

## THE SURGICAL TREATMENT OF PARKINSON'S DISEASE : CRYOTHALAMECTOMY\*

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The purpose of this paper is to bring to the attention of the medical profession the present status of surgery in the treatment of Parkinson's disease. Using techniques which have only become available in the past few years has resulted in a high success rate, a low percentage of complications, and a negligible mortality rate in cases correctly assessed and selected.

The first surgical attempt to correct involuntary movements was made in 1890 by Horsley<sup>17</sup> when he excised the precentral cortex for athetosis. In 1937 Klemme<sup>18</sup> and Bucy and Case<sup>19</sup> attempted to control the tremor of Parkinson's disease by resection of either the premotor cerebral cortex (area 6) or motor cerebral cortex (area 4), or both. Although tremor was abolished in a fair number of cases, hemiparesis was the price in all cases, epilepsy resulted in many, and rigidity and incapacity were never decreased and were sometimes increased. In an attempt to avoid some of these complications, attacks were made further down the pyramidal tract—pyramidotomy<sup>20</sup> at the second cervical segment, pedunculotomy,<sup>21</sup> and complete section of the lateral column of the cord.<sup>22</sup> These procedures all led to the false aphorism, 'tremor can only be relieved by producing paralysis'.

Operations such as posterior rhizotomy<sup>23</sup> and sympathectomy,<sup>24</sup> as could be anticipated, produced no good whatever; and ablation of the dentate nucleus of the cerebellum increased the tremor in Delmas-Marsalet and Van Bogaert's case.<sup>20</sup>

Attention turned to the basal ganglia in 1940 when Meyers resected the head of the caudate nucleus.<sup>20</sup> He subsequently combined this with extirpation of part of the globus pallidus and putamen,<sup>22</sup> and section of the pallidofugal fibres.<sup>21</sup> These operations were subsequently modified by Browder.<sup>7</sup> In 1947 Spiegel *et al.*<sup>25</sup> described a human stereo-encephalotomy using the anterior commissure identified by air ventriculography as a reference point, to make lesions in the ansa lenticularis. They were followed by various workers,<sup>19,23,27,31</sup> each of whom produced a stereotaxic apparatus with which meticulously placed lesions were made in the globus pallidus, ansa lenticularis and ventrolateral nucleus of the thalamus. Lesions were made by electrocoagulation or procaine injection. Fenelon and Thiebaut,<sup>11</sup> Guiot and Brion<sup>15</sup> and Bertrand<sup>1</sup> employed a direct approach to the ansa lenticularis and mesial globus pallidus, where lesions were made with a leucotome or by electrocoagulation.

In 1952 Cooper<sup>8</sup> accidentally discovered that ligation of the anterior choroidal artery resulted in elimination of Parkinsonian tremor, and in 1953 he developed a simple technique of injecting procaine into the globus pallidus using a basal ganglia guide.<sup>7</sup> Cooper's original basal ganglia guide was not a stereotaxic instrument. With this was developed a technique of physiological testing to confirm the position in which the lesion was to be made: procaine

was injected or a balloon inflated in the target area, and if the desired effects were achieved without side-effects then a permanent lesion was made by the injection of absolute alcohol or some other sclerosing substance. This procedure is the classical chemopallidectomy or chemothalamectomy. Subsequently other techniques have been employed to produce the lesion, such as ultrasound and cryosurgery. With each procedure developed, the results have improved while the percentage of undesirable side-effects has lessened.

The neurophysiology of the extrapyramidal system and the pathogenesis of parkinsonism are but poorly understood and the rationale for various surgical procedures is far from clear. Suffice it to say that lesions made in the postero-inferolateral portion of the ventrolateral nucleus of the thalamus or in the H<sub>1</sub> field of Forel will produce cessation of tremor and reduction of rigidity, without producing hemiparesis.<sup>25</sup>

Spiegel<sup>25</sup> has conducted a survey of stereo-encephalotomies (i.e. stereotaxic operations) performed throughout the world until 1965. This survey showed that almost 26,000 stereotaxic procedures had been performed up to that date.

### MODERN TECHNIQUE

Over 800 procedures have been performed in this unit, where the lesion is made in the ventrolateral nucleus by means of a cryosurgical probe using the Leksell stereotaxic instrument. Occasionally, a lesion is made in the globus pallidus as well as in the ventrolateral nucleus in cases of particularly intractable tremor.

### Selection of Cases

Cooper<sup>8</sup> has demonstrated by means of follow-up studies that the incidence of success following operations for parkinsonism is directly proportional to fulfilment of the criteria of selection of patients. Analysis of his series shows that 90% of patients who were classified as good candidates had satisfactory relief of symptoms following surgery, 70% classed as fair pre-operatively were satisfactorily relieved by surgery, and only 40% of those classed as poor candidates benefited from surgery.

The ideal candidate is one in whom only tremor and rigidity are present unilaterally, with no autonomic involvement or disturbance of speech and gait. The duration of symptoms seems not to affect the result. The good candidate is one who has had unilateral parkinsonism for some time and has recently developed similar symptoms in less severe form on the other side, without autonomic or psychological impairment. The fair candidate is one with equal bilateral disease and signs of midline structure involvement. This is evidenced by deteriorating speech and possibly gait, and by autonomic disturbances. The poor candidate is one with bilateral disease, autonomic disturbances, speech difficulties, and who is essentially confined to bed. Age plays no part in the selection of cases, al-

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though, obviously, better results are obtained in younger patients.

#### Contraindications

The one absolute contraindication to surgery is mental deterioration, which should not be confused with drug-induced confusion. Relative contraindications are severe hypertension and diabetes, which, because of arterial disease, may result in haemorrhage during operation; chronic pulmonary disease may produce mortality in the postoperative period. Other relative contraindications are severe involvement of speech and/or gait. Cases which present mainly with akinesia or autonomic disturbances are not suitable for surgery.

#### Technique

The technique of the procedure may be divided into 3 phases: localization of the area to be destroyed, confirmation of the selected area by testing, and, finally, production of the lesion.

The localization of the area to be destroyed is dependent upon a fixed marker system attached to the skull (the stereotaxic frame) and the identification of reference points within the brain which can then be correlated with the frame. From the large mass of data available on the human brain in various atlases, the coordinates of the target structure can be calculated.

The stereotaxic instrument used in this unit is that devised by Leksell<sup>®</sup> (Fig. 1). This is a light, accurate and versatile instrument which is attached to the skull by three retaining pins in such a way that the frontal pin is in the midline, with the two parietal pins placed so that there is no rotation of the skull within the frame; the horizontal bar of the frame is placed along Reid's baseline (Fig. 2). The frame has engraved, radio-opaque millimetre and centimetre markings, giving distances in the vertical, horizon-

tal and lateral planes. Air ventriculography is performed through a frontal burr-hole on the same side as the intended lesion after the frame has been attached to the head.

The procedure is carried out under local anaesthesia for reasons to be discussed presently, injections of lignocaine 2% being quite adequate in the areas of the fixing pins and the burr-hole. The patient experiences only a few minutes of discomfort during the initial stages while the frame is held by ear-plugs until the fixing pins are in place; the ear-plugs are then removed and the patient experiences no further discomfort.

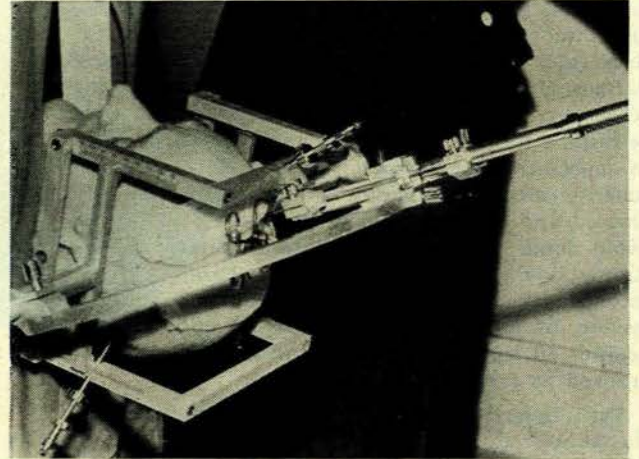


Fig. 2. The Leksell instrument attached to the patient's head under local anaesthesia. The frontal pin is in the midline, the head is not rotated, and the horizontal bar lies on Reid's baseline. A cryogenic probe has been passed through the burr-hole to the target point and is clamped to the arc.

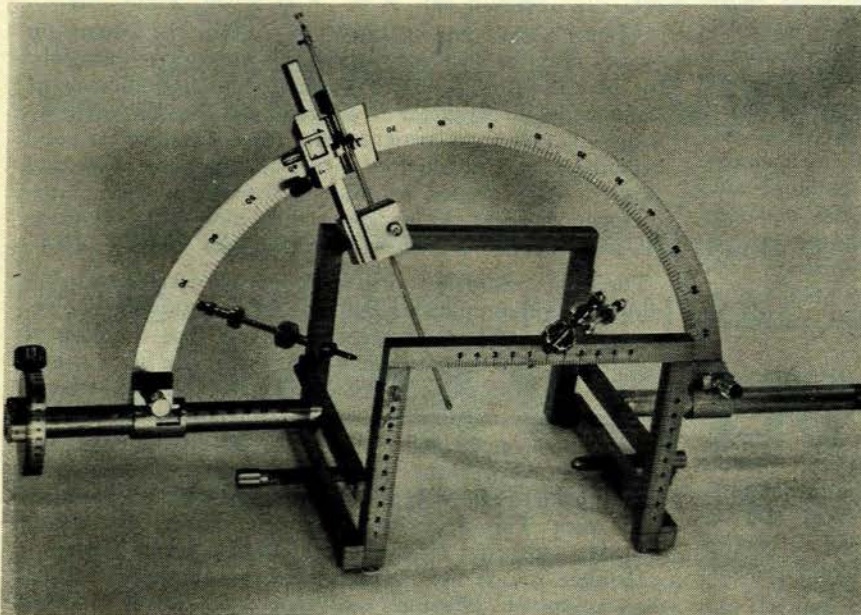


Fig. 1. Leksell's stereotaxic instrument.

Sufficient air is injected to outline the frontal horns of both lateral ventricles, the third ventricle and the upper part of the aqueduct of Sylvius. From the ventriculogram the anterior and posterior commissures can be accurately pinpointed and the inter-commissural line determined (Fig. 3). By comparison with atlases and models of average ventricular systems the average position of the ventrolateral nucleus in relation to the inter-commissural line can be marked in the anteroposterior and horizontal planes. The lateral edge of the thalamus is determined from a perpendicular line drawn from the outer border of the lateral ventricle on the A-P plate, indicating the margin between the ventrolateral nucleus and the internal capsule (Fig. 4). The 3 coordinates thus obtained are then transferred to the stereotaxic instrument so that it will deliver the tip of the probe producing the lesion to the

postero-inferolateral portion of the ventrolateral nucleus; the arc of the stereotaxic instrument carries a clamp for the probe and is attached to the frame according to the coordinates. The probe is then passed to the target position through the burr-hole made for the ventriculogram.

Due to variability of different brains it is necessary, before making a permanent lesion, to ensure that the calculated area is indeed the correct one. The older method used in chemopallidectomy depended on the elimination of tremor without producing paresis by the injection of procaine into the area or by inflation of a small balloon. These methods have been abandoned with the introduction of more sophisticated techniques. Some workers use electrophysiological studies to confirm the position of the ventrolateral nucleus. A recording electrode is introduced and the positions of the ventroposterior nuclei and the internal capsule can be confirmed by their spontaneous electrical activity and responses to evoked potentials. This method requires expensive apparatus and technicians to maintain and operate it, a fair amount of experience and knowledge of electrophysiology and either very expensive recording electrodes such as Jasper's electrodes, or, if a simpler electrode is used, a second posterior burr-hole in order to pass the electrode via the ventroposterior lateralis nucleus through the ventrolateral nucleus to the internal capsule. In addition, such recording is time-consuming, more than doubling the time required for the procedure.

The method of physiological testing used in this unit is incorporated in the actual production of the lesion so that it does not add to the time of the procedure, requires no additional apparatus or personnel, and is simple in conception. The lesion is produced by cold, utilizing circulating liquid nitrogen in a vacuum-insulated probe. The tip-temperature of the probe can be accurately selected and maintained. Using this method devised by Cooper *et al.*,<sup>9</sup> the lesion is slowly increased in size by small decrements of the probe-tip temperature until the required lesion is obtained. The cold lesion is initially reversible, so that if untoward effects are noted, such as paraesthesia or hemiparesis, the probe is immediately rewarmed and normal function is restored after a few moments. The probe position can then be adjusted accordingly. Similarly, the effect on tremor and rigidity can be observed before the final

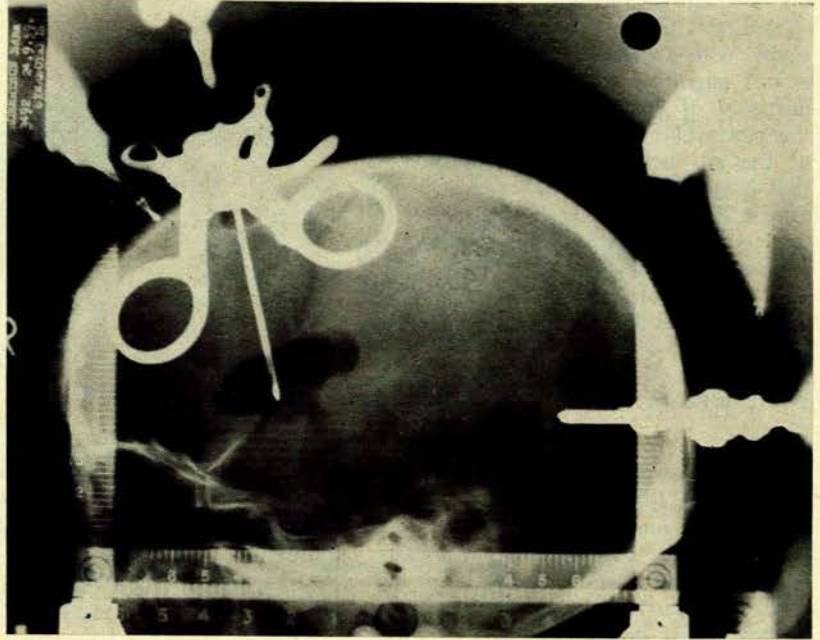


Fig. 3. Air ventriculogram, lateral projection. The anterior and posterior commissures have been pinpointed. The opaque graduated markings on the frame can be seen.

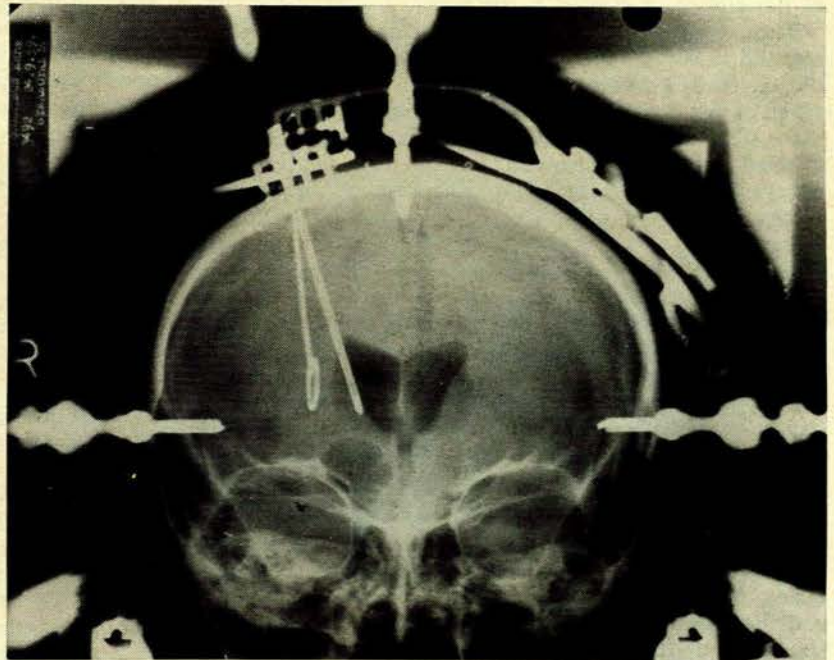


Fig. 4. Air ventriculogram, anteroposterior projection.

lesion is made. This is usually achieved at  $-80^{\circ}\text{C}$  for 90 seconds. The total time required for making the lesion in the average case as described above is  $6\frac{1}{2}$  minutes. The method is both safe and effective, as reported by Cooper *et al.*<sup>9</sup> and confirmed by the large number of cases

operated on in this unit.

The final lesion is roughly globular in shape, with a diameter of 6 mm., and it is not haemorrhagic (Fig. 5). It is for purposes of confirming the position of the cryoprobe and observing the effects of the advancing lesion on the tremor that it is essential to perform the procedure with a fully conscious and cooperative patient. The whole procedure, comprising ventriculography and production of the lesion, takes about 1 hour.

Only one side is done at a time. If the contralateral side requires surgery, a period of 2-3 months is permitted to elapse between the two procedures.

#### RESULTS

It should be emphasized that surgery does not halt the progression of the disease, but removes some of the more disabling and embarrassing manifestations of parkinsonism. It does prevent sufferers from becoming bed-ridden and permits most individuals to cope with life unaided; some previously helpless patients may be rehabilitated after surgery. Most cases require to continue medical therapy following surgery, to control advance of those symptoms of the disease unaffected by surgery.

Those aspects of parkinsonism that can be expected to respond to surgery are tremor and rigidity. The ideal candidate stands a better than 90% chance of full and lasting relief of his symptoms.<sup>8</sup> The good candidate has a better than 80% chance of relief of symptoms on the more affected side, and operation for the opposite side can always be considered if it is desired or the tremor becomes worse. For the most part, patients who fall into the category of poor candidates can only expect a 40-50% chance of becoming functionally independent; patients over the age of 60 in this class should usually be rejected. However, any patient with advanced parkinsonism with postural deformities of long standing, even when bed-ridden for some time, may be considered for operation if he is not physiologically aged and does not have other contraindications to operation. It must be stressed that patients caught at an early stage of the disease benefit much more than advanced cases, and no patient should be allowed to progress to that stage before surgery is contemplated.<sup>8</sup>

Together with relief of the rigidity, those features consequent on the rigidity are immediately relieved.<sup>8</sup> The easing of pain is a striking benefit of reduced muscle tone, and the postural deformities of the fingers and hand are reduced immediately. Associated movements do not return, and the patient must be re-taught to walk correctly and swing the arms. Facial expression may be improved after operation. The common festinant gait is improved in about 40% of cases, though there may be some deterioration in other cases. Poor phonation, due to rigidity of muscles concerned, is often improved. Oculogyric crises are either abolished or reduced in frequency in half of the cases submitted to bilateral operation.<sup>14</sup> Akinesia and



Fig. 5. Section of brain with a cryogenic lesion made 3 months before death in the ventrolateral nucleus of the right thalamus.

bradykinesia are unaltered by surgery, and therefore disorders of gait due to these factors will not be improved. Nor are any of the autonomic disturbances improved by surgery: excessive salivation and perspiration, oily skin, disturbances of micturition and increased heat production.<sup>16</sup> Cases presenting predominantly with akinesia or autonomic dysfunction are unsuitable for surgery. Recurrence of tremor occurs in 10% of cases.<sup>16</sup> These can be re-operated on as soon as the burr-hole has healed—usually after about 14 days.

Hankinson<sup>16</sup> has assessed all his patients in respect of general functional ability in working or looking after themselves by a system of scoring of 30 items before and after operation. On this basis in his cases, 65% were considered to have an excellent result and 25% a good result, while 10% were unchanged or worse.

In these 800 cases there were 3 operative deaths (0.4%), 2 due to intracerebral haemorrhage with death on the 1st and 21st postoperative days; the third patient, a bilateral case, died on insertion of the ventricular cannula at the start of the second operation, also from haemorrhage. There were 6 late deaths (0.75%), of which one was in a bilateral case who became akinetic and mute after the second operation and died with extensive bedsores 4 months later. Of the remaining 5 cases, 1 died of meningitis 3 months after surgery, 2 of bronchopneumonia at 2 and 3 months, one of intracerebral haemorrhage at 10 weeks, and one at home 1 month after operation, of an unknown cause. There have been no deaths in the last 200 cases. The over-all mortality is 1.13%.

#### Complications

The incidence of permanent complications in this series is 2.5%. Transient disturbances of neurological function occur in 10% of cases. The incidence of complications is

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