Stereotaxic Spinal Surgery
A Preliminary Report

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The principles and practice of stereotaxic supratentorial surgery are well established and have resulted in important advances in physiology and therapy. The possibility of spinal stereotaxic surgery has received little or no attention although as long ago as 1921 Clarke\(^1\) devised a simple electrode carrier to make spinal cord lesions in animals. The success of percutaneous spinthalamic tractotomy,\(^6,7,9\) even with present aiming techniques,\(^5\) suggests that with improvement in target siting, reliability of fixation and lesion making, this procedure could become as effective as open procedures and infinitely more selective.

Rand, et al.,\(^a\) in 1965 used a stereotaxic procedure to insert a cryoprobe via the C1-C2 interlaminar space so that it contacted the anterior quadrant of the spinal cord. The first attempt produced only a transient partial hypalgesia of the C-5 dermatome, but this was accompanied by a progressive, although transient, weakness of the hand and leg. A second attempt was only partially successful in that the hypalgesic level was not sustained, and pain recurred within 10 days.

Methods
Cadaveric experiments and surgical observations over the past 4 years have demonstrated the relative immobility of the medulla and first and second cervical cord segments which are held by the lower cranial nerves and the large first dentate ligament. We have therefore attempted to produce stereotaxic intraspinal lesions via the interval between the foramen magnum and the arch of the atlas. The coordinates used were based on personal observations on a series of high cervical spinothalamic tractotomies at the C1-C2 segments, some of this experience being reported in 1967.\(^8-4\)

Initially the odontoid was used as a landmark with the approximate formulation that the cord at this level (C-1 segment) was 15 mm wide in the lateral plane and 10 mm deep in the anteroposterior plane. The anterior surface of the cord was assumed to be 2 mm from the posterior aspect of the odontoid based on direct observation during open cordotomies with the head in the fully flexed position.

The target was chosen according to the analgesic level desired and was thus anterior to the midpoint of the cord and medial or lateral by larger or smaller amounts depending on whether upper or lower body levels were desired. For upper body levels, the coordinates were 3 mm lateral to the midline of the odontoid and 3 mm posterior to the odontoid; this was regarded as a target site 3 mm from the midline and 1 mm posterior from the anterior surface of the cord. For lower body levels, the coordinates were 6 mm from the midline and 6 mm posterior to the surface of the odontoid process. This was regarded as a target site 6 mm from the midline and 4 mm posterior to the anterior surface of the spinal cord.

With the neck in the fully flexed position, a rigid wide-bore stainless steel needle was passed through the neck percutaneously between the arch of the atlas and the foramen magnum in a selected plane, angle, and depth within the guiding system of the electrode carrier. The needle was advanced until cerebrospinal fluid was aspirated; approximately 5 to 10 ml of air were then injected to outline the cord. The cord outline, however, corresponded so closely to the calculated cord volume that a change of target site seemed unnecessary in these cases. Various electrodes of different gauges were tested, but the larger electrodes did not prove as successful as tungsten wire insulated except for 2 mm at the tip which was advanced until the cord was penetrated.

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Old Stereotaxic Frame. The first clinical attempt was made using a modified Leksell frame; this case is reported below.

Case 1. The patient was a 22-year-old man with severe intractable pain in both arms from a metastatic teratoma in the cervico-thoracic region. A successful left-sided spinothalamic lesion was produced on June 2, 1967. The target was 3 mm posterior to the odontoid and 3 mm lateral to the midline. A special needle was held in the electrode holder and inserted through the atlanto-occipital membrane until cerebrospinal fluid could be aspirated. An electrode was then passed through the needle toward the target. He complained of pain in the left side of the face during passage of the electrode and with further advancement to the target, a burning sensation in the right arm. A radiofrequency lesion was made achieving right-sided analgesia up to C-3 including complete relief of pain in the right arm; there was also analgesia in the left side of the face affecting all three divisions of the trigeminal nerve. The attempt to create a right-sided spinothalamic lesion was unsuccessful. The patient succumbed to widespread metastatic disease 12 days later. Histological examination revealed a stereotaxic lesion in the lower part of the medulla at the level of the pyramidal decussation (Fig. 1).

It seemed evident from this case that, although stereotaxic spinothalamic tractotomy was feasible at this level by this approach, an entirely new stereotaxic frame was required to surmount the particular difficulties of this route.

New Stereotaxic Frame. The new frame (Fig. 2), is a rigid metal alloy hollow square with one point for rigid skull fixation threaded in the midline and two in opposing corners. The sides of the frame are marked off with radio-opaque 2-mm divisions on either side of a zero central point on each side of the frame. A sliding fixture attached to the posterior bar of the instrument holds the vertical bar of the electrode carrier. This permits lateral and vertical adjustment, bringing the axis of the electrode carrier to the lateral and vertical coordinates of the target point. The vertical bar is marked off with radio-opaque divisions at 2-mm intervals and has an offset portion which receives the horizontal bar of the electrode carrier, also marked off in 2-mm radio-opaque divisions. Standard x-ray plates are held parallel to the frame by clamps.

The frame is applied with the central fixation point at the midline of the forehead just above the supra-orbital ridge. The two posterior fixation points penetrate the outer table of the skull just above and behind the mastoid process.

Radiographs are taken with the x-ray tube 3 meters from the frame so that errors due to magnification are minimal. The antero-posterior radiograph is taken through the open mouth to obtain good definition of the odontoid, and the midline of the head is chosen as the axis of the odontoid. This axis is projected on the film through the anterior and posterior bars, and the offset of the midline of the odontoid and the frame is calculated directly from the divisions on the frame.

The sliding fixture is then adjusted so that the axis of the electrode carrier which passes through the horizontal bar is in the axis of the odontoid. The vertical bar is then set at a known length in relation to the frame.

A lateral radiograph is then taken and the target point. The vertical bar is marked off from this target point parallel to the horizontal bar until it intersects the vertical bar measurements, thus giving the vertical coordinate. The distance from target point to the