AMPLITUDES OF SURAL AND RADIAL SENSORY NERVE ACTION POTENTIALS IN ORTHODROMIC AND ANTRIDROMIC STUDEIS IN CHILDREN

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Abstract- Several previous studies of adults have reported that the amplitudes of the sural and superficial radial nerve (SN and SRN) action potentials are larger with antidromic than with Orthodromic recordings. However, this difference has not been documented in children. This study evaluated the amplitudes of SN and SRN sensory nerve action potentials (SNAPs), obtained with antidromic and orthodromic recordings in children with and without neuropathy, and compared these data with similar findings in adults. The SNAPs of SN or SRN or both of 10 neurologically normal children, 6 children with neuropathy and 7 healthy adults were studied with surface stimulation and recording. The position of the stimulating and recording electrodes for the orthodromic recordings were the reverse of that for the antidromic recordings. Peak to peak SNAP amplitudes were measured and analyzed. The mean of the SRN SNAP amplitude was significantly higher with the antidromic than the Orthodromic technique for the first and third groups (P<0.05). The mean SN SNAP amplitude was higher in the three groups, but the difference was not statistically significant because of the small number of subjects. This difference became significant when the data for the children and normal adult groups were combined and reanalyzed (P<0.05). Consistent responses were obtained with both techniques. However, the antidromic technique was superior to the orthodromic technique because of the greater amplitude of responses. We recommend the use of the antidromic technique for its greater amplitudes, ease of use and potential reduction of discomfort to the patient.

Acta Medica Iranica, 42(5): 359-362; 2004

Key words: Sural, superficial radial nerve, sensory nerve action potentials, antidromic, orthodromic

INTRODUCTION

The sensory nerve action potential (SNAP) amplitude is used to quantify the degree of axonal damage in neuropathies. The sural nerve (SN) and the superficial radial nerve (SRN) are two sensory nerves commonly studied. However, use of different techniques to study the SN and SRN, either orthodromic or antidromic surface stimulation and recordings, have produced varied results: some investigators (1-4) have obtained larger amplitudes with antidromic techniques, while others could not demonstrate this difference (5, 6).

Most of these sensory studies have been done on adults. So far, only a few studies have reported SN and SRN recordings in children. Most of these sensory nerve recordings in children have been obtained with the orthodromic technique; no single study has compared SNAP amplitudes obtained with both orthodromic and antidromic techniques. The purpose of this study was to evaluate the amplitude of the SRN and SN SNAP with antidromic and

Received: 22 July 2002, Revised: 31 Aug. 2002, Accepted: 4 Feb. 2004

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orthodromic surface recordings in children with and without neuropathies to find out which technique yields a higher SNAP amplitude and to compare these data with findings in healthy adults. We hypothesized that the recordings obtained with antidromic surface stimulation would produce larger SNAP amplitudes than those obtained with orthodromic techniques.

MATERIALS AND METHODS

Between July 1, 1995, and January 31, 1996, 23 subjects seen at the Hospital for Sick Children in Toronto, Canada, were divided into three groups and evaluated in a SNAP amplitude study of SRN or SN or both. The subjects in each group were chosen consecutively from volunteers and patients seen in the Neuromuscular Clinic at the hospital. Informed consent was obtained from each subject and from the parent or legal guardian for each child.

To be included in the study, subjects had to be healthy and less than 18 years old in group 1; with a clinical manifestation of peripheral neuropathy and less than 18 years old in group 2; and healthy and between 18 and 40 years old in group 3. The first group was consisted of 10 children (7 boys, 3 girls; mean age 12.7 yr.; range 7 to 17 yr); the second, 6 children (3 boys, 3 girls; mean age 13.3 yrs; range: 7 to 17 yrs) with clinical manifestations of sensory or motor neuropathy (weakness, areflexia, dysesthesia or paresthesia in extremities); the third, 7 healthy adults (3 men, 4 women, mean age 32 yrs; range: 28 to 42 yrs). Not all the subjects in each group were evaluated for both nerves (SRN and SR), mostly because of time constraints, occasionally because of lack of cooperation. Antidromic and orthodromic surface sensory conduction studies of the superficial radial and sural nerves were done with a Dantec Counterpoint MK2 electrodiagnostic electromyographic machine (Dantec Electronics, Denmark).

Antidromic surface stimulation of the SRN was done on the dorsolateral aspects of the radius over the junction of the middle and distal thirds of the forearm. The skin where the electrodes were attached was first cleaned with a gauze impregnated with alcohol. The ground electrode was placed between the stimulating and recording electrodes. The surface active electrode (G1) was placed over the main portion of the nerve over the extensor pollicis longus tendon.

The reference electrode (G2) was placed 2.5 cm distal to the Gl, approximately midway between the first and second metacarpophalangeal joints. For Orthodromic surface stimulation, the same procedure was used, except for the position of the stimulating and recording electrodes that were reversed.

Antidromic surface stimulation of the SN was done slightly distal to the lower border of the bellies of the gastrocnemius muscle, approximately at the junction to the midline. The ground electrode was placed between the stimulating and recording electrodes. The G1 was placed between the lateral malleolus and Achilles tendon at the malleolar level with the G2, 2.5 cm distal to the G1. Again for Orthodromic surface stimulation, the procedure was the same, except for the position of the stimulating and recording electrodes that were reversed. Both Antidromic and Orthodromic studies for both the SRN and the SN were done with supramaximal current stimulus for 0.05 msec. Each subject was stimulated 5 to 10 times at 1 Hz; the responses were recorded and averaged. Sweep speed was 2 msec per division. All studies were carried out in an air-conditioned room at a constant temperature, with patients lying comfortably on the bed. The amplitudes of the SNAPs were measured between the negative and subsequent positive peaks. Statistical analysis was done with a two - tailed Student's *t* test. A *P* value of less than 0.05 was considered significant.

RESULTS

Group 1

The antidromic technique for the SRN elicited a significantly higher amplitude response than the orthodromic method in 7 of the 8 subjects tested; in 1 subject the amplitudes were equal ($P < 0.05$). The mean SNAP amplitude was 48.0 µV with the antidromic and 29.5 µV with orthodromic technique. The antidromic stimulation technique for the SN, done in 8 of the 10 subjects in this group, produced a higher amplitude response than the orthodromic technique, but the difference was not significant.

Table1. Sensory Nerve Action Potential (SNAP) amplitude of superficial radial nerve

	SNAP amplitudes (μV)						
	Antidromic			Orthodromic			
Group	**Mean**	**Range**	**SD**	**Mean**	**Range**	**SD**	**Significance***
1(n=8)	48.0	37-63	8.7	29.5	10.2- 43	12.2	*P*<0.05
2(n=5)	25.2	0.4- 39	15.6	14.7	0.2- 22.1	8.6	NS
3(n=7)	57.8	25.1-97	27.6	44.1	5.6-79	26.4	*P*<0.05

Abbreviations: μV, microvolt; SD, standard deviation; NS, not significant.
* Student's *t* test.

Table 2. Sensory nerve action potential (SNAP) amplitude of sural nerve

	SNAP amplitudes (μV)						
	Antidromic			Orthodromic			
Group	**Mean**	**Ranae**	**SD**	**Mean**	**Range**	**SD**	**Significance***
1 (n=8)	25.4	11.8-34	7.0	19.5	1.2-36	12.4	NS
2 (n=3)	4.0	0.5-6.9	3.2	2.1	1-3.4	1.2	NS
3 (n=6)	17.3	5.7-33	10.2	13.6	6.9-27	8.1	NS

Abbriviations: μV, microvolt; SD, standard deviation; NS, not significant.
* Student's *t* test.

The mean SNAP amplitude was 25.4 μV with the antidromic and 19.5 μV with the orthodromic technique (Tables 1 and 2).

Group 2

The SRN was studied in 5 of 6 children in group 2. Although the antidromic technique elicited higher amplitude responses than the orthodromic study in all subjects studied, this difference was not statistically significant. The mean SNAP amplitude was 25.2 μV with the antidromic and 14.7 μV with the orthodromic technique.

The SN was studied in 3 of the 6 children in this group. In 2 of these 3 subjects the antidromic technique elicited higher amplitude responses than the orthodromic technique. In the other subject, the responses were of equal amplitude (Tables 1 and 2).

Group 3

The mean antidromically recorded SRN SNAP amplitude (57.8 μV) was significantly higher than the orthodromically recorded one (44.1 μV, *P*<0.05) in the subjects in group 3. The mean SN SNAP amplitude was 17.3 μV and 13.6 μV, with the antidromic and orthodromic techniques respectively (Tables 1 and 2). Although the SN recordings did not show a significant difference in SNAP amplitudes between the two techniques, the SNAP tended to be greater with the antidromic technique.

To overcome the limitations of the small number of subjects in each healthy group (i.e. groups 1 and 3), we combined the orthodromic SNAP amplitudes from both groups and compared them with the similarly combined antidromic SNAP amplitudes. The combined data showed a statistically significant difference in which the antidromic response was greater (*P*<0.05).

DISCUSSION

The SRN and SN responses obtained in this study were greater with the antidromic technique than those obtained with the orthodromic technique in all three groups. Although the difference was not statistically significant for the SN in each group because of the small number of subjects, this difference became significant when data for groups 1 and 3 were combined and analyzed again.

The recorded SNAP amplitude is the result of the electromotive forces of the contributing fibers. The electromotive force of each nerve fiber is defined by Ohms law with this formula: $e = I (R + r)$, where e is the electromotive force of an individual nerve fiber in volts, I is the current, R is the external resistance and r is the internal resistance of the individual nerve fiber (7). The electromotive forces of all the individual fibers in each nerve contribute to the maximal peak amplitude equally (8). The external resistance is composed of two main components: 1**)** the common external resistance of the subcutaneous tissue and the skin, and 2) the resistance of the internal neural structures such as the myelin of the adjacent fibers, as well as the intervening epineural and perineural structures. The current must flow through all these tissues before it is recorded. Thus, the larger SRN SNAP obtained with antidromic stimulation could be caused by its anatomical situation; that is because of the closer proximity of the recording electrodes to the nerve in the antidromic studies the external resistance is smaller with the antidromic than the orthodromic technique.

The same explanation could be used for the SN, except that we found equal SNAP amplitudes in several subjects with the orthodromic technique. Buchthal and Rosenfalk reported that the SNAP amplitude increased as the number of stimulated nerve fibers increased (9). This finding is true only for the Orthodromic technique, as demonstrated by Meythaler *et al.* (7). Furthermore, different anatomical distributions of the branches of the SN have been demonstrated: multiple variations of the nerve and its branches have been found (10). Therefore, on the basis of Buchthal and Rosenfalk's work (9), we conclude that the orthodromic technique yields higher SNAP amplitudes in subjects in whom the stimulation site is above or at the place where the Sural nerve branching begins, and vice versa, the technique yields smaller SNAP amplitudes in subjects in whom the stimulation site is over the smaller branches.

Based on this study, we recommend the use of the antidromic technique for recording SRN and SN in children, as well as in adults. The SNAP responses obtained with antidromic techniques were greater, easy to obtain and reliable, and might eliminate the need for repeated stimulation. If repeated stimulation was eliminated, the lesser amount of discomfort experienced with a single stimulation would undoubtedly be greatly appreciated by all subjects, in particular, children.

Acknowledgments

We would like to thank Lynn J. Macmillan and Dr. Daune MacGregor for their help with the study. This paper was prepared with the assistance of Editorial Services, The Hospital for Sick Children, Toronto, Ontario, Canada.

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