The Effect of Radiofrequency Current and Heat on Peripheral Nerve Action Potential in the Cat*

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The use of radiofrequency (rf) current to produce cord lesions in percutaneous cordotomy14 prompted this study. The purpose was to see if the diameter of nerve fibers determined their sensitivity to rf current. Such differential sensitivity of nerve fibers to other forms of energy and manipulation is documented. Compression,4,5,6,10,16 cold,5,11 and anodal polarization11 all block the large A fibers first. By contrast, high voltage alternating current2 and local anesthetics6,8,10 depress C fibers before the A group.

Evidence indicates that peripheral nerve fibers maintain their size ranges in post-synaptic spinal cord projections.5 Thus, it is probable that any demonstrable relationship between fiber size and sensitivity to rf current in peripheral nerve would hold true for spinal cord. Since the effect of rf current is due to the heat that is generated,1 the effect of graded hyperthemia was also examined.

Methods

In vitro observations were made on 19 saphenous nerves from 11 cats. Under moderate Nembutal anesthesia, the nerve was dissected from the inguinal ligament to below the knee, producing a nerve specimen of from 5 to 10 cm in length. It was laid across electrodes in a chamber maintained at a temperature of 37°C. The nerve specimen was kept moist by periodic spraying with warm Tyrodes solution. Both stimulating and recording electrodes were 18-gauge silver wires, and a distance of 2 to 7 cm separated stimulating from recording leads. A Grass stimulator was used to deliver 0.2 msec square waves through a General Radio isolation transformer at a frequency of 1/sec. Two stimulus strengths were used, one to elicit the alpha-beta and delta elevations (10% above an intensity that elicited a maximal delta response) and another for the C elevation (about 10% above an intensity that evokes a maximal C wave). The compound action potential was recorded monophasically by placing the recording electrodes on either side of a crushed segment near one end of the nerve. A recording period was limited to 30 minutes, and consisted of recording control responses after each lesion induction. To determine the rate of spontaneous deterioration of nerve responsiveness in these in vitro preparations, serial recordings were carried out for 1-hour periods in several nerves in which no lesions were induced.

A Grass LM 3 Lesion Maker was used to pass rf current through a pair of 18-gauge silver wires that made contact with the nerve opposite each other. A drop of Tyrodes solution enclosed the two electrodes with the nerve between to prevent drying. The segment of nerve across which current was passed was approximately 1 mm in width; a discrete lesion was thus produced. The low intensity rf current was applied in small increments until a decrease in the height of any of the elevations of the action potential was observed. It was found that the wattage necessary to produce changes in the compound action potential was just below that necessary to begin the coagulation of egg albumin, with the same electrode separation used. Current pulses lasted from 15 to 60 seconds.

A small plastic chamber with a volume of 0.4 cc was used to produce heat lesions. The heat chamber which enclosed the nerve between stimulating and recording electrodes was filled with saline previously heated to temperatures from 37° to 60°C. The length of nerve in contact with the saline was about 1 cm. A temperature of 37°C was used ini-

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tially and then the temperature was increased in small increments. It was possible to fill the chamber with heated saline and remove it rapidly. For each temperature tested the saline was in contact with the nerve for 15 to 60 seconds.

Results

Effect of Rf Current. Three fiber groups were systematically evaluated: the alpha-beta, delta, and C. In the controls (nerves kept at 37°C and not subjected to rf current or heat lesions), all elevations maintained 100% of the resting amplitude for 30 minutes and at least 50% of the control level for 1 hour (Fig. 1). As the nerve died, all elevations decreased proportionately and simultaneously.

Carefully graded low-intensity rf currents were necessary to produce the observations to be described. Intensities that were only 15 to 20% above the level that produced the earliest detectable change abolished the entire response. Following an rf lesion which caused all elevations to disappear from the record it was possible to record a normal response in the same nerve once again. This was done by replacing the recording electrode so as to exclude the area of the lesion from the nerve segment separating stimulating and recording leads. No change in stimulus parameters was necessary and amplitudes of all response components were those which one would expect from a freshly excised nerve in which no lesions had been induced. Thus, in some nerves we made more than one set of observations.

In 21 of 22 instances (15 nerves), rf current caused the delta and C elevations to disappear before the alpha-beta wave. At the time of disappearance of the delta and C elevations, the alpha-beta deflection was 10%

![Fig. 1. Control: fate of compound action potential of saphenous nerve in absence of rf current or heat lesions. Interelectrode distance 4 cm. Stimulus strength in A and B, 2 v; in C, 20 v. Records at higher gain are shown in B to permit a more valid comparison of delta amplitudes; the top of the alpha-beta elevation is off the tube face at this amplification. Records in C are on a much slower time line to permit detection of C wave. On this time line the alpha-beta and delta components fuse with the shock artifact. The irregular unit activity seen riding the baseline in C is due to repetitive discharge of alpha fibers which can occur at stimulus intensities necessary to produce C elevations. Records in Column 1 were taken immediately after placing nerve in the chamber. Records in Columns 2, 3, and 4 were taken 15, 30, and 60 minutes after the start of recording. In this and all subsequent figures, vertical arms of right angles are voltage calibrations (in μV); horizontal arms are time calibrations (in msec).](image-url)