SOMATOSENSORY EVOKED POTENTIALS IN SPINAL CORD INJURED PATIENTS

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Abstract. Out of 25 patients with traumatic spinal cord injuries, ten patients with complete and 15 incomplete (five serially) were evaluated with somatosensory evoked potentials. Clinical correlations are presented and discussed.

Introduction

IN 1941, Marshall *et al.* described the cerebral somatosensory projection of primates. Dawson (1950, 1954, 1956) first evoked somatosensory cerebral potentials (SEPs) in man by electrically stimulating the fingers. The evoked potentials had an amplitude of less than 10 microvolts and were isolated at first by superimposition and later by averaging techniques from the contralateral cerebral hemisphere. Since then, SEPs have been isolated after stimulation of the upper extremities (Allison, 1962; Goff *et al.*, 1962; Giblin, 1964; Halliday, 1967) and of the lower extremities (Liberson *et al.*, 1963; Bergamini *et al.*, 1965; Oester *et al.*, 1972; Tsumoto *et al.*, 1972).

SEP values include transmission of the evoked potential through the spinal cord (Desmedt, 1971; Desmedt *et al.*, 1973). An involvement of the posterior column of the spinal cord has resulted in prolonged or absent SEP values (Halliday *et al.*, 1963). The lower extremity SEP values reappeared (though delayed) after removal of an extradural benign tumour (Oester *et al.*, 1972). The importance of the posterior column of the spinal cord in the transmission of SEPs has recently been confirmed (Cusick *et al.*, 1979), especially with regard to the early components of the SEPs of the spinal cord (Wiederholt, 1978). SEPs then reflect the continuity of the posterior columns. However, none of the above observers had studied SEPs in a number of spinal cord injured patients. The object of this study was to explore the use of SEPs to evaluate the status of the spinal cord in spinal cord injured patients.

Methods and Materials

Patients (Table I)

Twenty healthy unpaid volunteers comprised the control group. None of the volunteers had any history of diabetes, alcoholism or any neurological disorder. Ten patients with traumatic spinal cord injuries (SCI) had no evidence of motor or sensory function bilaterally below the level of the lesion (complete SCI group). Another ten patients with traumatic spinal cord injuries had sensa-

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TABLE I

Group	Patients	Age range (median)	Neurological level	Duration (weeks)
Control	20	28-49 (36)	none	—
Complete spinal cord injuries	10	20-47 (40)	D4-D9	4-8
Incomplete spinal cord injuries	10	24-55 (34)	C7-L2	4-8
Serial examination	5	20-34 (27)	L1-L4	3-5 (first) 6-9 (second)

tion bilaterally below the level of the injury (incomplete SCI group). Five patients initially presented with traumatic spinal cord injuries had no sensation below the level of the lesion. All were initially evaluated from 3 to 5 weeks after the onset of the injury. All five patients were retested after an additional 3 to 5 weeks (serial exam group).

Methods

SEPs were obtained after electric stimulation of the median nerve according to the method of Kaplan (1978). The medial plantar nerve was stimulated with bipolar surface electrodes placed on the first toe. Square wave electric pulses were delivered (0.01 to 1 ms duration, 1 Hz frequency) of 100 to 300 V intensity. SEPs were recorded from a monopolar electrode placed over the contralateral hemisphere, 4 cm below the vertex and 2 cm behind the line connecting the

FIG. 1

Determination of nomenclature of somatosensory cerebral evoked potentials.

vertex to the ear. The reference electrode was fastened to the vertex and the ground electrode to the patient's forehead. A TECA model TE-4 electromyograph was used (high frequency filter 8K Hz, low frequency filter 1.6 HZ). Bioelectric signals were averaged with a model AVM6 evoked potential averager. One hundred stimulations were averaged. The patient must be rested and quiet.

Latency values of the SEPs were measured from stimulation to departure from the isoelectric line and also to the peak of the first evoked potential. After stimulation of the median nerve, this evoked potential was the first negative response (N_1). That for the medial plantar nerve was the first positive response (P_1). This nomenclature system was used by Desmedt *et al.* (1973). The methodology is illustrated in Figure 1. In each patient, both nerves were stimulated on the stronger side.

Results

The results of the control, incomplete SCI, and complete SCI groups are presented in Table II. SEPs were obtained in each of the control volunteers after stimulation of the median and medial plantar nerves.

In the incomplete SCI group, SEPs were obtained in each patient after stimulation of the median and medial plantar nerves. The values were not significantly different from the control population.

In the complete SCI group, SEPs were obtained in each patient after stimulation of the median nerves. However, no SEPs could be obtained after stimulation of the medial plantar nerves. The SEP values recorded after stimulation of the median nerves were not significantly different from control values.

The values for the serial examination group are presented in Table III. SEP values, not significantly different from control values, were obtained at the first and second evaluations after stimulation of the median nerves. SEPs could not be obtained after stimulation of the medial plantar nerves at the first examina-

TABLE II

Group	Nerve stimulated	Somatosensory evoked potential	
		Latency (ms)	Peak latency (ms)
Control	Median	N_1 18.8 ± 2.2	N_1 21.4 ± 1.7
	Medial plantar	P_1 39.1 ± 3.1	P_1 41.2 ± 2.2
Complete spinal cord injuries	Median	N_1 18.6 ± 2.4	N_1 21.3 ± 1.6
	Medial plantar	P_1 Absent	P_1 Absent
Incomplete spinal cord injuries	Median	N_1 18.9 ± 2.3	N_1 21.0 ± 1.7
	Medial plantar	P_1 38.9 ± 3.0	P_1 40.7 ± 2.5

TABLE III

Group patients	Nerve	Somatosensory evoked potentials (ms)*	
		First exam.	Second exam.
Serial exam. (5)	Median	21.1 ± 1.3	21.5 ± 1.6
	Medial plantar	Absent	41.1 ± 3.7

Key: * Peak latencies only

tion. However, SEP latency values, not significantly different from control values, were observed at the second examination. At the time of the re-examination, all five patients had sensation bilaterally below the neurological level.

Discussion

The median and medial plantar nerves when stimulated from the index finger or first toe send evoked responses to the spinal cord through the C6, 7, 8 and L4, 5 spinal nerve roots respectively (Warwick *et al.*, 1973). Therefore, SEPs obtained after stimulation of the median nerve evaluated spinal cord function to the C8 neurological level. SEPs from the medial plantar nerve similarly evaluate function to the L5 neurological level. Indeed, SEPs mirror spinal cord function to the extent that a normal spinal cord conduction velocity of 55.1–99 M/sec has been obtained using SEPs (Dorfman, 1977).

SEP values accurately reflected clinical findings in the serial exam group as well as in the complete and incomplete SCI groups. Early components of the SEP reflect activity in the posterior column of the spinal cord, in the medial lemniscus, in the ventroposteriolateral nucleus of the thalamus and in the sensory radiation to the cortex (Wiederholt, 1978). The cortical responses themselves have also been characterised. N_1 of the SEP after stimulation of the median nerve (Noel *et al.*, 1975) has relatively short latencies, limited scalp distribution, prompt recovery and relative stability. They, therefore, are responses procured by impulses of the presynaptic thalamocortical projection system (Bremer, 1958). P_1 of the SEP after stimulation of the medial plantar nerve has been positive rather than negative, of longer duration, and has had a longer recovery after maximal excitation (Towe, 1956; Tsumoto *et al.*, 1972). Therefore, it is probably postsynaptic. Both N_1 and P_1 are generated posterior to the rolandic sulcus (Tsumoto *et al.*, 1972). Therefore, SEPs have clear pathways from the spinal cord and may accurately reflect anatomical changes affecting dorsal column conduction within the spinal cord.

Future uses of SEPs in spinal cord injured patients might also involve the study of acutely injured patients. Evidence of significant deterioration would be shown in the acutely spinal cord injured patient who at first had a SEP from stimulation of the medial plantar nerve and then lost it. The disadvantages of doing the test in acutely injured patients are the requirements for a rested, quiet attitude of the patient and the need for space for the electromyograph, preferably away from electrical machines that could interfere with the bioelectric signal.

SUMMARY

A vertical and longitudinal study of SEPs in a control population (SEP median nerve = 19.1 ± 1.7 ms; SEP medial plantar nerve = 41.2 ± 2.2 ms), and in groups of spinal cord injured patients revealed that the SEP accurately reflected the clinical status of the patients. It was of use in documenting return of function in spinal cord injured patients.

RÉSUMÉ

Sortie de 25 malades souffrant de lésions de l'épine dorsale, 10 malades avec complètes lésions et 15 malades avec incomplètes lésions (5 série) ont été examinés en utilisant les potentiels évoqués corticaux. Les corrélations cliniques sont présentées et interprétées.

ZUSAMMENFASSUNG

25 Patienten mit traumatischen Wirbelsäuleverletzungen, 10 Patienten mit totalen und 15 Patienten mit unvollständigen Verletzungen (5 Reihenweise), wurden durch Gebrauch von somatosensorischem hervorgemfenem Potentiell untersucht. Klinisch gegenseitige Verhältnisse werden präsentiert und discutiert.

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