Med. J. Malaysia Vol. XXXIII No. 2, December, 1978

NERVE CONDUCTION VELOCITIES AND DISTAL LATENCIES IN NORMAL MALAYSIAN SUBJECTS

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INTRODUCTION

NERVE CONDUCTION velocities are easily measured on peripheral nerves. Nerve impulses are triggered with graded stimuli of an electrical stimulator. Once the action potential threshold of a nerve fibre is reached the electrical impulse propagates along it in a saltatory manner according to the 'all or none' principle at a rate of a few to about a hundred metres per second. This velocity of propagation varies directly with the diameter of the nerve fibre (Gasser and Grundfest, 1939; Hursh, 1939) and its temperature (Henriksen, 1956; Buchthal and Rosenfalck, 1966). It is influenced by age (Norris *et al.*, 1953; Thomas and Lambert 1960; Downie and Newell, 1961; Buchthal and Rosenfalck, 1966).

The peripheral nerve conduction velocity was first measured by Helmholtz in 1850. The technique of conduction study in clinical practice was introduced by Hodes and associates in 1948 and became well established in the sixties.

This test is an important diagnostic tool in the investigation of some neurological disorders. In conjunction with electomyography, it helps to differentiate primarily muscle disorders from nerve diseases. It aids in localization of the site of the nerve lesions particularly entrapment syndromes, e.g. carpal tunnel syndrome. It may indicate either an axonal or demylinating type of peripheral neuropathy (Gilliat, 1966). Here we would like to report a series of normal values and the techniques which we employed to obtain them.

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MATERIAL

The measurements were made on the upper and lower limbs of 27 male and 20 female volunteers with no clinical evidence of neuromuscular disorders. The volunteers with ages between 19 and 35 years, with a mean of 25.6. and a S.D. of 4 years, consisted mainly of medical laboratory technologists and medical students.

METHOD

In each subject autodromic motor and antidromic sensory distal latencies and conduction velocities of the median and ulnar nerves were measured. On the lateral popliteal and posterior tibial nerves only motor velocities were studied. In addition, antidromic sensory conduction velocity was measured on the sural nerve.

The sites of stimulating and recording electrode placement are shown in the Table I. The electrodes were held in place by skin adhesive tape. The electrical contact was maintained by NaCl solution and/or electrode paste.

The nerves were supramaximally stimulated with square wave of duration 0.2 msec and voltages up to 500 volts at a rate of one pulse per second. The stimulating pulses were delivered from DISA 14E10 stimulator via an isolation transformer. The electrode consisted of an anode and a cathode held 25 mm apart. They were made of 6 mm cotton wick held in a stainless steel cup. During stimulation the cathode was placed directly above the nerve trunks distal to the anode.

The action potentials were picked up by the recording electrodes made of either silver disc. of 10 mm in diameter or 3-5 mm by 50 mm flexible silver strips for the fingers. The action potentials were led to DISA 14A30 3-channel electromyograph which amplified at 100 uv/Div. and 10

Table 1

Sites of stimulating and recording electrode placement

Nerve		Site of Stimulation	Site of Recording
Median	Motor	wrist, elbow and axilla	thenar muscle
	Sensory	wrist, elbow and axilla	index finger
Ulnar	Motor	wrist, elbow and axilla	hypothenar and 1st dorsal interosseous muscles
	Sensory	wrist, elbow and axilla	last finger
Lateral popliteal	Motor	ankle and knee	extensor digitorum brevis muscles
Post. tibial	Motor	ankle and knee	abductor hallucis muscles
Sural	Sensory	7, 14 and 21 cm above the recording electrode	lateral malleolus

mv/Div. for sensory and motor potentials respectively. The stimulus artefacts and the responses were displayed on a large cathode ray tube. The latencies were measured electronically from the stimulus artefact to the onset of motor action potentials and to the 1st negative peak of sensory action potentials (Fig. 1).

For safety reasons and reduction of main inteference a ground electrode of a lead strip was placed in between the stimulating and the recording electrodes.

The lengths of a nerve were estimated from the measurement with a flexible measuring tape along the surface of the limb between the cathode positions. The distal latencies in msec were taken from direct readout and the conduction velocities in metres per second (m/s) were calculated by dividing the segment length with the latency difference.

The room and skin temperatures were measured with an electronic thermometer ELLAB Type TE3.

RESULTS

The means and standard deviations of both motor and sensory distal latencies and conduction velocities of the ulnar and median nerves in the upper limbs are shown in the TableII. The values for the upper segment are generally higher with greater scatter. The mean motor distal latency of the ulnar nerve from wrist to the 1st dorsal interosseous muscle was 4.0 msec S.D. 0.6 msec. The values for the lateral popliteal and the posterior tibial nerves are shown in the Table III The conductions are generally slower than those of the upper limb. The antidromic sensory conduction values of the sural nerve are shown in the Table IV.

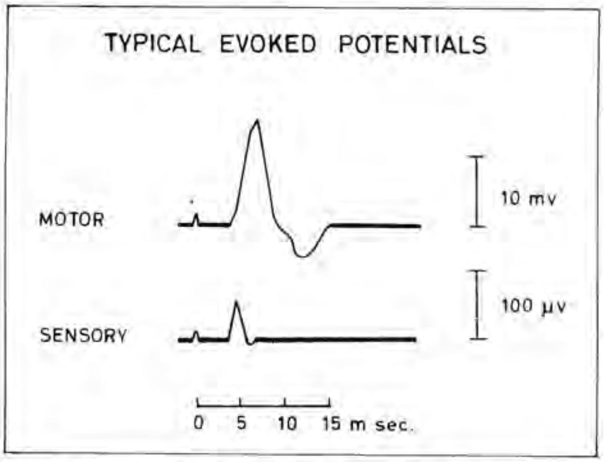

Fig. 1. Schematic diagram showing stimulus artefacts preceding the evoked motor and sensory nerve potentials.

The surface temperatures near the recording electrodes and room temperatures are shown in TableV.

Table II

Motor and sensory conduction in the upper limb

Nerve		Distal latency msec	Conduction velocity wrist — elbow m/s	Conduction velocity elbow — axilla m/s
Ulnar	Motor	3.1 ± 0.7	56.8 ± 4.9	62.5 ± 7.7
	Sen.	3.0 ± 0.4	58.7 ± 4.2	60.2 ± 7.7
Median	Motor	3.5 ± 0.5	58.6 ± 4.2	68.6 ± 5.6
	Sen.	3.3 ± 0.4	58.6± 4.9	65.9 ± 6.4

Table III

Motor conduction in the lower limb

Nerve	Distal latency msec	Conduction velocity ankle — knee m/sec
Lat. Popliteal	4.5 ± 0.4	50. 8 ± 5.0
Posterior Tibial	4.3 ± 0.7	48.8 ± 5.8

Table IV

Sural nerve conduction

	Distal latency msec	Conduction velocity m/s
Lower Segment	2.3 ± 0.2	50.0 ± 6.0
Upper Segment	3.7 ± 0.3	53.2 ± 5.2

Table V

Skin and room temperatures at test

LOCATION	Mean °C	S.D. °C	Range °C
Ulnar N.*	30.3	±2.1	24.3 — 37.0
Median N.*	30.8	±4.1	27.0 — 35.5
Lat. Popliteal N.*	30.0	±2.0	25.8 — 36.0
Post. Tibial & Sural N.*	29.3	±1.9	25.3 — 32.5
Room	22.9	±2.0	21.5 — 24.8

*Skin temperature near the recording electrodes

DISCUSSION

Surface electrodes were used instead of needle electrodes for stimulating the nerves and for recording the responses. This method is painless. Trojaborg (1964) had shown that there was no significant difference in the motor conduction velocities derived by either surface or needle stimulating and recording electrodes. Since the lengths of nerve segment were estimated by surface measurement it introduces a 4 5% error to the nerve conduction velocities (Buchthal and Rosenfalck, 1966), basing on the finding that surface measurements were only 0.3 to 0.8 mm shorter than the dissected median and ulnar nerve lengths (Carpendales, 1956).

The results of this present study of motor conduction of the peripheral nerves are comparable with the average of the published series of some workers from 1948 up to 1966 (Table VI). The values of these workers were mostly measured from Caucasian subjects. Tong and Wong (1977) in 268 Singaporeans obtained

Table VI

Motor nerve conduction velocities (M/SEC)++

Ulnaris	Medianus	Peronaeus	Tibialis	Authors
64*	60 — 65	56.6±0.91	45 — 50	Hodes et al. 1948, 1949
55 (45 — 68)***				Magladery and McDougal 1950
58.4 (SD4.28)*				Wagman and Lesse 1952
54 (46 — 62.7)**				Bolzani 1954
59.1 (49.1 — 65.5)*	58.5 (53 — 64.3)	51.2 (45.6 — 56.3)		Henriksen 1956
57.5 (51 — 75)*	60.5 (52 — 79)			Redford 1958
56.2 (SD4.2)**	57.2 (SD4.2)	49.7 (SD7.1)	43.2(SD4.9)	Thomas et al. 1959
62.4 (SD4.5)*	62.4 (SD4.5)			Ferrari et al. 1960
55.1 (SD6.4)*	50.1 (SD7.2)		50.2(SD9.3)	Johnson and Olsen 1960b
59.9 (44 — 76)*	58.8 (46 — 70)	50.2 (36 — 66)		Mulder et al. 1961
62.4±1.44*	59.1±1.12	47.1+0.92		Lawrence and Locke 1961
52.3 (SD5.1)***				Corbat 1961
56.4 (SD6.2)*		49.3 (SD5.7)		Skilman and Johnson 1961
			43.8±0.51	Skorpil and Kolman 1961
63.9±7.0**				Pinelli et al. 1961
56±1 (SD5)**	56±1 (SD5)	50+1 (SD4)		Trojaborg 1962
53.1±0.04**				Vyklicky 1962
60.0 (56 — 62.7)*	64.3 (59.8 — 70.4)			Marvor and Libman 1962
53.3 (SD6.5)**	53.8 (SD5.3)	51.5 (SD5.7)		Wiesendanger and Bischoff 1962
63.0 (SD5.6)*	63.0 (SD5.6)	56.0 (SD5.2)		Gamstorp 1963a
54.27±0.66**	54.27±0.66			Poloni and Sala 1962
			46.3 (SD3.3)	Arrigo et al. 1962
57.8±2.1*	58.9±2.2	49.5±5.6	45.5±3.8	Mayer 1963
56.18±4.55**				Drechsler et al. 1964
59.78±2.08**				Krebda et al. 1965
	58.8±5.91		44.5±4.13	Kyral 1964
58 (SD5.32)*	56 (SD4.24)	50 (SD5.09)	46 (SD4.70)	Kaeser 1965
			45.9±2.9	Doutlik and Skorpil 1966
Av.57 m/sec	59 m/sec	51 m/sec	46 m/sec	
*+56.8 (SD4.9)**	*58.6 (SD4.2)*	*50.8 (SD5.0)*	*48.8 (SD5.8)*	*Present Series*

* Surface electrodes
** Needle electrodes
+ The italics are our own insertion.
++ We thank Elsevier/North-Holland Biomedical Press, Amsterdam for permission to reproduce these tables from Handbook of Electroencephalography and Clinical Neurophysiology 1976, 16A: 80 — 87.

conduction values similar to those of our series with a difference of less than 5% after correction for a difference in temperature of 1°C between the two series. However, the distal latency of the posterior tibial nerve measured by them is more prolonged than our value by 20% (Table VII). We are unable to explain this difference.

The antidromic technique was employed to elicit sensory conduction. This technique was described by Sears in 1959. Although Buchthal and Rosenfalck (1966) demonstrated that the antidromic conduction velocities were the same as the orthodromic ones, our sensory results are not comparable with the Singapore series. In the upper limbs, the antidromic conduction velocity were studied between wrist and elbow, elbow and axilla, whereas Tong and Wong obtained the orthodromic conduction velocity between the wrist and the fingers. Our values however fall between those of the published series since 1958 up to 1966 (Table VIII).

Using computer averaging technique in 30 normal subjects, Murai *et al.*, (1969) obtained a mean sensory sural nerve conduction velocity of 54 m/sec with a S.D. of 3.3 m/sec; a value very close to our value of 53.2 m/sec, S.D. 5.2 m/sec for the upper segment and 50.0 m/sec, S.D. 6.0 m/sec for the lower segment.

Table VII

Comparison of motor conductions between present series and Singapore series

	Median mean ±S.D.		Ulnar mean ±S.D.		Lat. popliteal mean ±S.D.		Post. tibial mean ±S.D.	
	Dist. Lat. msec	Cond. Vel. m/sec	Dist. Lat. msec	Cond. Vel. m/sec	Dist. Lat. msec	Cond. Vel. m/sec	Dist. Lat. msec	Cond. Vel. m/sec
Present Series (19 — 35 yrs.)	3.5 ±0.5	58.6 ± 4.2	3.1 ±0.7	56.8 ± 4.9	4.5 ±0.4	50.8 ± 5.0	4.3 ±0.7	48.8 ± 5.8
Singapore Series (21 — 30 yrs.)	3.1 ±0.4	62.5 ± 5.2	2.8 ±0.5	62.1 ± 5.4	4.1 ±0.8	52.1 ± 6.2	5.1 ±0.8	50.4 ± 4.9
1 °C Compensation in the Singapore Series	3.4	60.5	3.1	60.1	4.4	50.1	5.4	48.4

Table VIII

Sensory conduction velocities in the upper extremity ++

Nerve	N	Age (years)	Conduction time Finger-wrist msec	Conduction velocity Finger-wrist m/sec	Conduction velocity Wrist-elbow m/sec	Conduction velocity Elbow-axilla m/sec	Authors
Ulnaris:	SE 39		2.2 — 3.4				Gilliatt and Sears 1958
					55.7±6.26	52.2±3.32	Vyklicky 1960
	SE 30	10 — 35		67.7±3.9	63.8±3.8	63.1±4.3	Mayer 1963
	16	36 — 50		66.5±3.4	67.1±4.7	70.6±2.4	Mayer 1963
	18	51 — 58		57.5±6.6	56.7±3.7	64.4±3.0	Mayer 1963
	NE			63.5±0.9	63.5±0.9	63.5±0.9	Rosenfalck and Buchthal 1963
	NE 9	18 — 25	2.8+0.2	51.9±1.9 (SD5.6)	63.9±1.7 (SD5.1)	62.5±2.4	Buchthal and Rosenfalck 1966c
	NE 8	70 — 88	3.0+0.1	50.2±1.2 (SD3.7)	54.2±1.7 (SD5.1)	64.4±3.7 (SD9.9)	Buchthal and Rosenfalck 1966c
	+SE 47	*19 — 35*	*3.0 (SD0.4)*	—	*58.7 (SD4.2)*	*60.2 (SD7.7)*	*Present Series*
Medianus:	SE 28		2.5 — 4.0				Gilliatt and Sears 1958
	SE 30	10 — 35		67.5±4.7	67.7±4.4	70.4±4.8	Mayer 1963
	SE 16	36 — 50		65.8±5.7	65.8±3.1	70.4±3.4	Mayer 1963
	SE 18	51 — 80		59.4±4.9	62.8±5.4	66.2±3.6	Mayer 1963
	NE 66	18 — 25	3.1+0.1	55.2±1.4 (SD5.2)	64.8±0.6 (SD5.2)	68.7±1.0 (SD7.2)	Buchthal and Rosenfalck 1966c
	NE 11	40 — 61	3.3+0.1	54.9±1.2 (SD4.4)	55.5±0.8 (SD2.6)	67.7±3.1 (SD10.2)	Buchthal and Rosenfalck 1966c
	NE 24	70 — 80	3.5+0.1	53.1±0.9 (SD2.6)	53.5±1.0 (SD4.7)	60.9±1.8 (SD7.8)	Buchthal and Rosenfalck 1966c
	+ SE 47	*19 — 35*	*3.3 (SD0.4)*	—	*58.6 (SD4.9)*	*65.9 (SD6.4)*	*Present Series*

SE = surface electrodes, bipolar.
NE = needle electrodes, monopolar.
\+ = The italics are our own insertion.
++ = We thank Elsevier/North-Holland Biomedical Press, Amsterdam for permission to reproduce these tables from Handbook of Electroencephalography and Clinical Neurophysiology 1976, 16A: 80 — 87.

Buchthal and Rosenfalck (1966) and Henriksen (1956) reported a drop of nerve conduction velocity of 2 and 2.4 m/sec respectively for every 1°C fall in temperature. An increase of 0.3 msec in the distal latency for 1°C drop in temperature was reported by Redford (1958). The room temperatures monitored during our measurements fluctuated between 21.5 and 24.8°C with a mean of 22.9°C (S.D. 2.0°C). The skin temperatures varied around 30°C, a value considered to be satisfactory for nerve conduction study by Lenman and Ritchie (1977). With the stable room temperature in our tropical climate conduction variability due to temperature change is likely to be small. Extreme temperature fluctuation causing laboratory error is a distinct possibility in temperate countries.

CONCLUSION

Nerve conduction study is a useful and harmless investigation which is easily performed with a minimal cooperation from the patient. The results are objective and easily reproducible.

SUMMARY

Motor and sensory conduction velocities and distal latencies were obtained from the median, ulnar, lateral popliteal, posterior tibial and sural nerves of 47 healthy Malaysian young adults. Their arithmetic means and standard deviations were tabulated. Comparisons of our results with those of other workers were made. The material, methods, equipment used were described.

ACKNOWLEDGEMENT

The authors would like to thank Ms. Lisa Ooi for her tireless assistance and all the volunteers for their kind cooperation and the Elseview Publising Company for their generous permission to reproduce the tables 6 and 8.

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