Subthalamotomy in Treatment of Parkinsonian Tremor*

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IN the neurosurgical treatment of parkinsonian tremor, a major question to be answered is, where is the optimum site of target for the lesion? The present study is an attempt to evaluate the posterior ventrolateral area of the thalamus, internal capsule, medial region of the globus pallidus and posterior subthalamus. The comparative value of lesions in these structures was determined by (1) noting differences in reduction of tremor associated with insertion of electrodes, and (2) a comparison of the amount of radio-frequency electrical energy (expressed as Bovie-time factor) necessary to obtain over 75 per cent reduction in tremor.

The primary objective of this presentation is to demonstrate that lesions in the posterior subthalamus are the most efficient for reducing parkinsonian tremor.

Technique

Patients. From a group of 150 parkinsonian patients with varying degrees of tremor and rigidity, only those patients having unilateral or bilateral tremor as the major finding were utilized for this study. Tremor was bilateral in the majority of the 58 patients although usually it was more pronounced on one side. The mean age of the patients was 58 and ranged from 41 to 80 years. All patients had been receiving a variety of medications before operation which did not satisfactorily control the tremor. Patients with bilateral tremor were replaced on medication postoperatively. Since these observations were made in patients distributed over the past 7 years, the traditionally desired 5-year detailed follow-up was not possible. The shortest period of follow-up was 4 months (3 patients).

Operation. A total of 72 operations were performed in the 58 patients. Bilateral operations were done in 6 patients and in 1 it was repeated. Repeated unilateral operations were performed in 6 and the rest of the patients had unilateral procedures. Operations were done with patients in the supine position. One per cent Xylocaine was used for local anesthesia of the scalp. The patients were not premedicated and remained awake throughout the procedure. A frontal burr hole, ¾ inch in diameter, was placed 1½ cm. from the midline and 7½ to 8 cm. posterior to the glabella. A ventriculogram was performed and utilized for calculating coordinate measurements. These were supplemented with preoperative pneumoencephalograms. Roentgen-ray tube-plate distances of 40° were used for both lateral and frontal views. The central beam was directed just above the sella in the lateral view and proper corrections were made for distortions.

Coordinate System of Measurement. Horizontal zero consisted of a plane extending from the mid-posterior margin of the anterior commissure to the anterior margin of the posterior commissure. Frontal zero plane was at a point midway between the anterior and posterior commissure at right angles to the horizontal plane. Sagittal zero plane was identified by a vertical line passing through the center of the 3rd ventricle in the frontal projection. For purposes of this study, the localizations were expressed in terms of the electrode-tip position. However, it must be emphasized that the electrode was oriented in approximately a 40-degree angle with the horizontal zero plane in the sagittal projection.

Radio-frequency Lesions. Lesions were made with the Bovie, a spark-gap generator of radio-frequency current. The current was applied through electrodes insulated up to 4 to 10 mm. from the tip. Four to 5 mm. bare tips were used for subthalamic lesions and 6 to 10 mm. bare tips for lesions of internal capsule, thalamus, and globus pallidus. The diameter of the electrode was slightly over 1 mm. Characteristics of the Bovie in relation to making a lesion were determined in egg white and in 20 cat brains.

Size of Lesion. With a constant size of electrodes, the size of an electrically induced lesion is proportional to two major factors: (1) magnitude and (2) duration of the applied current. For purposes of this study, therefore, the lesion necessary to reduce tremor was expressed in terms of the “Bovie-time factor.” This value was obtained by multiplying the Bovie setting and the duration of the applied current (in seconds). The relation between “Bovie-time factor” and size of the lesion is given under Results. Bovie settings of 7½ to 30 with durations of 5 to 15 sec. were used. In

most instances, the Bovie setting was varied and the duration of the applied current was maintained at 15 sec. The current was re-applied at 15- to 20-min. intervals until the desired reduction in tremor was obtained. "Bovie-time factors" utilized ranged from 75 to 3,500.

**Evaluations of Tremor.** Evaluation of tremor was made by clinical observation, tremogram recordings and, in some instances, with motion-picture recordings. Exact quantification of the output of tremor by evaluating the tremograms was attempted and was found to be very difficult. Thus, objective, but nonquantitative methods were used to evaluate patterns of tremor, periodicity, amplitude, frequency, persistence, and reaction to stress over time. To observe changes in tremor during insertion of the electrode, the electrode was advanced in increments of 2 to 4 mm. A minimum pause of 15 to 30 sec. was used to evaluate the tremor between each increment of insertion.

**High-frequency Lesions in Cat Brains and Egg Albumin.** Twenty-two cats were used to determine the Bovie characteristics in producing a radio-frequency lesion. A lesion was placed in both hemispheres of each cat and in several cats two small lesions were placed in one hemisphere. Electrode punctures of the brain without coagulation and electrocoagulation without a ground were utilized as controls. One week after lesions were placed animals were sacrificed and the brains were cut serially. To avoid the marked shrinkage of tissue associated with paraffin- and celloidin-embedding techniques, the serial frozen-section technique was used. Transverse diameters of the lesions were then measured directly from the histological sections which were stained with cresyl violet. For purposes of this study, no correction was necessary for shrinkage of tissue since it was relatively small. In addition, 3 cats and egg whites were used to correlate different Bovie settings with output of current. Egg white was used to correlate the size of the coagulum for various Bovie settings and durations necessary to producing bubbling and charring. The graphs present studies done with a 4 mm. bare tip of the electrode (Figs. 1 and 2).

**Sagittal Planes for Presentation of Results.** Results were plotted in sagittal stereotaxic planes for two reasons: (1) the brain stem is narrower than it is long and therefore fewer figures were needed to represent the points of localization and (2) the electrode was oriented at approximately a 40-degree angle with the horizontal zero line, in the sagittal plane, and directed from a frontal approach, 1½ mm. from the midline. The tips of the electrodes were located in sagittal planes 8 mm. through sagittal plane 22 mm. from the midline. Consequently, they were divided into four composite groups as follows: lateral 8.0–10.5 mm., 10.5–13.5 mm., 13.6–17.5 mm., and 17.6–22.0 mm. Each of these composite groups represented widths of 2.5 mm., 3 mm., 4 mm., and 4.4 mm. respectively. The width represented in each group was chosen to allow for one standard deviation in the neuroanatomic variability as described by Van Buren and Maccubbin. Greater variability was allowed for sagittal planes as they progressed further away from the point of reference.

**Statistical Analysis.** Statistical analyses were performed utilizing chi-square and two-tailed t-tests.

**Results**

**Bovie Output.** Since the Bovie is a spark-gap radio-frequency device, it presents problems in the measurement of its output of power. However, an indication of its output contributing to the development of a lesion was obtained by placing an incandescent lamp in series with the electrode. The light from the lamp was measured photoelectrically and the Bovie output at each setting of power was determined by "calibrating" the lamp with a direct current. Fig. 1 shows the relationship obtained between equivalent DC current and Bovie setting of output. Since power is a function of current, these results indicate an increase in output of power with increased setting of Bovie. The energy dissipated in the tissue is a function of power and time; consequently, we have chosen to relate the lesion to the "Bovie-time factor."

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