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Original article

Comparison of the two types of stimulating electrodes in the study of motor nerve conduction in dogs

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Abstract

In this research two kinds of stimulation electrodes were compared in motor nerve conduction study: needle electrodes used in human medicine and electrodes made of injection needles connected to the stimulator via alligator-type electrodes. A study was conducted in 22 mixed-breed dogs. The resulting values of the potential amplitudes of the stimulus, the parameters of the complex muscle potentials, and the motor nerve conduction velocity were statistically compared. There was no statistical difference between the parameters obtained with the two types of stimulation electrodes. The results of our research constitute a basis for improving present-day procedures, improving aseptic procedures, reducing tissue trauma during research and lowering research costs due to the introduction of injection-needle electrodes and their benefits into the study of motor nerve conduction in animals.

Key words: stimulation electrodes, motor nerve conduction

Introduction

Electrodiagnostic examination of muscles and nerves has been used in animal medicine since the 1970s. Since then, there have been many attempts to develop detailed techniques of examination and interpretation of the results (Lee and Bowen 1970, Walker et al. 1979). To date, the electrodes most widely used for the induction and recording of complex muscle action potentials (CMAPs, M waves) were needle electrodes borrowed directly from human medicine (Walker et al. 1979, Cozzi et al. 1998, Freeman et al 2009, Turan et al. 2014). Due to the high price of electrodes for NCV study, individual pieces are used to stimulate more than one body site. This practice results in many adverse effects. First, reuse of a single electrode tends to make it dull, which can exacerbate tissue trauma at the site of insertion. Secondly, despite the use of disinfectants, repeated use of a single electrode can favor the development of infection at the point of insertion (Burris and Fairchild 1986, Nolan et al. 1991). Considering the minimal price of

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injection needles, their one-time use as stimulating electrodes would prevent the above-mentioned issues. Literature concerning a different method of stimulating or recording action potentials that can be found is very limited (Lee and Bowen 1970, Malik et al. 1989, Turan and Bolukbasi 2004, Bolukbasi and Ocal 2007). The goal of the study was to examine reliability of injection needle electrodes in nerve stimulation techniques.

Materials and Methods

Twenty-two mixed-breed dogs (9 females, 13 males) underwent examinations of motor nerve conduction. The dogs were clinically and neurologically examined; no abnormalities were found. The dogs weighed between 5.5 and 32.5 kg (the average weight was 17 kg). The age of the dogs ranged between 1 and 9 years (the mean was 3.5 years). The study was conducted under intravenous anaesthesia: premedication with medetomidine (Domitor 1 mg/ml) 20 mμg/kg and butorphanol (Butomidor 10 mg/ml) 0.2 mg/kg, induction and maintenance with propofol (Scanofol 10 mg/ml) 1 mg/kg followed with CRI 6-24 mg/kg/h. Viasys Viking Quest equipment was used to record and measure electrophysiological parameters. Alligator-type electrodes (GVB geliMED, Germany) were used to record CMAPs from the skin surface. A monopolar needle electrode (GVB geliMED 13 mm length) was used as a ground. Monopolar needle electrodes (GVB geliMED Φ=0.35 mm, length 45 mm) or injection needles (Φ=0.7 mm, length 40 mm, attached to the amplifier via alligator connectors) were used on both limbs (Fig. 1). The study was performed on the sciatic and tibial nerves of both hind limbs. The left limb was studied first. The study of the left limb started with the use of standard needle electrodes, while on the right limb the study was performed in reverse order. The measurement was performed on the underside of the metatarsus to obtain a CMAP of the interosseous muscles. In this study, surface electrodes for the collection of CMAPs have also been used. The surface electrodes were placed on the skin shaved, rubbed with alcohol and covered with a conductive gel prior to measurements. The stimulation was performed consecutively at three points on the surface projection of the examined nerves: point 1- cranially from the gastrocnemius muscle tendon; point 2- caudally from the distal femur epiphysis; point 3- in the space between the ischial tuberosity and the greater trochanter (Fig. 2). Each time, the exact site of electrode insertion was determined on the basis of the stimulation and recording parameters, in order to obtain the maximum amplitude of the CMAP with the minimum amplitude of the potential stimulus. Stimulus locations were marked on the animal with a Sharpie pen to enable insertion of both electrode types at the same site. A single square-wave electric potential with a frequency of 2 Hz, duration of 0.2 ms and amplitude of 0-400 V was used for stimulation. The stimulation amplitude was always adjusted to supramaximal values, i.e. 20% higher than the stimulus that evoked maximal CMAP amplitude. The distance between stimulation points was measured with a tape measure scaled in centimeters. The nerve conduction velocity (NCV) was calculated by dividing the distance between adjacent points of stimulation by the difference in obtained latencies. All of the variable recording and stimulation parameters (stimulus amplitude, latency, CMAP amplitude, CMAP duration, CMAP surface area and NCV) were stored separately for each side and point of stimulation. The room temperature for all the recordings was 20^{o}C. Values obtained with standard needle electrodes were statistically compared with those obtained with injection-needle electrodes. Where the distribution of the parameter values was close to normal distribution, Student's t-test was used; otherwise, the Mann-Whitney U test was used. For both tests, $\alpha=0.05$ was assumed. StatSoft STATISTICA software was used for statistical analysis. The entire study was conducted with the permission of the local ethical committee.

Results

The following results are presented as a mean and standard deviation (±SD) values. The CMAP amplitudes acquired with standard electrodes were as follows: 22.04 ± 6.72, 17.14 ± 6.72, 13.93 ± 5.79 mV on three consecutive points (described in Methods) of left sciatic nerve and 22.55 ± 9.85, 17.81 ± 8.92, 14.75 ± 7.42 mV on the same points of right sciatic nerve. The same parameters measured after stimulation with injection needle electrodes were 22.28 ± 8.28, 16.1 ± 6.86, 13.84 ± 6.18 mV on the left limb and 23.72 ± 10.26, 17.61 ± 8.8, 14.60 ± 7.58 mV on the right limb (the recorded values were summarized in Table 1). Statistical analysis done on CMAP amplitudes resulted in p values as follows: 0.92, 0.61, 0.96 on the three points of left sciatic nerve and 0.69, 0.94, 0.95 on the right sciatic nerve points ($\alpha=0.05$).

Mean NCV results measured with standard electrodes on the distal and proximal part of the sciatic nerve were as follows: 56.6 ± 13.24, 69.13 ± 9.01 m/s on the left limb and 69.13 ± 9.01, 74.07 ± 11.5 m/s on the right limb. NCV measurement done with injection

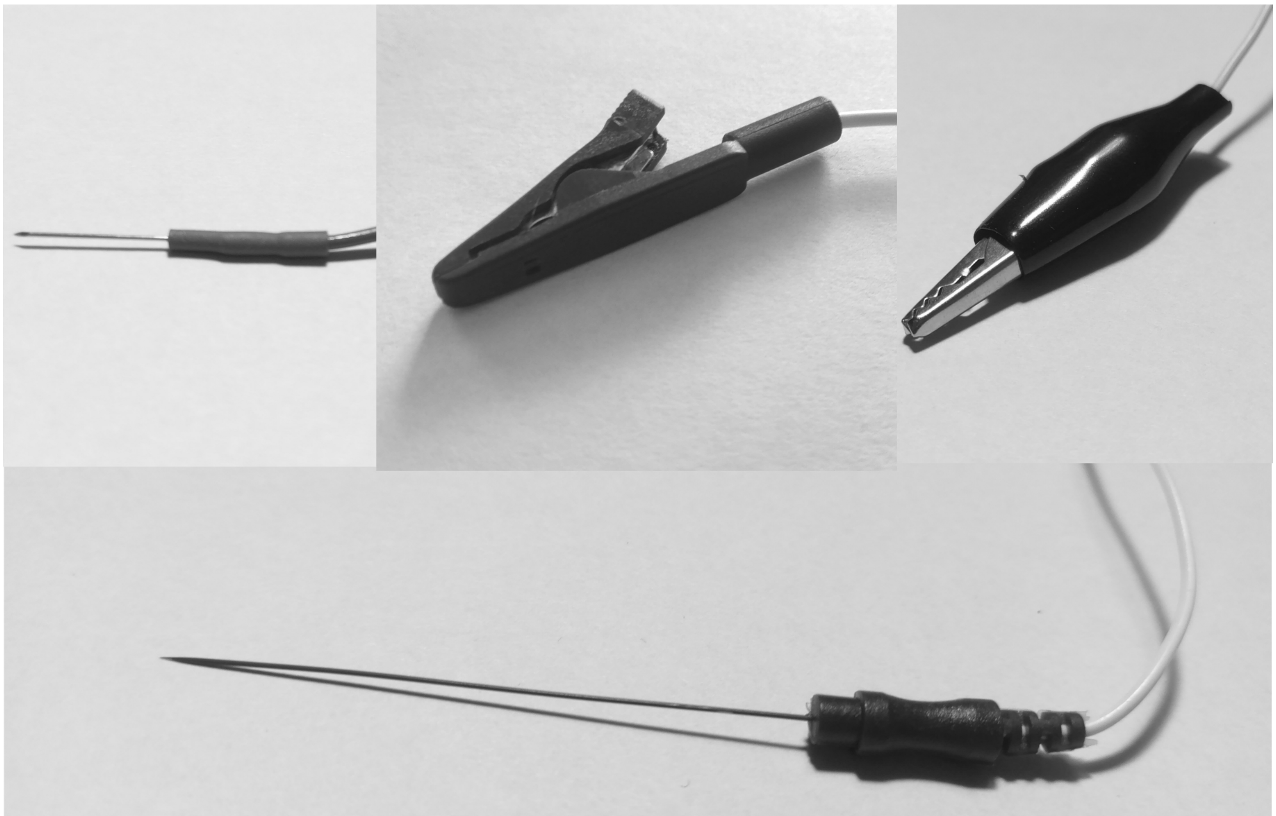

Fig. 1. Electrodes used in our study, top left: needle electrode used as a ground; top middle: alligator clip, which connected to the injection needle is used as stimulation electrode; top right: alligator clip used as the surface record electrode; bottom: stimulation needle electrode used in human medicine.

Table 1. Mean and SD (±) values of the recording parameters. abbreviations used: stand. – standard needle electrodes, inj. – injection-needle electrodes, amp. – CMAP amplitude, dur. – CMAP duration, area – CMAP surface area.

Side	Electrode	Amp. 1	Amp. 2	Amp. 3	Dur. 1	Dur. 2	Dur. 3	Area 1	Area 2	Area 3
Left	stand.	22.04 mV ± 6.72	17.14 mV ± 6.72	13.93 mV ± 5.79	6.7 ms ± 2.31	6.95 ms ± 2.42	6.98 ms ± 2.21	22.13 ± 6.88	16.54 ± 5.53	16.99 ± 5.65
	inj.	22.28 mV ± 8.28	16.1 mV ± 6.86	13.84 mV ± 6.18	6.29 ms ± 1.72	6.25 ms ± 1.72	6.51 ms ± 1.60	21.38 ± 6.58	16.75 ± 5.23	16.08 ± 5.45
Right	stand.	22.55 mV ± 9.85	17.81 mV ± 8.92	14.75 mV ± 7.42	6.07 ms ± 1.17	6.40 ms ± 1.27	6.39 ms ± 1.3	20.63 ± 7.89	17.68 ± 7.43	15.6 ± 6.2
	inj.	23.72 mV ± 10.26	17.61 mV ± 8.8	14.60 mV ± 7.58	6.41 ms ± 1.97	6.54 ms ± 2.06	6.83 ms ± 1.74	22.76 ± 8.95	18.34 ± 8.1	16.62 ± 6.49

needle electrodes provided the following results: 50.99 ± 9.81, 74.55 ± 13.97 m/s on the left limb and 53.07 ± 6.89, 69.93 ± 15.82 m/s on the right limb (Table 2). NCV measurements comparison showed no statistical difference (α=0.05) between two kinds of electrodes and the p values acquired on the distal and proximal parts of the sciatic nerve were as follows: 0.12, 0.28 on the left limb and 0.09, 0.12 on the right limb, respectively.

Mean amplitudes of the stimulus (amps.) evoked with standard electrodes on the three consecutive points (described in Methods) of sciatic nerve were 50.77 ± 25.57, 71.91 ± 41.43, 43.45 ± 30.95 V and 52.68 ± 27.3, 53.14 ± 27.16, 40.86 ± 21.06 V for the left and the right limb respectively. Mean amps. evoked with injection needle electrodes were as follows: 50.5 ± 24.96, 74.09 ± 72.82, 47.09 ± 18.61 on the left limb and 48.55 ± 20.88, 65.00 ± 35.43, 47.91 ± 23.35 V on

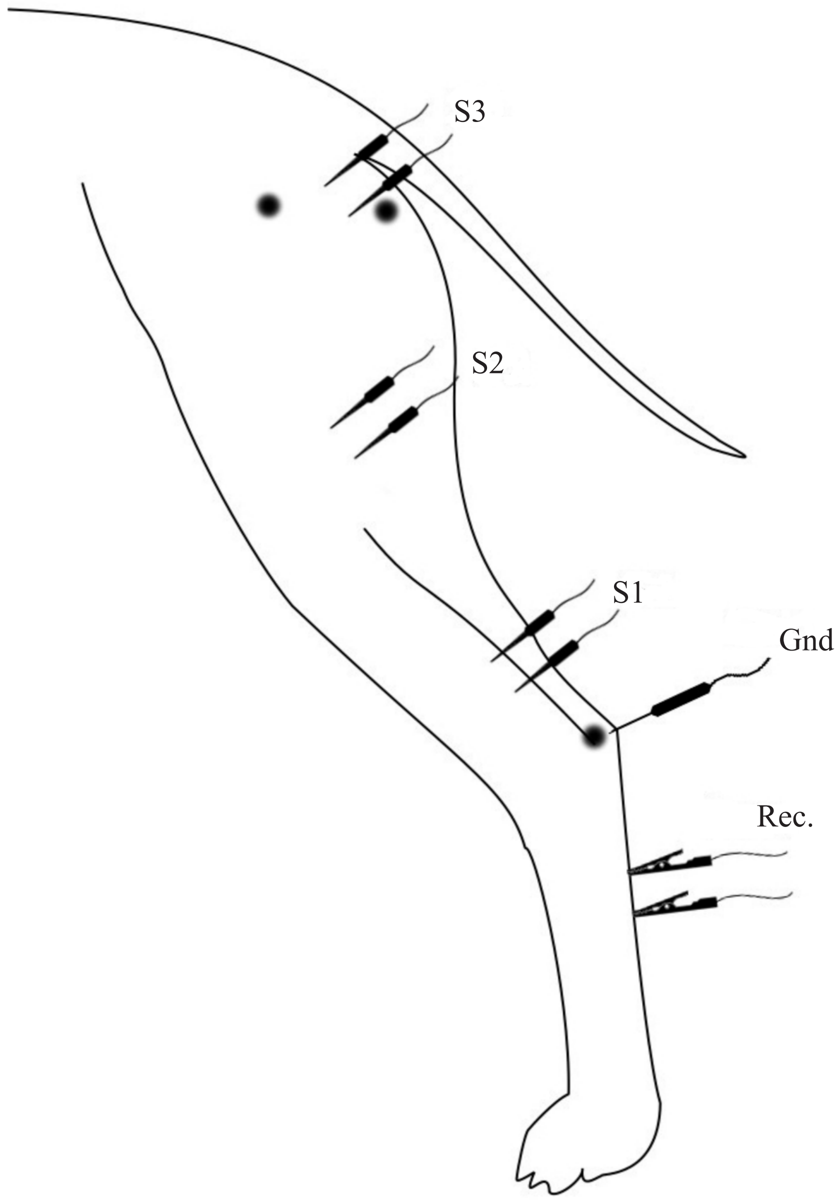

Fig. 2. Stimulation, ground and recording sites used in our study, black points are placed to depict osseous protuberances: trochanter major, ischial tuberosity and tuber calcaneus.

Table 2. Mean and SD (±) values of the recording parameters , continued. Abbreviations used: stand. – standard needle electrodes, inj. – injection-needle electrodes, lat. – latency, NCV – nerve conduction velocity.

Side	Electrode	Lat. 1	Lat. 2	Lat. 3	NCV 1	NCV 2
Left	stand.	4.07 ms ± 0.79	6.16 ms ± 1.06	8.19 ms ± 1.57	56.6 m/s ± 13.24	69.13 m/s ± 9.01
	inj.	3.93 ms ± 0.72	6.31 ms ± 1.06	8.16 ms ± 1.43	50.99 m/s ± 9.81	74.55 m/s ± 13.97
Right	stand.	4.04 ms ± 0.82	6.18 ms ± 1.29	8.04 ms ± 1.64	58.88 m/s ± 11.71	74.07 m/s ± 11.50
	inj.	4.06 ms ± 0.78	6.41 ms ± 1.27	8.1 ms ± 1.55	53.07 m/s ± 6.89	69.93 m/s ± 15.82

the right limb (Table 3). Amps. comparison showed no statistical difference (α=0.05) between stimulation with two kinds of electrodes and the p values acquired on the three points of sciatic nerve were as follows: 0.92, 0.72, 0.14 on the left limb and 0.58, 0.26, 0.20 on the right limb (Table 4).

Discussion

In this article, the authors wish to add their own observations concerning the use of 2 types of needle electrodes (electrodes from human medicine and injection-needle electrodes) to the existing knowledge.

Table 3. Mean and SD (±) values of the amplitudes of the stimulus. Abbreviations used: stand. – standard needle electrodes, inj. – injection-needle electrodes, amps. – stimulus amplitude.

Side	Electrode	Amps. 1	Amps. 2	Amps. 3
Left	stand.	50.77 V ± 25.57	71.91 V ± 41.43	43.45 V ± 30.95
	inj.	50.5 V ± 24.96	74.09 V ± 72.82	47.09 V ± 18.61
Right	stand.	52.68 V ± 27.30	53.14 V ± 27.16	40.86 V ± 21.06
	inj.	48.55 V ± 20.88	65.00 V ± 35.43	47.91 V ± 23.35

Table 4. *p* values obtained in statistical tests (α=0.05). Values marked with * were obtained via the Mann-Whitney U test; the remaining values were obtained via Student's t-test.

	Latency		NCV		CMAP amplitude		CMAP duration		Stimulus amplitude	
	left	right	left	right	left	right	left	right	left	right
1	0.54	0.94	0.12	0.09*	0.92	0.69*	0.51	0.49	0.92*	0.58
2	0.78*	0.55	0.28*	0.12*	0.61	0.94	0.27	0.80	0.72*	0.26*
3	0.95	0.90	X	X	0.96	0.95	0.42	0.35	0.14*	0.20*

Our study has shown that there is no statistical difference between measurements obtained with standard needle electrodes and those using injection-needle electrodes.

Distinct differences in parameter values (high SD values) may be caused by the diversity in weight within the group of dogs. It has been proved that NCV estimation at lengths shorter than 10 cm may result in larger measurement error (Kimura 2001). Studies in which examined groups were less diverse in terms of weight resulted in significantly lower standard deviations (Takakura and Inada 1983). Nevertheless, NCV values in our study were not statistically different between both types of electrodes.

In the NCV study, we were able to determine whether the electrodes were placed in direct proximity to the examined nerve. It is possible, with maneuvering the electrode, to obtain the highest CMAP amplitude by the stimulation with the lowest amplitude. An additional advantage of the electrodes made of injection needles used for stimulation can be the precise administration of drugs in the vicinity of a nerve, when needed. Similar techniques for locating a nerve and evaluating its anesthesia blockade have already been noted in the literature (Gatson et al. 2016).

Surface electrodes were used in our study for recording CMAPs. The authors found very few reports on the use of this type of electrodes in veterinary medicine (Kawasaki et al. 2004, Turan and Bolukbasi 2004, Turan et al. 2014). Given the correct preparation of the body parts to be studied, it is possible to record CMAPs from the surface of the skin (Kawasaki et al. 2004). Surface electrodes enable the recording of overall CMAP and accurate assessment of its amplitude and duration. Needle electrodes are better choice for recording CMAPs only when the patient has suffered significant atrophy of the examined muscle; this is because needle electrodes are capable of recording potentials of very low amplitudes (Kimura 2001).

Our study shows that the use of injection-needle electrodes to stimulate motor conduction yields reliable results, comparable to the methods previously used. Considering the benefits of this approach, including the minimizing of tissue trauma and preventing the infection of the examined site, the authors encourage the use of injection-needle electrodes in electrodiagnostic nerve examinations.

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