 hours per day for 5 days each week) was recommended for subacute stroke phase inpatient rehabilitation [8]. In this facility, individuals are involved in therapy for 3 hours per day, including approximately 1hour of UE treatment [9,10]. In addition, these patients spend more than 50% of the day time hours alone and resting [9]. These findings indicate that there is considerable time during the day for individuals to engage in therapeutic activity outside of conventional rehabilitation therapy time with their therapist.

A gradual recovery of UE muscle strength and function may be expected during rehabilitation treatment of paretic upper extremities after stroke. In addition, a study indicated that additional UE self-administered exercises improve UE function in subacute stroke patients [11]. Moreover, self-administered exercise programs have been successfully prescribed for the upper extremities in the home setting and have shown favorable results for improved UE function in cases of chronic stroke [12-14].

However, these previous good results were obtained only on patients who had mild to moderately impaired UE function (patients who had their shoulder motor power above fair grade) [11-13]. Patients in previous studies could do their shoulder exercise without assistance.

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In contrast, patients with severe UE paresis (who had their shoulder motor power below poor) cannot perform shoulder exercise without assistance. Additional problems related with UE weakness, such as shoulder-girdle tendon injury or GHS, may occur if patients perform self-administered exercise without exact alignment of the shoulder. In addition, patients who are severely disabled and/or exhibit poor cooperation cannot exercise without assistance. In these cases, a caregiver's supervision and engagement is important for the patient's bedside exercise program.

To the best of our knowledge, the effect of bedside shoulder exercise in stroke patients with severely impaired UE function has not been evaluated. We designed an easy and simple shoulder range of motion exercise program that could be administered by a caregiver at the patient's bedside in a hospital ward. Our hypothesis was that subacute stroke patients who participate in the supplemental shoulder exercise program with the help of caregiver would recover greater UE function compared to those who underwent only the regular inpatient rehabilitation program, even though patients were severely disabled. We investigated the effects of bedside shoulder exercises administered by caregiver in the ward for subacute stroke patients with severely impaired UE function.

Materials and Methods

Subjects

Subacute stroke patients with severe UE weakness were enrolled in this pilot, case-control study. We enrolled stroke patients with severely impaired UE weakness that had a grade below poor for their motor power of the shoulder. This study was conducted from May 2013 to October 2015 in Dong-A University Hospital, Busan-Ulsan Regional Cardiocerebrovascular center, Republic of Korea.

We excluded patients who had tetraplegia or double hemiplegia, those who complained of severe pain in the paretic UE, and those with a seriously restricted range of motion of the shoulder joint. Patients who had a history of trauma or surgery in the UE and the chest area or had a history of peripheral neuropathy were also excluded from this study. Decreased patient cooperation was not an exclusion criterion because the caregiver could assist the patient in performing bedside shoulder exercises. Bedside shoulder exercises were performed with the caregiver's assistance, and therefore, those patients whose primary caregiver changed were excluded. An age-, stroke lesion-, and shoulder motor power-matched control group were enrolled in this study. Physical therapy and occupational therapy of the same time were applied to both groups.

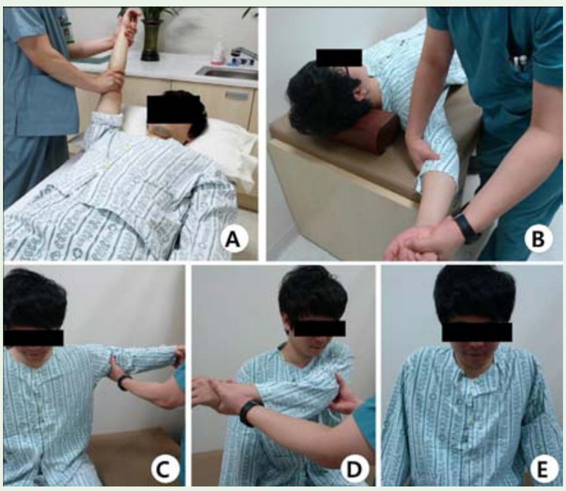

Figure 1: Bedside shoulder exercises. (A) Shoulder forward flexion. (B) Shoulder abduction. (C) Horizontal shoulder abduction. (D) Horizontal shoulder adduction. (E) Shoulder shrug.

The study protocol was approved by the institutional review board, and all participants provided written informed consent (IRB No. 14-151).

Bedside shoulder exercises in the experimental group

Two physiatrists explained and demonstrated shoulder exercises to the patients and their caregivers. With the assistance of caregivers, subjects in the experimental group performed bedside shoulder exercise, shoulder forward flexion and shoulder abduction in a supine position, and shoulder forward flexion, abduction, horizontal shoulder adduction, horizontal shoulder abduction, and shoulder shrug in a seated position (Figure 1). The entire range of joint motion was defined as one repetition. Each shoulder movement was performed 10 times in each session, with 3 sessions per day, 5 days per week, for 3 weeks. Therefore, subjects could participate in a maximum of 45 sessions. During the bedside shoulder exercises, a caregiver supported the subject's shoulder, elbow, and wrist and assisted the subject in perform a precise shoulder exercise while minimizing GHS.

If a subject complained of pain during a certain joint range movement, he/she was instructed to perform a shoulder exercise at the maximum range that did not cause pain. In addition, during the bedside shoulder exercises, if the subject complained of pain the physiatrists discontinued the exercise if necessary.

All patients received concurrent physical and occupational therapy. The patients also wore arm slings to correct GHS except while they were taking part in occupational therapy.

Outcome measures

To evaluate shoulder function, the Manual Function Test (MFT), the UE portion of the Fugl-Meyer Scale (FMS), the Manual Muscle Test (MMT) of the shoulder abductor and flexor, and the Modified Ashworth Scale (MAS) of the shoulder were used. The Korean-Modified Barthel Index (K-MBI) was used to assess activities of daily living.

The MFT measures gross and fine motor dexterities in the UE on a scale of 0 to 32, and its reliability is considered excellent [15]. Scores are divided into shoulder/elbow/forearm and hand dexterity segments, each of which is scored on a scale of 0 to 16. The motor subset of the FMS for the UE, which uses a scale of 0 to 66, is used to assess sensation, range of motion, reflexes, synergy, and fine and gross hand movements; and its reliability and validity are considered good [16,17]. The MMT is the most commonly used method for documenting muscle strength impairment [18] and is conducted on the shoulder forward flexor and abductor. The MAS is a clinical measure of muscle tone and a nominal-level measure of resistance to passive movement. The reliability of the scale appears better for measuring spasticity [19]. The K-MBI was translated by six senior Korean physiatrists using the 5th version of the MBI, and its reliability and validity were approved [20].

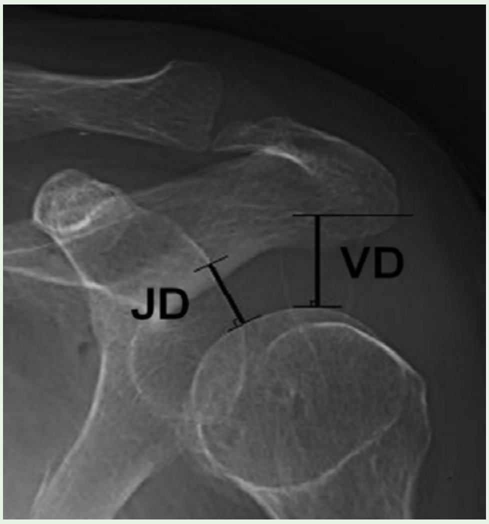

Figure 2: Shoulder anterior-posterior simple radiograph in a sitting position. Vertical Distance (VD) is the distance between the most inferior and lateral level of acromion and the uppermost level of humeral head. Joint Distance (JD) is the shortest distance between upper glenoid rim and humeral head.

GHS was defined as shoulder instability and partial dislocation of the shoulder joint of more than one fingerbreadth during a physical examination. The degree of GHS was measured from a shoulder anterior-posterior simple radiograph in a sitting position without the arm sling before and after 3weeks of bedside shoulder exercises. Using the methods proposed by Keats, Lusted [21], and Han et al. [22] the Vertical Distance (VD) between the inferior acromial point and the upper end of the humeral head was calculated, and the Joint Distance (JD), which is the shortest distance between the humeral head and the upper margin of the glenoid fossa, was determined (Figure 2).

To evaluate factors that influence the effects of the bedside shoulder exercise, we divided each group based on their shoulder motor power (poor grade vs. trace and/or zero grade) and performed subgroup analysis. We also evaluated the relationship between exercise effects and patient's compliance, which was defined as the number of shoulder exercises completed.

All evaluations were performed before and immediately after the 3-week shoulder exercise program by a single experienced occupational therapist that was not aware of the protocol.

Statistical analysis

SPSS 21.0 for Windows was used for the statistical analyses. The Mann-Whitney U-test or Student's *t*-test was used to test the homogeneity between groups before the study. Because the outcome measurement data showed parametric distributions, the paired *t*-test was used to compare data obtained before and after treatment in each group. The treatment effects in each outcome measure were evaluated as the change from pre- to post-treatment and compared this across groups using Student's *t*-test. The Pearson's correlation coefficient was used to examine the correlation among indices according to the number of exercises performed. A *p*-value less than 0.05 were considered statistically significant.

Results

One-hundred twenty-one patients with impaired unilateral UE motor function due to stroke were evaluated. Of these patients, 54 met our inclusion criteria and were enrolled. During the bedside shoulder exercises, 7 patients complained of shoulder pain on the paretic side. Of those patients, 4 experienced neuropathic pain, and their symptoms improved after medical treatment. The remaining three were verified to have rotator cuff disease or adhesive capsulitis based on an ultrasound of the shoulder joint and were treated with an ultrasound-guided injection. An additional 4 patients who performed less than 50% of the shoulder exercises were also excluded. Finally, 43 subjects were able to complete the 3-week bedside shoulder exercise program.

Demographic characteristics, including stroke-related characteristics and initial evaluations, did not significantly differ between the two groups (Table 1). The mean ages were 60.3±11.6 years for the experimental group and 58.7±13.5 years for the control group.

Table 1: Baseline characteristics of both groups.

Variables	Experimental group(n=43)	Control group (n=50)	P- value
Age (yr)	60.3±11.6	58.7±13.5	0.36
Gender (M/F)	20 /23	24/ 26	
Paretic side (right/left)	18 / 25	14-Sep	
Stroke Type (ischemic/hemorrhagic)	27/16	30/20	
Stroke lesion (cortex/subcortex)	30/13	35/15	
Time since stroke (days)	33.9±15.2	37.1±11.6	0.14
MMSE	15.8±9.5	16.1±13.3	0.353
MFT	4.6±3.3	3.8±3.2	0.25
FMS of upper limb	10.7±9.8	11.7±7.9	0.561
MMT of shoulder	1.6±0.7	1.8±0.5	0.274
MAS of shoulder	0.6±0.3	0.7±0.2	0.371
K-MBI	35.8±17.6	31.3±20.5	0.477
Glenohumeral subluxation–VD (mm)	17.5±4.9	18.2±6.1	0.328
Glenohumeral subluxation– JD (mm)	12.6±5.3	11.8±5.9	0.62

The values are numbers or mean±SD.
MMSE, Mini Mental Status Exam; MFT, Manual Function Test; FMS, Fugl-Meyer Scale; MMT, Manual Muscle Test; MAS, Modified Ashworth Scale; K-MBI, Korean Version of Modified Barthel Index; VD, Vertical Distance; JD, Joint Distance.

Table 2: Changes of measurements.

	Experimental group (n=43)			Control group (n=50)		
	Pre	Post	Changes	Pre	Post	Changes
MFT	4.6±3.3	14.1±7.5*	10.6±3.1†	3.8±3.2	12.7±2.3*	8.8±4.6
FMS	10.7±9.8	28.2±11.4*	19.5±11.8†	11.7±7.9	25.9±12.8*	15.7±9.1
MMT	1.6±0.7	3.1±0.6*	1.8±0.6	1.8±0.5	2.6±0.7*	1.5±1.0
MAS	0.6±0.3	0.7±0.6	0.1±0.2	0.7±0.2	1.0±0.4	0.2±0.2
K-MBI	35.8±17.6	58.1±14.3*	25.4±9.7	31.3±20.5	52.1±25.4*	26.5±11.8
VD	17.5±4.9	11.7±2.1*	-5.8±1.9†	18.2±6.1	14.3±5.3	-4.9±3.7
JD	12.6±5.3	7.8±1.9	-3.8±3.3	11.8±5.9	8.9±3.6	-2.9±2.6

The values are mean±SD

MFT, Manual function test; FMS, Fugl-Meyer Scale; MMT, Manual Muscle Test; MAS, Modified Ashworth Scale; K-MBI, Korean Version of Modified Barthel Index; VD, Vertical Distance; JD, Joint Distance.

*: $p<0.05$ by Paired t-test in each group.

†: $p<0.05$ by Student t-test between group.

Pre- and post- treatment characteristics of the two groups

Table 2 shows the evaluations of the two groups recorded before and after treatment. A within-group analysis using a paired *t*-test showed that both groups demonstrated significant improvements in MFT, FMS, MMT and K-MBI scores after the 3-week therapy program. In contrast to the control group, the experimental group showed a significant change in VD. To determine the shoulder exercise effect for different UE joints, a sub-score analysis was performed using the MFT and FMS. Both groups showed significant improvements in the shoulder/elbow/forearm segment in the MFT and FMS sub-scores. The hand dexterity segment showed no significant improved in either group.

When the changes in parameters were compared between the two groups, the experimental group showed significantly greater improvement in MFT and FMS scores, and in the radiological findings for GHS (Table 2).

Bedside shoulder exercise effects and related factors

Table 3 showed bedside shoulder exercise effect according to their shoulder motor power (poor grade vs. trace and/or zero grades). Both

Table 3: Bedside shoulder exercise effect according to their shoulder motor power.

Shoulder motor power	Poor Grade		Trace and/or Zero Grade	
	Experimental (n=20)	Control (n=24)	Experimental (n=23)	Control (n=26)
ÄMFT	13.5±5.1	10.7±4.3*	4.0±2.6	3.6±2.3
ÄFMS	21.7±9.8	17.2±6.4*	7.6±3.1	7.9±4.8
ÄMMT	1.9±1.1	1.9±1.3	0.7±0.3	0.6±0.2
ÄMAS	0.1±0.1	0.1±0.2	0.2±0.2	0.2±0.1
ÄK-MBI	32.5±16.7	34.2±19.8	15.5±7.81	16.1±10.4*
ÄVD	-6.9±2.4	-5.1±3.3*	-1.6±3.7	-1.4±2.3
ÄJD	-6.3±3.1	-4.7±2.8*	-0.9±1.8	-1.1±1.6

The values are mean±SD.

MFT, Manual Function Test; FMS, Fugl-Meyer Scale; MMT, Manual Muscle Test; MAS, Modified Ashworth Scale; K-MBI, Korean Version of Modified Barthel Index; VD, Vertical Distance; JD, Joint Distance.

*: $p<0.05$ by Student t-test.

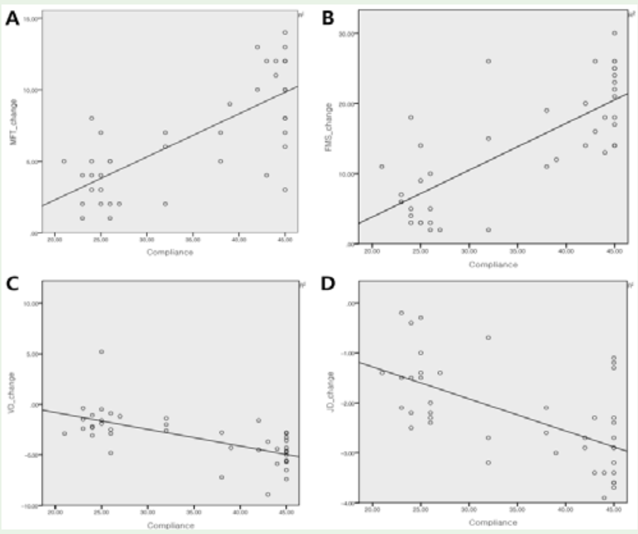

Figure 3: Correlation between compliance and exercise effects. Compliance was defined as the number of shoulder exercise. The changes of MFT, FMS, and radiologic findings showed significant correlation according to the patients' compliance. A: Correlation between compliance and changes of MFT (Correlation co-efficiency = 0.739, *p*=0.01), B: Correlation between compliance and changes of FMS (Correlation co-efficiency = 0.757, *p*=0.01), C: Correlation between compliance and changes of VD (Correlation co-efficiency = -0.652, *p*=0.01), D: Correlation between compliance and changes of JD (Correlation co-efficiency = -0.813, *p*=0.01).

the experimental and control groups showed more improvement in patients with a poor grade of shoulder motor power than in patients with trace and/or zero grades. In patients with a poor grade of shoulder motor power, the experimental group demonstrated significantly higher improvement than did the control group in the MFT and FMS scores and in the radiological findings. In patients with trace and/or zero grades, there were no significant differences between groups for either shoulder function or radiological findings.

When evaluating the relationship between exercise effects and patient's compliance, the changes in MFT and FMS scores and in radiological findings showed a significant correlation with the level of patient's compliance (Figure 3).

Discussion

The major finding of our study is that bedside shoulder exercises are effective for improving both shoulder function and radiological findings of GHS to subacute stroke patients with severely impaired UE function. When a caregiver assists a patient with bedside shoulder exercise, the exercises become suitable for a wide range of individuals with severe UE paresis and/or cognitive impairment. In addition, we identified suitable indications of bedside shoulder exercises. Our results showed that this protocol was more effective when a patient's shoulder motor power grade was better than poor and the patient's compliance was high.

Bedside shoulder exercise effect

Our exercise protocol was simple, had no associated costs, and was feasible in a clinical setting. Many previous studies have demonstrated the effects of bedside or home-based self-administered shoulder exercises [11-14]. Harris et al. [11] reported that when patients in an experimental group performed self-administered UE exercises in addition to a general rehabilitation program, they showed a significant recovery of UE function compared to a control group. Bedside shoulder exercises, which are generally not included in conventional rehabilitation treatment with a therapist, had an additional effect on functional improvement of the UE. Systematic reviews revealed that a greater intensity of occupational therapy during stroke rehabilitation results in improved functional outcomes [6,23,24].

Previous studies almost included subjects with mild to moderate impairment of the UE at the baseline evaluation [6,11-14]. In addition, subjects in these studies displayed good cooperation, and could perform self-administered exercise without help. By contrast, we enrolled patients with severe UE weakness whose motor power of the shoulder was below a grade of poor and who had GHS. The more severe the UE paralysis, the greater the GHS frequency [4], both of which are associated with poor outcomes [5]. Our results showed that patients with severe UE weakness could achieve improvements in shoulder function and GHS through bedside shoulder exercises. Our results are consistent with a systematic review suggesting that greater intensities of therapy result in better improvement [6,23,24].

The role of caregiver involvement in bedside shoulder exercises

In this study, the caregiver's role was very important. During the bedside shoulder exercises, a caregiver supported the subject's shoulder, elbow, and wrist and assisted the subject in performing a precise shoulder exercise while minimizing GHS. They acted as a supervisor and/or therapist, and they provided feedback and helped the patient correct his or her posture during the exercises. They also encouraged patients while performing exercise through multilevel interactions between the patient and caregiver.

Patients with severe UE weakness cannot perform shoulder exercises without assistance. When patients with GHS perform self-administered exercises on the affected shoulder with malalignment of the shoulder joint, the risk of shoulder-girdle muscle tendon injury or shoulder pain would be increases. Patients who show apathy or decreased cooperation also cannot perform exercise without assistance. For these patients, the caregiver's role is more important. With the help of a caregiver, a wide range of stroke patients with severe motor weakness, GHS, and poor cooperation could exercise at their bedside. This study showed that bedside shoulder exercises administered by a caregiver were effective for treating severe UE impairment.

Good response to bedside shoulder exercises

To determine which patients benefited most from bedside shoulder exercises, we analyzed the exercise effect based on the patient's motor power and the patient's compliance. The results of sub-group analysis indicated that patients who had a poor grade of shoulder motor power benefited most from bedside shoulder exercises. In addition, patient's participation is important. A previous study demonstrated that when patients performed UE exercises themselves, the group to which a caregiver provided active assistance showed a greater recovery in UE function than did the group without caregiver assistance [25]. Our results are consistent with those of a previous study, which showed that a caregiver's participation was positively correlated with the effect of bedside shoulder exercises. A greater intensity of occupational therapy during stroke rehabilitation also results in improved functional outcomes [6,23,24].

Strength and Limitations of Study

To our knowledge, this is the first study to evaluate the effect of bedside shoulder exercises to stroke patients with severe UE impairment. This is also the first study that demonstrates the effect of bedside shoulder exercises on GHS. We emphasize the caregiver's role on a patient's bedside shoulder exercises. A wide range of severely impaired patients can perform these bedside shoulder exercises.

However, this study has several limitations. Although this is a case-control study, it was difficult to clearly differentiate whether improvements of the upper extremities were due to the effect of bedside shoulder exercises or part of the natural recovery process. In addition, sensory loss, age and/or other medical problems that can influence functional outcomes could not be accounted for. Finally, because these patients had severe UE function, we could not compare our results to the effect of shoulder exercises for mild to moderate patients.

Conclusion

This study demonstrated the effect of bedside shoulder exercises in subacute stroke patients with severely impaired UE function. We determined that bedside shoulder exercises administered by caregivers were effective for severely disabled patients as well as mildly disabled patients. This exercise program is simple, safe, and easy to apply in clinical settings. We suggest that bedside shoulder exercises might be a helpful therapeutic option to enhance shoulder function in stroke patients with severely impaired UE.

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