A preliminary study into the criterion validity of the Modified Modified Ashworth Scale using the new measure of the alpha motoneuron excitability in spastic hemiplegia

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A preliminary study into the criterion validity of the Modified Modified Ashworth Scale using the new measure of the alpha motoneuron excitability in spastic hemiplegia

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Abstract

The Modified Ashworth Scale (MAS) is the most widely used clinical test for the measurement of muscle spasticity. This scale that suffers from limitations and lack of reliability and validity has recently been remodified. The aim of the present study is to investigate the criterion validity of the new Modified MAS(MMAS) in the upper limb in post-stroke hemiplegia, using the Hslope/Mslope (Hslp/Mslp) as a novel index of alpha motor neuron excitability.

Prior to the validity study, the reliability of the MMAS was evaluated in 30 hemiplegic patients. The raters agreed on 23 patients (≈76%). The MMAS had good inter-rater reliability ($\kappa = 0.63$, $SE = 0.11$, $p < 0.001$) for the assessment of wrist flexors spasticity in hemiplegic patients.

12 adult patients (7 women and 5 men) with first ever stroke resulting in hemiplegia with a mean age of 58.9 ± 11.9 years (range, 37-73) were included in the validity study. The outcome measures were the MMAS for the clinical assessment of spasticity, and the Hslope/Mslope and the Hmax /Mmax ratio for the electrophysiological evaluation.

The results showed an increase in mean rank of Hslp / Mslp in patients with a score of 1, 2 or 3 on the MMAS. However, the difference among the groups was not significant ($p > 0.05$). There was also no relationship between the clinical scale of MMAS and either the traditional [Hmax / Mmax ratio ($r = -0.06$)] or the new index [Hslp / Mslp ($r = 0.24$)] of spinal excitability.

This preliminary study recruited a small number of patients, and failed to confirm a linear correlation between these variables. A study with a larg number of patients is suggested to clarify the outcome.

Key-words: spasticity, measurement, Modified Modified Ashworth Scale, H-reflex.

Introduction

Spasticity is one of common impairments that can develop following an injury to the central nervous system (1). Lance (1980) has defined it as "a velocity dependent increase in the tonic stretch reflex (muscle tone) with exaggerated tendon reflexes, resulting from the hyper excitability of the stretch reflex, as one component of the upper motor neurone (UMN) syndrome" (2). Spasticity, a hallmark of UMN lesions, is easy to identify but difficult to measure and treat (3). It is claimed that spasticity can lead to contractures,pain and weakness. Therefore, the treatment of spasticity has been important in the clinical management of patients with UMN lesions. Current trends in research and clinical practice suggest that this focus has not changed substantially (4).

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A valid and reliable outcome measure that can be used easily in clinical settings is necessary for accurate evaluation of the effectiveness of the therapeutic interventions used in the management of muscle spasticity (5). The Modified Ashworth Scale (MAS) is probably the most widely used clinical test for the measurement of muscle spasticity (6).

However, this method suffers from limitations and lacks reliability and validity (1, 5, 7, 8, 9). Pandyan et al. (2001) showed that the MAS had a poor association with a biomechanical measure of resistance to passive movement (RTPM) (1). A further work has found that the MAS has not sufficient validity to be used as an ordinal level measure of spasticity at lower grades but it may provide a measure of RTPM (8). A study by Bakheit et al. (2003) demonstrated a nonlinear relationship between the MAS scores and alpha motor neurone excitability, suggesting the MAS as a measure of muscle hypertonia rather than spasticity (5). In the upper limb of 65 post stroke patients measurements obtained with the MAS ratings, especially higher scores, had a significant correlation with Hmax/Mmax values, confirming usefulness of clinical scales as a tool for assessing spastic patients. However, they should be integrated with objective neurophysiological assessments to provide a more precise and reliable measure of spasticity (10). Ghotbi et al. (2006), using the traditional and new indicators of alpha motor neuron excitability investigated the relationship between the MAS scores and electrophysiologic parameters.

Although a weak significant correlation was found between the MAS scores and soleus Hmax/Mmax ratio, there was no significant relationship between the MAS scores and either Hslp/Mslp or H-reflex latency, indicating the MAS as a tool to measure RTPM (9).

Recently, Ansari et al. (2006) presented the results of a study comparing inter-rater reliability of the original and of the modified Ashworth Scales for measuring muscle spasticity in elbow flexors of fifteen patients with hemiplegia. The scales showed similar levels of poor reliability (7). They found that the reduction in the reliability of the Ashworth scales may be centered around the disagreement between grades 1 and 2. They modified the MAS to distinguish the grades in the scale from one another (table 1). The aim of this study is to investigate the criterion validity of the new Modified MAS (MMAS) in the upper limb in post-stroke hemiplegia, using the Hslp/Mslp as a novel index of alpha motor neuron excitability (11).

Methods

Reliability study

Prior to data collection, reliability of the Modified MAS, using a standard procedure, was evaluated in 30 hemiplegic patients (17 males and 13 females), with a mean age of 55.6 ± 1.4 years, who were not participating in the study, agreed to participate in the assessment of reliability. The wrist flexors spasticity was assessed according to the Modified MAS by two skilled female physiotherapists. The raters agreed on 23 patients (76%) and the most agreement occured for score 3 (46.7%) and 0 (16.7%) respectively. Kappa value was good ($k = 0.63$, $SE = 0.11$, $p < 0.001$).

The Modified MAS appeared to have good inter-rater reliability for the assessment of wrist flexors spasticity in hemiplegic patients. The results were deemed to be appropriate for proceeding with this study.

Validity study

Subjects

Twelve adult patients with first ever stroke resulting in hemiplegia were included if they were able to comply with the study protocol, had a clinically detectable increase in muscle tone and were not taking antispastic drugs. Those with fixed muscle contractures and pain at the wrist joint, contraindications to passive movements, diabetic neuropathy, and discopathy were excluded. Prior to testing, all subjects provided written informed consent directly or via a care giver as approved by the research board of rehabilitation faculty, Iran University of Medical Sciences.

The outcome measures were the Modified Modified Ashworth Scale (MMAS) for the assessment of spasticity, the Hslp/Mslp, and the Hmax /Mmax ratio. The measurements were made in a same session and the assessment of spasticity using the MMAS was always carried out first.

Table 1. – *Definitions of the Modified Modified Ashworth Scale.*

Grade	Modified Modified Ashworth Scale (Ansari et al., 2006)
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension.
2	Marked increase in muscle tone, manifested by a catch in the middle range and resistance throughout the remainder of the range of motion, affected part (s) easily moved
3	Considerable increase in muscle tone, passive movement difficult
4	Affected part(s) rigid in flexion or extension.

Procedure

Demographic data were collected from subjects to document age, gender, the time post-injury, cause, and affected side. Muscle tone of wrist flexors graded according to the MMAS (7), which describes the resistance to passive movement throughout joint range of motion. A single examiner experienced at using MMAS, measured muscle spasticity at the wrist joint. In all cases, clinical measure of muscle spasticity was obtained followed by H-reflex measurements. All electrophysiological measurements were performed by a trained clinician.

The Modified Modified Ashworth Scale

Spasticity of the wrist flexors was assessed clinically with the MMAS (7). In order to eliminate inter-rater variability, the tests were carried out by one physiotherapist. The spasticity was measured at the wrist joint of the hemiplegic upper limb with the patient in the supine position.

H-Reflex Evoking Techniques

The patients underwent an electrophysiologic study of both upper limbs to assess maximum H-reflex and maximum M-response. The H-reflex and the M-wave were obtained with the MytoII EMG machine (Italy). The bandpass filter was set at 5 Hz to 3 kHz, sweep rate at 5 ms/div, and sensitivity at 500μV to 2 mV/div was used. Rectangular electric pulses, 1 ms in duration, were repeated every 5 seconds the output of which ranged from 0-100 mA. The procedure described by Jabree (12) was followed. A bipolar stimulating ball electrode was used to stimulate the median nerve at the elbow crease.

The recording electrodes were placed over the muscle belly of Flexor Carpi Radialis (FCR). Paired surface electrodes (Ag/AgCl) were used. Active electrode was placed on the belly of FCR at one third of the proximal distance between the medial epicondyl of humerus and the radial styloid. The electric resistance between the two electrodes was less than 10 kΩ. The ground was attached to the skin between stimulating and recording electrodes. The measures were made with the forearm fully supinated. The electrophysiological tests in either affected or unaffected side were randomly assigned. The amplified signals were digitized and stored in the PC computer for subsequent calculation of the electrophysiological parameters.

Recruitment curves

To produce recruitment curves, data were collected in accordance with the Funase et al. (11-13). The H-reflexes and M-waves recorded in response to stepwise increases in stimulus intensity from below threshold for the H-reflex to that eliciting a maximal M-wave. The intensity of pulses was gradually increased with 0.5 mA steps. Three pulses were collected at each stimulus intensity and the mean was calculated. The maximum amplitudes of the H-reflex and M-wave were measured Peak -to –peak, from the largest peak of the positive to the largest peak of the negative deflections from the baseline. The mean of the three H-reflexes and M-waves obtained at each stimulus intensity was expressed as a percentage of the maximal M-wave (Mmax; the mean maximal amplitude was calculated from all maximal M- responses evoked at the highest stimulus intensity). Stimulus intensity was presented as the ratio to the threshold of the M-response (Mth). Hmax was defined as the highest mean amplitude of three H-reflexes.

The equation of the simple linear regression line fitted to the recruitment curve of the size of the H-reflex was calculated from all data measured at stimulus intensities less than the threshold of the M-response. In this way, the rate of the ascending slope rise was calculated. The slope of the regression line of the H-reflex was considered as H-slope (Hslp). The slope of the regression line of the M-response was calculated in a similar manner from all M-response data and called M-slope (Mslp).

Data were analysed by using the Hslp/Mslp ratio and the Hmax/Mmax ratio. The parameter of Hmax/Mmax ratio compares the maximal H-reflex to that of the Mwave, and reflects the maximal number of alpha motoneurons firing. The Hslp/Mslp ratio has been claimed as a more sensitive measure at assessing excitability of the motor neuron pool as it excludes alterations in peripheral factors from influencing H-reflex amplitude (11-13).

Statistical analysis

The Kruskal-Wallis test was used to compare groups of cases with different MMAS scores on the indexes of spinal excitability measures. The correlation between the MMAS scores and the H-reflex indexes was calculated using the Spearman's rho test. The statistical procedures were carried out using SPSS (v 11.5).

Results

Twelve patients (7 women; 5 men) who fulfilled the study entry criteria completed the evaluation. Patients were grouped according to the clinical severity of the spasticity, as rated by the MMAS. The patients scored 1, 2 or 3 on the MMAS. There were four patients in each group. One subject had a MMAS score of 0 and was excluded from further analysis. Nine patients had left hemiplegia. Details of the patients' characteristics, demographic and H-reflex indexes, are given in table 2.

The mean age of patients was 58.9 ± 11.9 years (range, 37-73). Patients had a mean time since the stroke onset of 27.2 ± 21.3 months (range, 9-84). The mean (SD, range) of the Hmax/Mmax ratio and Hslp/Mslp was 0.49 (0.28, 0.09-0.94) and 1.45 (1.06, 0.15-3.9), respectively. The difference among the groups was not statistically significant ($p > 0.05$) (table 3). There was no significant correlation between the MMAS scores and either Hslp/Mslp ratio ($r = 0.24$) or Hmax/Mmax ratio ($r = 0.06$). The correlation between the two H-reflex indexes ($r = 0.52$, $p = 0.09$) was not significant, as well. In only 3 of the 12 patients, the H-reflex was elicitable from the unaffected side; therefore the related data were not analysed.

Table 2. – *Patients' demographic and clinical characteristics*

Patient	Age (yrs) / gender	Time since stroke (months)	MMAS* score	H / M ratio	Hslp / Mslp
1	58/m	48	1	0.73	0.94
2	73/m	18	1	0.13	0.22
3	37/f	19	1	0.67	1.63
4	61/f	26	1	0.36	1.81
5	53/f	9	2	0.34	1.70
6	72/m	13	2	0.94	3.90
7	70/f	9	2	0.86	0.56
8	73/m	18	2	0.09	0.15
9	59/f	24	3	0.50	1.90
10	49/m	40	3	0.28	1.51
11	59/f	19	3	0.68	2.46
12	43/f	84	3	0.36	0.65

* MMAS, Modified Modified Ashworth Scale

Table 3. – *The results of Kruskal-Wallis test*

Measures	MMAS* scores	Number of patients	Mean rank	Chi-Square	df	*P* value
Hmax / M max ratio	1	4	6.50	0.15	2	0.93
	2	4	7			
	3	4	6			
Hslp / Mslp	1	4	5.75	0.73	2	0.69
	2	4	6			
	3	4	7.75			

* MMAS, Modified Modified Ashworth Scale

Discussion

This study was designed to investigate the criterion validity of the MMAS using a new index of alpha motor neuron excitability, Hslp / Mslp, in post-stroke patients with muscle spasticity.

The results showed an increase in mean rank of Hslp / Mslp in patients with a score of 1, 2 or 3 on the MMAS. However, the difference among the groups was not significant.

There was also no relationship between the clinical scale of MMAS and either the traditional (Hmax / Mmax ratio) and new index (Hslp / Mslp) of spinal excitability. One possible explanation may be the small sample of patients in each groups. It may be also that each assess different aspects of spasticity. The qualitative scale of MMAS which relies on the subjective judgement of the assessor, documents resistance to passive movement. This resistance has not only a neural component, but has also a mechanical component with combination of spasticity, thixothropy and contracture (14). We excluded patients with fixed contractures, and the evidence indicates that in the absence of clinically detectable fixed contractures, the mechanical factor such as contracture is unlikely to participate in the resistance (15). However, the literature supports the notion that, although spasticity is multifactorial and neural in origin, significant structural alterations in muscle, and the changes in passive mechanical properties of muscle after spasticity also occur (5, 16).

There was no significant relationship between the neurophysiological indexes used in this study. Our results confirm an increase in the mean values of the Hmax / Mmax ratio in patients with MMAS score of 1 and 2, but not in patients with severe spasticity score of 3. There were also marked variations between individuals with the same degree of spasticity. Interestingly, the Hmax / Mmax ratio was higher in the group of patients who scored 2 on the MMAS than in those who had a score of 1 or 3. However, the differences among the groups were not statistically significant. In contrary to Hmax / Mmax ratio, the Hslp / Mslp showed an ordinal mean rank among patients with mild to severe muscle spasticity. The patients with a score of 3 on the MMAS had a higher Hslp / Mslp than in those with spasticity score 1 and 2. The patients with spasticity score of 1 on the MMAS had the least value of Hslp / Mslp. This suggests that the new index of spinal excitability may be more sensitive than the traditional indicator for evaluating the motoneuron pool excitability in spastic patients (17). The previous study (9) used the data points in the central two-thirds of the linear portion of the H-reflex and M wave recruitment curves to calculate the rate of rise of the ascending slope. We followed the method to calculate the new index of Hslp / Mslp described by Funase et al. (11). When we calculated the Hslp / Mslp using the central two-thirds of the linear portion of the H-reflex and M-wave recruitment curves, the ordinal rank of the mean value of the Hslp / Mslp in the patient groups with different MMAS scores disappeared. This finding confirms that in such investigations, the points between Hth and Hmax should be used to calculate the linear regression line fitting the development of the H-reflex to obtain the highest correlation coefficient (11, 16).

Conclusion

The results of present study showed that although the Modified Modified Ashworth Scale is a reliable measure of spasticity when used for the assessment of spasticity at wrist flexors, the relationship between the MMAS scores and the Hslp / Mslp ratio as the new index of spinal excitability is not statistically significant.

Nevertheless, the Hslp / Mslp showed an ordinal increase in mean rank in patients with a score of 1, 2 or 3. This preliminary study recruited a small number of patients, and failed to confirm a linear correlation between these variables. It follows that a study with a large number of patients would have allowed us to draw firm conclusions. A study with a larger sample of patients is underway.

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