การทำงานของกล้ามเนื้อแขนในข้างอัมพาตของผู้ป่วยโรคหลอดเลือดสมอง

Muscle Activity in Paretic Upper Limb of the Stroke

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บทคัดย่อ

การศึกษานี้เป็นการศึกษาภาคตัดขวาง เพื่อศึกษาการทำงานของกล้ามเนื้อแขนในข้างอัมพาตในอาสาสมัครผู้ป่วยโรคหลอดเลือดสมองที่มีกล้ามเนื้อแขนเกร็งแต่เคลื่อนไหวแขนได้จำนวน 10 คนและผู้มีสุขภาพดีที่มีอายุเท่ากันจำนวน 10 คน การศึกษานี้วัดคลื่นไฟฟ้ากล้ามเนื้อขณะเคลื่อนไหวแขน 10 แบบ คือ เอื้อมแขนไปข้างหน้า, เอื้อมแขนขณะกางแขน, ยกแขนขณะเหยียดศอก, ยกแขนขณะงอศอก, หมุนแขนออกขณะงอศอก, หมุนแขนออกขณะเหยียดศอก, งอศอกขณะคว่ำมือ, งอศอกขณะหงายมือ, กระดกข้อมือขณะเหยียดนิ้วมือ และกระดกข้อมือขณะงอนิ้วมือ

ผลการศึกษาคลื่นไฟฟ้ากล้ามเนื้อในท่าต่าง ๆ ระหว่างผู้ป่วยโรคหลอดเลือดสมองและผู้มีสุขภาพดี พบความแตกต่างของคลื่นไฟฟ้ากล้ามเนื้อ Serratus Anterior ในท่าเอื้อมแขนไปข้างหน้า (p=0.001) และเอื้อมแขนขณะกางแขน (p=0.049) พบความแตกต่างของคลื่นไฟฟ้ากล้ามเนื้อ Brachioradialis ในท่างอศอกขณะหงายมือ (p=0.015) ยังพบความแตกต่างของคลื่นไฟฟ้ากล้ามเนื้อ Extensor Carpi Ulnaris (p=0.041) และ Extensor Digitorum (p=0.025) ในท่ากระดกข้อมือขณะเหยียดนิ้วมือ และพบความแตกต่างของคลื่นไฟฟ้ากล้ามเนื้อ Extensor Carpi Radialis ในท่ากระดกข้อมือขณะงอนิ้วมือ (p=0.035)

ผลการศึกษาสรุปได้ว่ากล้ามเนื้อ Serratus Anterior, Brachioradialis, Extensor Carpi Ulnaris, Extensor Digitorum และ Extensor Carpi Radialis ในแขนข้างอัมพาตของผู้ป่วยโรคหลอดเลือดสมองทำงานแตกต่างไปจากแขนของผู้มีสุขภาพดี การศึกษานี้เสนอว่าควรเน้นฝึกการทำงานของกล้ามเนื้อดังกล่าวเพื่อช่วยผู้ป่วยโรคหลอดเลือดสมองเอื้อมแขน งอศอก และกระดกข้อมือ ได้ใกล้เคียงปกติมากที่สุด

คำสำคัญ : โรคหลอดเลือดสมอง อัมพาตครึ่งซีก คลื่นไฟฟ้ากล้ามเนื้อ แขน

ABSTRACT

This cross sectional study determined muscle activity in the paretic upper extremity of the 10 stroke patients who had ability to move their paretic arms and 10 age-matched non-disabled controls. Muscle activity was recorded by surface electromyography (EMG) during performing 10 movement patterns; reaching in shoulder flexion, reaching in shoulder abduction, shoulder flexion with elbow extension, shoulder flexion with elbow flexion, elbow flexion in pronation, elbow flexion in supination, wrist extension with fingers extension, and wrist extension with finger flexion.

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The results showed muscle activity differences between the stroke and the control, demonstrating in Serratus Anterior muscle activity during performing reaching in shoulder flexion (p=0.001) and reaching in shoulder abduction (p=0.049). The significant difference in Brachioradialis muscle activity (P=0.015) was found in elbow flexion with supination. Additionally, significant difference in muscle activity in Extensor Carpi Ulnaris (p=0.041) and Extensor Digitorum (p=0.025) was observed in wrist extension with fingers extension. For wrist extension with fingers flexion, Extensor Carpi Radialis muscle activity was significantly (p=0.035) observed.

In conclusion, muscle activity in Serratus Anterior, Brachioradialis, Extensor Carpi Ulnaris, Extensor Digitorum, and Extensor Carpi Radialis in the paretic upper limb of the stroke was different from that in the limb of the control. It is suggested to emphasize to train these muscles in order to improve reaching, elbow flexion, and wrist extension to be closed to normal movement patterns.

Keywords : Stroke, hemiparesis, electromyography, upper extremity

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INTRODUCTION

Following a stroke, upper limb function impairment is one of the most common problems and it limits the daily activity and may contribute to permanent disability (1). The increase in muscle tones usually happen showing in shoulder adductors, shoulder internal rotators, elbow flexors, forearm pronators, wrist flexors, and finger flexors (2). These cause the stroke held upper limb in adduction and internal rotation of the shoulder. Elbow commonly appears in flexion and pronation, and wrist is commonly looked in a flexion posture (3,4). This is a factor in voluntary movement disturbances in the upper limb, in addition to upper limb muscle weakness (5-7).

The change in upper limb muscle features in the stroke leads to movement problems, showing abnormal movement patterns. It can be assumed that the action of prime mover muscle for each movement may not completely function. Furthermore, accessory muscles may work as a prime mover muscle. Therefore, the present study aimed to investigate muscle activation during active movement in the affected upper limb of the stroke and in the dominant side of the controls. It is anticipated that the investigation leads the knowledge to apply in therapeutic exercise in the stroke.

METHODS

Participants

Right hemiparetic patients with first stroke (n=10) and age-matched non-disabled healthy subjects with right side dominance (n=10) participated in the study. The general characteristics of participants are summarized in Table 1. In addition, the features of participants with stroke are shown in Table 2. Individuals with stroke who had sensory impairments and other orthopedic impairments affecting movements were excluded. The study was approved by the ethic committee of Mahidol University.

Table 1 General characteristic of the participants

Characteristics	Stroke (n = 10)	Control (n = 10)	p-value[#]
	Mean ± SD	Mean ± SD	
Age (years)	63.1 ± 9.31	62.8 ± 9.19	0.943
Weight (kg)	59.0 ± 9.85	61.3 ± 10.9	0.627
Height (m.)	1.61 ± 0.09	1.61 ± 0.10	0.962
BMI (kg/m^2)	23.0 ± 2.52	23.7 ± 4.03	0.659

[#] p-value from independent t-test

Table 2 Clinical data of individual with stroke

Individual with stroke	Cognitive score[a]	Upper limb spasticity score[b]	Upper limb functional evaluation[c]	Time since stroke (months)
1	30	1-1+	66	18
2	27	1-2+	56	12
3	23	0-2	51	36
4	28	0-1+	60	30
5	30	0-1+	66	48
6	28	0-1+	61	15
7	30	0-1+	56	18
8	29	0-2	49	48
9	30	1-2	50	76
10	27	0-2	51	36

[a] Based on Thai Mental State Examination

[b] modified Ashworth scale (0 = normal tone, 5 = severe spasticity)

[c] Based on Fugl-Meyer scale (maximum score for upper limb = 66)

Electromyography (EMG) Measurement

EMG activity was recorded from surface EMG (Noraxon INC., USA©2006). Ag-AgCl disposable surface electrodes (Blue Sensor, Olystyke, Denmark) with a 10mm contact area were placed over the muscles during performing the tasks, as shown in Table 3. The EMG signals were recorded with the sampling frequency of 1500 Hz and the cut-off frequency of 500 Hz.

Table 3 Muscles for recording electromyography during perform various movement patterns

Muscles for EMG recording	Movement patterns
Serratus anterior Pectoralis major	Reaching - In shoulder flexion - In shoulder abduction
Pectoralis major Anterior deltoid Biceps brachii Upper trapezius	Shoulder flexion - with elbow extension - with elbow flexion
Biceps brachii Infraspinatus Triceps brachii Posterior deltoid	Shoulder external rotation - with elbow flexion - with elbow extension
Biceps brachii Flexor carpi radialis Brachioradialis Pronator teres	Elbow flexion - in pronation - in supination
Extensor carpi radialis Extensor carpi ulnaris Extensor digitorum Flexor digitorum superficialis	Wrist extension - with fingers extension - with fingers flexion

Procedures

Participant learned to perform movement patterns (Table 3) by means of passive movements. To perform the movements during collecting data, individual with stroke actively moved the affected side, while healthy participant actively moved the right arm.

Participant's skin was shaved with a disposable shaver and cleaned with isopropyl alcohol to reduce skin resistance. After skin preparation, surface electrodes were placed over the muscles shown in Table 3. After collecting data, the maximal voluntary isometric contraction (MVC) of each muscle was recorded in unaffected side of the stroke and right side of the control. Each subject was asked to perform three maximal isometric contractions against manual resistance that apply by the investigator for 3 seconds. Between each contraction, the 15 seconds resting period is allowed (8,9).

Data Analysis

EMG data from each muscle was normalized, and was presented in %MVC. Kolmogorov-Smirnov Goodness of Fit test was performed to test normal distribution. Unpaired t-test was conducted to compare normal distribution data in muscle activity between the affected side of the stroke and control, otherwise Wilcoxon signed-rank test was used to compare the non-distribution data. Significant difference was set at $p<0.05$.

RESULTS AND DISCUSSION

Normal distribution was shown in the data. It was found significant difference in Serratus Anterior muscle activity in reaching with shoulder flexion ($p=0.001$) and in reaching with shoulder abduction ($p=0.049$) between the stroke and the control (Table 4), showing less Serratus Anterior muscle activity in the stroke. The muscle is agonistic muscle in scapular protraction (9). It can be inferred that scapular protraction is hardly generated in the stroke. The possible is that the muscle is weak and there is an increase in scapular retractor muscle tone.

Muscle activity of brachioradialis was significantly ($p=0.015$) different in elbow flexion with supination between the stroke and the control (Table 4), showing less activity in the muscle in the stroke. Brachioradialis muscle is a strong elbow flexor when the forearm is in the mid-position (9). In clinic, the stroke cannot usually perform elbow flexion with supination. From the result, this may affect the stroke in flexing elbow in the mid-position. Consequently, it is hard to do elbow flexion with supination.

The result also showed significant difference in Extensor Carpi Ulnaris ($p=0.041$) and Extensor Digitorum ($p=0.025$) muscle activities during performing wrist extension with fingers extension between the stroke and the control (Table 4), demonstrating less activity in these muscles in the stroke. Generally, individuals with stroke show an increase in muscle tone in finger flexors. This may cause Extensor Carpi Ulnaris and Extensor Digitorum work difficulty when extended wrist with extended fingers.

Table 4 Muscle activity (mean ± SD) in various movement patterns of the stroke and the control

Tasks	Muscles	Muscle activity (% MVC)	
		Stroke	Control
Reaching			
in shoulder flexion	Serratus Anterior	17.4 ± 15.9 *	50.9 ± 21.1
	Pectoralis Major	17.1 ± 5.68	16.2 ± 10.1
in shoulder abduction	Serratus Anterior	13.2 ± 13.0 *	27.4 ± 16.8
	Pectoralis Major	20.4 ± 10.2	19.7 ± 7.62
Shoulder flexion			
with elbow extension	Pectoralis Major	23.5 ± 5.24	24.7 ± 12.1
	Anterior Deltoid	27.6 ± 19.7	24.3 ± 9.01
	Biceps Brachii	13.3 ± 11.1	19.8 ± 16.7
	Upper Trapezius	12.6 ± 10.7	15.7 ± 14.4
with elbow flexion	Pectoralis Major	18.5 ± 6.12	14.9 ± 7.52
	Anterior Deltoid	16.3 ± 12.0	12.2± 4.26
	Biceps Brachii	12.5 ± 9.55	13.3 ± 10.5
	Upper Trapezius	11.7 ± 17.0	8.05 ± 7.00
Shoulder external rotation			
with elbow flexion	Biceps Brachii	13.2 ± 17.1	4.46 ± 3.59
	Infraspinatus	21.8 ± 18.1	19.7 ± 19.6
	Triceps Brachii	6.21 ± 4.69	3.06 ± 2.28
	Posterior Deltoid	5.16 ± 4.54	5.04 ± 6.22
with elbow extension	Biceps Brachii	14.0 ± 10.3	19.2 ± 13.5
	Infraspinatus	13.7 ± 8.94	23.3 ± 12.2
	Triceps Brachii	9.72 ± 8.98	13.3 ± 8.89
	Posterior Deltoid	6.27 ± 10.3	8.83 ± 12.3
Elbow flexion			
in pronation	Biceps Brachii	17.7 ± 23.8	15.5 ± 13.2
	Flexor Carpi Radialis	12.7 ± 16.8	6.21 ± 4.83
	Brachioradialis	15.1 ± 21.0	22.7 ± 11.1
	Pronator Teres	25.6 ± 27.7	19.5 ± 10.3
in supination	Biceps Brachii	17.8 ± 12.7	26.5 ± 15.3
	Flexor Carpi Radialis	14.1 ± 17.3	11.4 ± 11.4
	Brachioradialis	10.7 ± 11.4 *	27.2 ± 15.8
	Pronator Teres	26.8 ± 26.1	26.6 ± 17.5
Wrist extension			
in finger extension	Extensor Carpi Radialis	36.4 ± 33.8	63.5 ± 22.4
	Extensor Carpi Ulnaris	20.6 ± 18.3 *	37.2 ± 15.4
	Extensor Digitorum	32.0 ± 21.6 *	52.5 ± 15.2
	Flexor Digitorum Superficialis	7.41 ± 3.87	6.38 ± 4.82
in finger flexion	Extensor Carpi Radialis	25.7 ± 22.4 *	44.5 ± 12.3
	Extensor Carpi Ulnaris	41.8 ± 23.9	32.7 ± 13.2
	Extensor Digitorum	20.6 ± 16.0	31.1 ± 12.5
	Flexor Digitorum Superficialis	14.4 ± 9.35	9.45 ± 7.75

* Significantly difference at $p<0.05$

For wrist extension with finger flexion, muscle activity of Extensor Carpi Radialis was significant ($p=0.035$) difference between the stroke and the control (Table 4), demonstrating less activity in the muscle in the stroke. Individuals with stroke have difficulty in performing wrist extension in the mid-position and often show wrist extension in abduction. Thus, less activity in Extensor Carpi Radialis may be from weakness in the muscle.

CONCLUSION AND SUGGESTION

There were differences in muscle activity between individuals with stroke and the controls in certain movement patterns. The muscles needed to emphasize in training are Serratus Anterior, Brachioradialis, Extensor Carpi Ulnaris, Extensor Carpi Radialis, and Extensor digitorum. It is hoped that increased these muscle activity improves movement patterns in the paretic upper limb of the stroke.

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