A NEW METHOD OF IMPLANTING ELECTRODES IN THE SPINAL CORD OF CATS OR DOGS IN ORDER TO RECORD ELECTRICAL ACTIVITY OF THE CONDUCTING PATHWAYS AND CENTERS DURING VOLUNTARY MOVEMENTS

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The method we have proposed differs from those described previously [1,2,3]in that it permits not one or two electrodes to be introduced into each segment but as many as are required to record the activity of all the ascending and descending tracts. The development of this method was first made possible by a study of the functional mosaic of the tracts of the spinal cord and of normal living conditions.

To introduce and support the electrodes we used a plastic electrode holder fixed to one of the vertebral spines (Fig. 1). To avoid movement of the holder it was fixed in two places: to the protuberance at the base of the spine where the latter approaches the caudal zygapophysis, and to the center of the spine.

The first point of fixation prevents movement of the electrode holder in the dorsoventral direction, and the second prevents transverse movement. The holder is fixed to the vertebral spine of a vertebra by means of a plastic bolt passing through an aperture in the center of the spine, and by a plastic nut.

In the electrode holder and in the vertebra beneath it a hole is drilled as far as the dura mater, for implantation of the electrodes. The dorsoventral extent to which the electrodes are submerged is made in relation to the task in hand and to the weight of the animal. For example, in a cat having an average weight of 2.5-3 kg, to lead off from the dorsal columns or dorsal horns, electrodes were implanted at a depth of 0.5-1.5 mm. To pick up activity from the anterior horns, the electrodes were inserted to a depth of 4-5mm. Activity of the spinocerebellar tracts were lead off by placing the electrodes at a depth of 0.5mm. The same indications were used in order to lead off in a horizontal direction. When the electrodes were placed on the transverse processat a depth of 1.5 mm, activity was picked up from the dorsal columns; at a depth of 3-4mm activity of the cerebellar tracts was recorded; at a point having coordinates of 2 mm dorsoventrally and 2 mm transversely activity of the spinothalamic tract was recorded. Similar calculations were made also for other tracts of the spinal cord (most of them approximate). It was only by stereotaxic measurements that the lead-off points became reliably established.

The principle, which was to use the vertebral spine as a support for the electric holder, is easy to realize for the lumbar vertebrae of a dog. In practice it is more convenient to implant the electrodes into the cord under visual control. For this purpose we removed some of the bone of the vertebra in the region of the posterior articular processes, leaving the dura mater untouched. We then passed the electrode through the aperture of the holder, and then could control visually the point and the depth to which it was inserted into the cord. For a dog of mean weight about 10 kg, in which the horizontal and dorsoventral diameters of the spinal cord at the level of the IV lumbar vertebra are about 10 mm, 7 mm respectively an electrode introduced 1.5-2 mm lateral to the articular process picked up activity from the posterior columns, and when introduced 3-4 mm lateral to the articular process it recorded activity from the spinocerebellar tracts. To lead off activity from the anterior horns the electrodes must be inserted to a depth of 4 mm.

The electrodes were prepared from stainless steel wire of initial diameter 0.3 mm. The electrode tip was sharpened by electrolysis to the required diameter (usually to 20-30 μ), at which thickness it would penetrate the

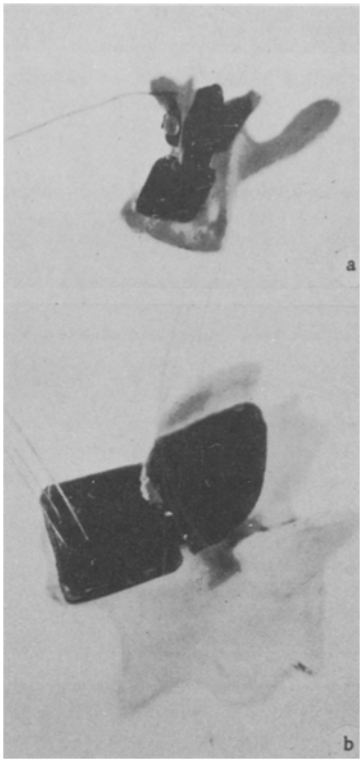

Fig. 1. Vertebrae of cat and dog with electrode holder. a) IV lumbar vertebra of cat. The protrusion at the base of the vertebral spine prevents the electrode holder from moving dorsoventrally. The nut and bolt prevent movement of the holder transversely. On the bolt is mounted a wire serving as indifferent electrode; b) II lumbar vertebra of dog. Three steel electrodes have been inserted in the bone.

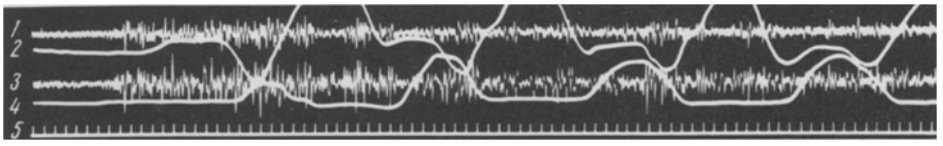

Fig. 2. Electrical record from spinal cord of dog. Curves, (top to bottom): recording from anterior horn (1); movement of right knee joint (flexion of knee corresponds to elevation of the line) (2); recording from posterior horn (3); movement of the left knee joint (4); time marker (0.02 seconds) (5).

dura. Electrodes with a diameter of less than 15 μ would not penetrate the dura, and had to be withdrawn. Electrolytic sharpening of the ends of the electrodes was made by immersing the tip in concentrated hydrochloric acid; a 6-volt storage cell was used as a current source. For sharpening, the electrode was connected to the positive pole of a storage cell; a similar steel wire was connected to the negative electrode.

After these procedures the electrodes were kept in a saline solution in order to neutralize the remaining acid; they were then washed in water, kept for twenty-four hours in acetone, and then covered with a cellulose nitrate varnish. The insulation was tested electrolytically.

In order to eliminate movement of the electrodes during the manipulations associated with their insertion we bent them at a right angle at a calculated distance, and before fixing them with silicate cement or with styracryl,* we placed a short wedge made from a pointed piece of wood in each aperture of the holder. The indifferent electrode was a varnished nichrome wire of 0.2 mm diameter wound on a bolt; its pointed end made contact with the vertebral spine. For a monopolar recording of each tract of the spinal cord several indifferent electrodes were required.

A variant of the implantation was as follows: an oval window measuring 5 x 10 mm was first made in the elec-

*Styracryl is probably a Russian trade name for a sort of binder or cement involving a styrene and acrylic polymer or copolymer—Publisher's Note.

trode holder and in it was fixed a block on which lead-off electrodes were fixed (with silicate cement) at a calculated separation. Silicate cement or styracryl were also use to fix the electrode block to the holder. Fig. 2 shows a record of potentials from the spinal cord together with movements of the knee joint during walking. There was no activity during the upright stance, and consistent changes are shown to the various phases of the walking movement.

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