Original Report

THE INVESTIGATION OF CRITERION VALIDITY OF THE MODIFIED ASHWORTH SCALE USING THE ALPHA MOTONEURON EXCITABILITY INDICATORS

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Abstract- The purpose of this study was to investigate the validity of the modified Ashworth Scale (MAS) by using both the conventional (Hmax/Mmax ratio) and the new indicators (Hslp/Mslp) of motoneuron excitability. This research was a correlational study on twenty post-stroke patients. Main outcome measures were the MAS and electrophysiologic assessments. The latter was performed using both conventional and new indicators of alpha motoneuron excitability. Data on 20 hemiplegic patients (seventeen men and three women) were analyzed. Correlation between the MAS and either soleus Hmax/Mmax or soleus Hslope/Mslope was not significant ($P > 0.05$). In ten patients whose H-reflex could be evoked bilaterally, only new spinal excitability indicator showed significant difference between the affected and non-affected sides ($P < 0.05$). Based on the results of this study, there is no relationship between the MAS and the indicators of alpha motoneuron excitability. This research suggests that the MAS is not a valid measure for the assessment of spasticity in ankle plantar flexors.

Acta Medica Iranica, 45(4): 290-294; 2007

Keywords: Stroke, Spasticity, MAS, Hoffmann Reflex, Motoneuron excitability

INTRODUCTION

Stroke is a common disorder, which causes long-term disability among adults (1). One of the positive features of stroke is spasticity. Spasticity has been defined as a "motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks resulting from hyper excitability of the stretch reflex as one component of the upper motor neuron (UMN) syndrome (2). Modified Ashworth scale (MAS) is a clinical rating test which is based on the assessment of resistance to passive movement at a joint. Currently, it is the most widely used test for measurement of muscle spasticity in research and clinical practice (3-8). However, despite the large body literature focused on the MAS, validity of the scale for measuring spasticity is still questionable (3, 6). Since spasticity is associated with increased excitability of alpha motoneurons (3) and H-reflex indirectly measures the spinal excitability; some researches mainly used the conventional indicator of H-reflex (Hmax/Mmax ratio) for assessing the spasticity (3, 9). However, as previously reported, Hmax/Mmax ratio may lead to false assessments of motor neuron pool excitability (10).

In order to overcome this obstacle, new indicator of Hoffmann reflex (i.e. Hslope/Mslope ratio) has been introduced. It is reported that this parameter is a more accurate and sensitive measure of spinal excitability (10-12).

Received: 2 Dec. 2005, Revised: 14 Jul. 2006, Accepted: 4 Sep. 2006

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In this respect, the main objective of current research was to investigate the validity of this scale by using both the conventional and new indicators of soleus Hoffmann reflex.

MATERIALS AND METHODS

Twenty hemiplegic patients due to first stroke participated in this correlational study. This study was approved by the Ethical Committee of Tehran University and each subject provided informed written consent. Inclusion criteria: absence of ankle fix contracture, no use of drugs which affects neuromuscular system and being in spastic phase.

Procedures

All information with regard to gender, weight, height and post stroke duration was recorded. Thereafter, clinical and electrophysiological assessments were performed in the same session and under the same conditions, respectively.

Clinical assessment

Patients were lying flat in supine position with socks and shoes removed. As the level of muscle tone can be affected by the volume of bladder, patients were asked to empty their bladder.

Spasticity of the calf muscles was rated according to the MAS. This scale measures the resistance to passive movement and is a 6-point scale from 0 (no increase in muscle tone) to 4 (affected part[s] rigid in flexion or extension) (13).

All tests were carried out by one investigator to eliminate inter-rater variability (3).

Electrophysiological assessment

Patients were comfortably positioned in prone lying and the feet suspended over the end of the bed. The skin temperature over the calf muscles was monitored via a digital thermometer. Paired surface electrodes (silver-silver chloride) were placed to the belly of the soleus muscle according to Hugon classic protocol (Hugon, 1973). Tibial nerve in the popliteal fossa was stimulated via a cathode placed on the skin overlying the nerve (with a rectangular electric pulse of 0.5 ms duration and a stimulus frequency of 1 per five seconds). The anodal electrode was placed on the quadriceps muscle above the patella. A cuff type ground electrode was placed between the stimulating cathode and the EMG electrodes.

The stimulus strength was gradually increased from below threshold to supramaximal. Three pulses were delivered sequentially at each stimulus intensity, and the mean was calculated to allow for normal variation in H-reflex amplitude at rest.

EMG signals were filtered (5, 5000Hz), and amplified (gain 500-2500 for H-reflex) with Toennies (Neuroscreen Plus, Germany) and stored for further analysis.

Data Analysis

Peak–to–peak H-reflex and M-wave amplitudes were measured from the largest positive and negative deflection from the baseline. The mean of the three H-reflexes collected at each stimulus intensity was expressed as a percentage of the maximal M-wave (Mmax).Stimulus intensity was expressed relative to the threshold intensity for an M-wave (Mth) (12, 10). For each patient, the data points being in the middle of the linear portion of the H-reflex recruitment curve were analyzed by linear regression. In this way, the rate of the ascending slope rise was calculated.

The rate of rise of the H-reflex recruitment curve described the increase in H-reflex amplitude per unit of threshold stimulus intensity and was called H-slope (Hslp) (Fig. 1).

The rate of rise of the linear portion of the M-wave recruitment curve was calculated in a similar manner and called M-slope (Mslp) (Fig. 1).

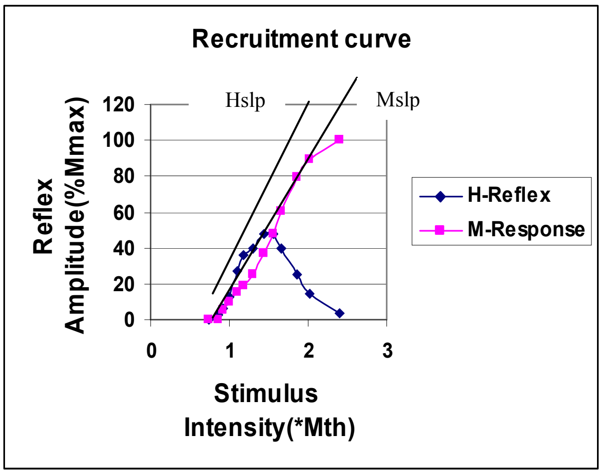

Fig. 1. Recruitment curve in a patient.

Figure 1 shows the recruitment curves of H-reflex and M-response in the affected side of a patient who had an MAS score of 2. The two lines represent the slope of H-curve and M-curve (H-slope & M-slope).

Statistical test

To determine the criterion validity of the scale, correlation between it and each of the alpha motoneuron excitability measures was calculated by Spearman rank correlation test.

Analysis of differences between affected and unaffected sides was made with the paired *t* test. Data were analyzed using the SPSS statistical package (version 11.5).

RESULTS

20 hemiplegic patients (3 women, 17 men) were investigated. Twelve patients had right hemiplegia, and eight subjects had left hemiplegia. Mean age, height and weight were 61.80 ± 11.98 years, 168.79 ± 11.38 cm and 75.89 ± 12.86 kg, respectively.

Descriptive information about the characteristics of the study population is included in table 1.

Range of the MAS scores was 0 to 3. Mean ± SD values of soleus Hmax/Mmax and Hslope/Mslope ratios were 0.45±0.25 and 1.56 ± 1.45, respectively. There was no significant correlation between degree of spasticity, as rated by the MAS and either Hmax/Mmax ratio or Hslope/ Mslope ratio ($P > 0.05$).

In 10 of 20 patients, H-reflex could be evoked bilaterally. Thus, mean ± SD values of the soleus Hmax/Mmax ratio (unaffected side: 0.25±0.23, affected side: 0.38 ± 0.19) and Hslope/Mslope ratio (unaffected side: 0.46 ± 0.30, affected side: 1.05 ± 0.53) was calculated in ten patients. Only Hslope/Mslope ratio showed a significant difference between two sides (t=4.2, df= 9, *P* = 0.002) (Fig. 2).

Table 1. Descriptive data in hemiplegic patients

1	47	4	1^{+}	0.60	1.60
2	54	22	2	0.26	0.31
3	69	12	2	0.28	0.59
4	57	29	1	0.63	1.87
5	59	10	2	0.47	1.49
6	64	60	3	0.14	0.24
7	39	26	3	0.91	4.69
8	72	1	1	0.64	2.51
9	81	54	3	0.49	1.36
10	70	8	1^{+}	0.32	2.01
11	53	13	0	0.04	0.05
12	42	12	1	0.45	0.83
13	68	32	1	0.41	1.10
14	47	1	1^{+}	0.23	0.85
15	80	12	1	0.09	0.36
16	76	9	0	0.31	1.84
17	67	36	2	0.78	1.48
18	65	60	1^{+}	0.46	1.31
19	63	5	0	0.68	2.46
20	63	9	2	0.82	5.84
Mean±SD	61.80±11.98	20.75±18.91		0.45±0.25	1.56±1.45
Range	39-81	1-60	0 - 3	0.04 -0.91	0.07 -5.84

Hslp means Hslope; Mslp means Mslope

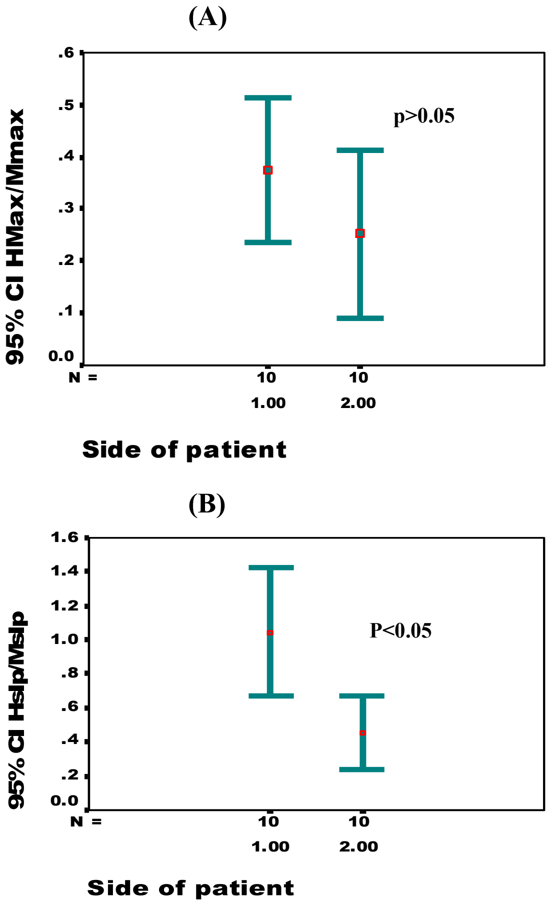

Fig. 2. Mean ± SD values of conventional (A) and new (B) indicators of alpha motoneuron excitability in the affected and unaffected of 10 patients. Number 1 and 2 indicates the values for affected and unaffected sides, respectively.

DISCUSSION

Up to the present, this research was the first to use recruitment curves for determining the validity of the MAS. Previous studies, investigated the relationship between MAS and either biomechanical measures (6) or traditional parameter of H-reflex (3, 7, 9, 14). Most of which showed low to moderate correlation (6, 14, 9) and some presented no correlation (7, 9).

Our findings showed that there was no significant correlation between the MAS scores and either Hmax/Mmax ratio or Hslope/Mslope ratio. New indicator of spinal excitability was calculated via recruitment curves of H-reflex and M-wave and linear regression line of them. Although, the Hslope/Mslope ratio is more sensitive than Hmax/Mmax ratio for the assessment of motoneuron excitability, the results of the present study showed that the Hslope/Mslope ratio has no relationship with the MAS scores. Since the MAS relies on subjective assessment of reflex activity, lack of its correlation with neurophysiologic tests may relate to problems inherent to the scale itself.

Only Hslope/Mslope ratios showed significant difference between the affected and unaffected sides in our patients. This finding was in agreement with Higashi et.al study (12) and may suggest that the rate of excitability of motoneurons is not symmetrical in both sides. The increase of spinal excitability in the affected side could be related to a decreased inhibitory control on the lower motoneuron or to an increase of stretch reflex excitability secondary to a presynaptic inhibition (15).

In the present study, in order to increase the reliability of experiments ,the following points were considered; both tests were carried out in the same session and under the same conditions and the factors which could influence the H-reflex test (e.g. head & limb position) (16) and the MAS test (e.g. bladder status) were controlled. Thus, in conclusion, no correlation between the scale and spinal excitability measures suggests that MAS does not provide a valid measure for evaluating spasticity in ankle plantar flexors.

Acknowledgment

This project was supported by a grant from the Postgraduate Studies and Research Program, Medical Sciences / University of Tehran, Tehran, Iran. The authors would like to acknowledge the generous assistance of the staff of Faculty of Rehabilitation, Tehran University.

Conflict of interests

The authors declare that they have no competing interests.

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