H-reflex excitability in children with spastic cerebral palsy

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Summary :

Background: Cerebral palsy is a disorder of movement and posture resulting from permanent, non-progressive defect or lesion of the immature brain. Spastic cerebral palsy is a common clinical type which is difficult to diagnose clinically in the early years of life. This study was conducted to identify the changes in the H-reflex excitability in children with spastic cerebral palsy as compared to normal children.

Methods: The excitability of the monosynaptic H-reflex pathway was tested in 36 children with spastic cerebral palsy during waking by calculation of the H-reflex wave amplitude with the ratio of maximal H /maximal M response amplitudes and compared with 32 normal children of the matching age. The Hoffman's reflex was evoked in the soleus muscle after stimulation of the tibial nerve at the popliteal fossa.

Results: The mean H-reflex wave amplitude (Ha) values are found to have statistical significant difference between both groups ($P < 0.05$) while the mean maximum M-response amplitude (Ma) showed no statistical differences between both groups ($P > 0.05$). However, the ratio of mean amplitude of the maximum H-wave to that of the maximum M-response (Ha/Ma) was significantly higher in the spastic children group than in controls ($P < 0.05$).

Conclusion: Our results showed that the Ha/Ma ratio does provide a helpful electrophysiological tool that can be correlated with the other clinical signs in the diagnosis of cerebral palsy by identifying motor neuron hyperexcitability.

Key words: The H-reflex, Spastic children, Cerebral palsy.

Introduction:

Cerebral palsy is a term used to denote a disorder of movement and posture resulting from permanent, non-progressive defect or lesion of the immature brain (1) .It represent a large problem because the children who suffer from cerebral palsy frequently have other sever handicaps; like intellectual impairment, epileptic seizures, speech disorders, ophthalmological abnormalities and deafness. (2)

Spastic cerebral palsy is a common clinical type which shows features of pyramidal tract lesion; such as muscle spasm, spastic posture of the limbs, exaggerated deep reflexes, ankle clonus and after the age of 2-3 years an extensor planter response.(1) In sever cases, the diagnosis is easy from the early weeks of life, however, in many cases early diagnosis is extremely difficult and in occasions impossible. It can be beyond the skill of the most experienced to decide just when the adductor muscle tone is out side normal limits or when knee jerks are pathologically brisk.(1) Most authors admit to have been confused rather than assisted by attempts to elicit and interpret most of the primitive reflexes described in the literature (1,2,3) furthermore, the examination of the deep stretch reflexes is rather difficult in neonates and young children. (1, 3)

The muscle stretch reflex provided a good measure of motor neuron excitability. However, clinical observations dose not objectively quantities the briskness, velocity and the bilateral symmetry of these reflex responses. These reflexes are usually elicited by taping the muscle tendon with the ordinary reflex hammer, to cause a sudden stretch of the muscle, during the clinical examination. However the stretch reflex can be elicited not only by stretching of the muscle (involving the activation of the muscle spindle receptors) but also by the electrical excitation of the corresponding afferent Ia nerve fibers (4). Therefore, electrophysiological recording of the stretch reflex, after mechanical triggering with a special hammer or after direct electrical stimulation to the Ia afferent fibers, do offer these advantages and can give more detailed results (5, 6). The "Hoffmann's reflex" is more practical and precise in providing the mentioned objectives since it can be elicited easily and recorded electrophysiologically and its parameters afford valuable information's about the conduction in the reflex circuit as well as about the motor neuron pool excitability.

The classical monosynaptic reflex responses were subjected to numerous studies in normal adult man and in the spastic man (7, 8, 9). In the child, few H-reflex studies were applied to children principally

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for studying the excitability of the motor neurons (10). It is well known that the classical H-reflex response, evoked by simulation of the tibial nerve at the poplitial fossa, recorded from the calf muscles in normal relaxed adult subject, may also be recorded from other muscles of the limbs, but not in the small muscles of the hand or foot (6, 11). However, in adult with upper motor neuron lesions, H-reflex can be evoked also in small hand and foot muscles due to alpha motor neurons hyperexcitability (12). It was found that the H-reflex monosynaptic pathway is already functioning at 25 weeks post cenceptional age in man and can be evoked easily in normal premature, newborns and infants of less than 6 months of age but no H-reflex could be recorded in these muscles after the age of 1 year (13), this was related to the increased alpha motor neuron excitability due to the imbalance between facilitatory and inhibitory effects on the spinal motor neuron as a result of the immaturity of the CNS (14,15). Therefore, the persistence of the H-reflex in the hand muscles beyond the age of 1 year has been interpreted as an evidence of CNS dysfunction (16,17).

The maximum H-reflex wave amplitude (Ha) in relation to the maximum muscle (Ma) response amplitude (Ha/Ma ratio) recorded from the calf (the soleus-gastrocnemius) muscles is used to assess reflex excitability (10, 15). Lesions of the motor cortex in adults make the H-reflex reappear in limb muscles at the level where it existed in the child and a significant rise in the (maximal H/maximal M ratio) in spastic adolescents or adults was reported (4,18,19,20). Moreover, in adult hemiplegics, the H/M ratio of the spastic limb was found to be higher than that of the non-affected side (4, 21). This finding is variable in children, as some published literatures found no significant difference in the mean H/M ratio between spastic and normal children (12, 22).

This study was conducted to identify the changes in the H-reflex excitability in children with spastic cerebral palsy as compared to normal children.

Patients and methods:

Subjects:Thirty-six (36) children, below 12 years of age, examined clinically and diagnosed to have spastic cerebral palsy by consultant neurologist, were the subjects of this study. The group included 6 neonates (1-28 days of age), 10 infants (1 month – 1 year of age) and 20 children (2-12 years of age).

A control group of 32 normal children matched with the same age (8 neonates, 12 infants and 12 children) of full term, normal deliveries, had no family or past medical history of neurological diseases and were normal on physical examination and by assessment of weight, height (length for infants and neonates) and head circumference.

Methods:

The H-reflex was recorded from the soleus muscles after stimulation of the tibial nerves at the popliteal fossae. DANTEC Counter-point EMG system was used .The DANTEC 13S93 Velcro ribbon strap-grounding electrode was placed between the stimulation and recording sties after being soaked in saline to ensure good electrical conduction. The bipolar stimulation electrode (DANTEC 13L36 for children, DANTEC 13L35 for infants and neonates was used, after soaking its felt tips in saline, to stimulate the tibial nerve in the popliteal fossa at the level of the popliteal crease (figure 1). The cathode was placed proximally, just lateral to the popliteal artery to avoid stimulating the peroneal nerve. Recording was made by a pair of DANTEC 13L20 disposable surface electrodes, which were applied, after cleaning the skin with spirit and the addition of the electrode paste (DANTEC 15B411), in such a way that the active electrode was placed at a point of bisection of the line connecting the popliteal crease and the proximal flare of the medial malleolus (at the muscle belly), while the reference electrode was placed 30mm distally (figure 1). These electrodes were connected to the amplifier by the electrode cable DANTEC 13L02.

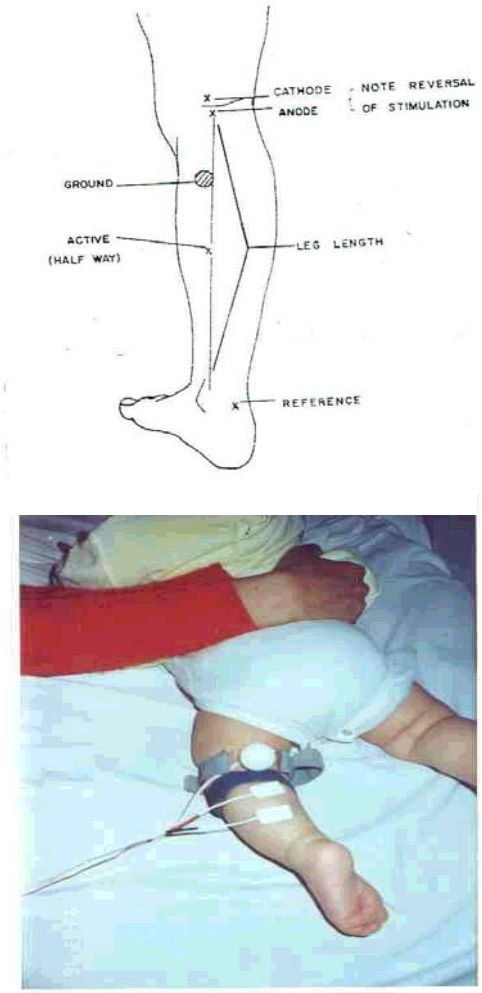

Figure 1: Sites of electrodes during H-reflex recording

The stimuli were constant current, square wave electric shocks of a negative polarity and 0.1 msec.

duration at a frequency of 1Hz. These were delivered with low intensity current. The stimulus intensity was increased to evoke an H-reflex. Then the intensity was further increased gradually until a maximum H-response was obtained with a minimum motor response (M) of the muscle.

Further increase in stimulus intensity reduces the H-reflex wave amplitude and increases the M-response amplitude. When supramaximal stimuli are used, H-wave disappears and is, in some times, replaced by the F-wave (figure 2).

The electromyographic setting was:

Frequency: 100-5000Hz

Sweep speed: 8 msec /Div.

Sensitivity: 500mV/Div.

Five H-reflex trials were recorded, to ensure reproducibility, and then the mean of the following parameters was recorded for further analysis: The amplitude of the maximum H-reflex wave,

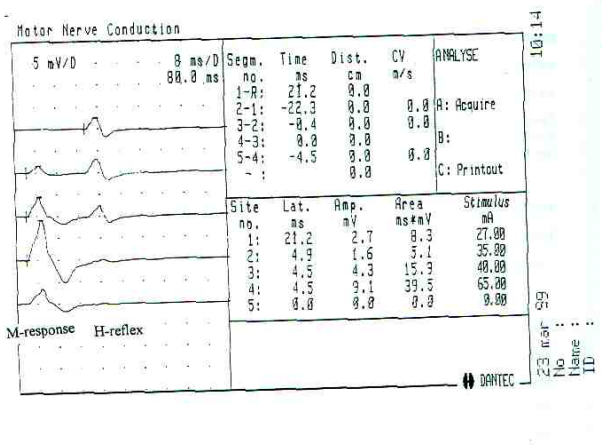

Figure 2: Trace of H-reflex recording

the maximum M-response amplitude and the H/M ratio.

The maximum H-reflex amplitude (Ha) and M-response amplitude (Ma) were measured from the most negative to the most positive deflection of the maximum responses from the base line. Ha/Ma was also calculated for each subject.

Standardization of the technique was strictly observed in all subjects. The children were either in reclining position with the lower limbs supported by a restraining table made in the laboratory, or lying in prone position on an examination couch with the feet suspended over the edge of the couch. A small pillow was placed under the ankles. In both cases, the limb position was 120^{O} flexion at the knee joint and 90^{O} flexion of the ankle joint [6] .The tests were performed in complete resting position in a quiet and warm room with a silent EMG recording to avoid active contractions of the agonist and antagonist muscles.

Results:

The mean H-reflex wave amplitude (Ha) was recorded to evaluate the excitability changes of the soleus motor neurons in the spastic subjects as compared to the normal control group. The mean Ha values are found to have statistical significant difference between both groups ($P < 0.05$).Table 1

The mean maximum M-response amplitude (Ma) showed no statistical differences between both groups ($P > 0.05$).

However, the mean amplitude of the maximum H-wave to that of the maximum M-response (Ha/Ma) was significantly higher in the spastic children group than in controls. Table 1

Table –1-

The characteristics of H-Reflex wave amplitude and Ha/Ma

Groups	H a mV	M a mV	Ha/Ma	No. of subjects
1 cerebral palsy	3.42±0.93	4.56±1.03	0.75±0.069	36
2 control	2.21±0.39*	4.27±0.79	0.42±0.015*	32

Values are in mean ± SD

*=Significant level ($P<0.05$)

Ha= maximal H-reflex amplitude

Ma= maximal M-response amplitude

mV= Milli Volts

Discussion:

The study of the H-reflex wave parameters in children can provide not only information about the conduction in the sensory and motor fibers of the reflex circuit but also it can determine the state of excitability of the reflex motor neurons, which is under the influence of higher centers; hence, it may give an indirect idea about the state of the central nervous system maturity and function (11).

The recording of the H-reflex to infants is much difficult, time consuming and requires patience, since full relaxation in an awake infant takes much effort. However we utilized the H-reflex evoked in the soleus muscle, since it is the only H-reflex that persists to adult life, to determine the excitability changes in the spinal motor neurons in spastic children.

The maximum H-reflex wave amplitude represents the total activity of the motor units activated by Ia afferent fibers. Our results showed that the maximum H- amplitude increases slightly but significantly in spastic children, indicating an increase the number of activated motor unites as a result of less supraspinal suppressor effects on the reflex pathway. (23)

While the maximum M-response amplitude (representing the activity of all motor neuron units in the muscle) did not show significant difference in the spastic children than the control group which is expected since the total motor units of the muscle are not affected by this central defect. Similar findings were reported (11,19,22) of increasing H but not M response amplitude in spastic children and in adult with upper motor neuron lesions (9) due to alpha motor neurons hyperexcitability.

The relation of the maximal H amplitude to the maximal M-response amplitude is an index of the

reflex motor neuron excitability and of what portion of the motor neuron pool can be activated by this reflex (7, 12, 14). The ratios determined in the calf muscles of the subjects included in our study were significantly higher than in the normal infants and children, which demonstrates an increased monosynaptic reflex excitability due to the cortical damage; since the suppressor effects on reflex excitability during infancy are, for most part, supraspinal (18) and cortical or subcortical lesions presumably suppress the descending inhibitory volleys, especially those affecting extensors, hence disturbing the physiological balance of reciprocal inhibition (24,25,26).

Our results showed that the H/M ratio does provide a helpful electrophysiological tool for the diagnosis of cerebral palsy by identifying motor neuron hyperexcitability where in most cases of cerebral palsy there is a reflexologic characteristic differentiating them from normal children. Further studies with larger sample size are needed.

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