NEUROSURGICAL TREATMENT OF BASAL GANGLIA DISEASES

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Neurosurgical treatment of basal ganglia diseases began in 1890, when Horsley removed the precentral gyrus of a patient with athetosis. The method he pioneered was perfected during the following 25 to 30 years, and two basic techniques emerged. One of these involved the creation of lesions in the motor areas of the brain (cortex, capsula interna, pedunculus cerebri, and the spinal pyramidal, tract). The second involved the creation of lesions in the extrapyramidal system (premotor cortex or the basal ganglia).

Although surgical treatment does not cure these diseases of the brain, it may remove the symptoms, either partially or completely. Lesions made in the basal ganglia alleviate tremors and rigidity. Lesions in the pyramidal system alleviate tremors, but motor impairment may cause spasticity, and the rigidity continue.

Parkinsonism was first treated surgically in 1935 when Bucy removed the motor and premotor areas of the brain in some of his patients. Although tremors ceased postoperatively in these patients, contralateral spastic hemiparesis and convulsions occurred and rigidity continued as before. In 1937 Klemme performed premotor cortical excisions in a series of cases. He reported that tremor stopped in 39 out of 100 cases without a trace of neurologic defect. Putnam, in 1938, sectioned the lateral pyramidal tract within the spinal cord at the level of the second cervical segment and below decussation. Ebin and Schurman in 1949, and Oliver in 1950 modified this method further. However, it was soon evident that, although these operations could stop tremors, they were ineffective in controlling rigidity and were generally accompanied by motor impairment. In some cases however, it was noted that motor power lost after the operation was regained later on.

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Other early attempts to relieve the symptoms of parkinsonism include Brower's removal of the front "leg" of the capsula interna, and Walker's pedunculotomy. This latter technique resulted in hemipharasia and hemiplegia in at least two instances. Operations performed on the nerve roots of the back, on the back columns of the spinal cord and in the paravertebral spinal ganglions failed either to correct tremor or to prevent rigidity and motor impairment. Pollock and Davis attempted posterior rhizotomy to correct these symptoms, and Pausepp, Rizatti and Moreno tried sympathectomy, but obtained no positive results. Delmas, Marsalet, and van Bogaert created lesions in the nucleus dentatus and in the middle cerebellar peduncle. After this operation a decrease in rigidity was noted but the patient died ten days later.

All of these operations on the motor cortex pyramidal tract resulted in almost total hemiplegia which improved in some cases and became a moderate hemiparesis. Tremor disappeared completely and permanently, but the operation had no effect on rigidity. Spacticity continued in many cases. The results obtained indicate that an operation on the motor cortex and/or the pyramidal tract should be considered only if tremors are predominant and unilateral.

The desire to alleviate tremors and rigidity without causing motor impairment has led to improvement in basal ganglia surgery during the past 20 years. Meyers made a great improvement in 1940 in this field. He had tried various types of operations, such as excision of the head of the caudate nucleus, excision of one-third of the globus pallidus and futamen, and excision of the pallido-fugal fibers arising in the globus pallidus. He obtained the most promising results from the last of these. This operation includes a series of transventricular interventions, following a cortical incision leading to the globus pallidus. Although in some cases tremor and rigidity disappeared completely, the results were not uniformly good and the mortality rate was 15.7 per cent. Browder, using a method similer to Meyers, cut out the putamen and a section of the globus pallidus and reported a decrease in both tremors and rigidity.

In 1950 Spiegel and Wycis perfected the stereotaxic apparatus developed by Horsley and Clarke, and used it in basal ganglia operations. Preoperative pneumoencephalograms enabled them to fix the foramen of Monro and determine the Target area. They reported positive results in two patients with choreo-athetosis following electrolytic lesion, one in the front part of the capsula interna and the

other in the globus pallidus. In 1954, they reported alleviation of tremors and rigidity without any trace of motor defect in five out of six cases of parkinsonism treated by ansotomy. In a later report, however, they noted recurrence of the symptoms in two cases. Later, positive results were reported in 70 per cent of 75 cases.

Since 1952 many neurosurgeons have created lesions in the medial portion of the globus pallidus in the treatment of parkinsonism by using different types of stereotaxic apparatus. Recently Wycis injected procaine to cause lesions in the basal ganglia. Narabayashi, using his own apparatus, injected procaine in oil to cause lesions in the medial globus pallidus, with apparently positive results. Leksell made "thermolesions" at temperatures around 70 C. Fenelon brought about lesions by coagulation through direct intervention and without the use of stereotaxic equipment or x-ray control. He tried various types of operations and reported positive results in 72 per cent of the cases in which transfrontal intervention was performed. Guiot caused coagulation by subfrontal direct craniectomy into the medial globus pallidus and ansa lenticularis. He reported positive results in 42.5 per cent of his 47 cases. Bertrand in Montreal and Gillingham in Edinburgh use a modified form of Guiot's technique.

Meyers and Fry made use of ultrasonic sound to cause deep intracerebral lesions. Recently, synchro-cyclotron and cross proton rays have been directed to the area in which the lesion is desired. This method can be used without the necessity of making an incision or a burr hole and there is little danger of bleeding. It is, however, still in the experimental stage.

In 1952 Cooper caused occlusion of the choriod artery anteriorly to treat parkinsonian tremor and rigidity, and reported success in up to 65 per cent of the patients with 10 per cent mortality rate. This artery is known to supply the medial section of the globus pallidus, the posterior leg the capsula interna, and the lateral aspect of the thalamus.

The following year, Cooper used direct procaine injection into the globus pallidus in treating hyperkinetic defects. He improved this method and obtained positive results in alleviating parkinsonian tremor and rigidity in many patients by chemothalamectomy and chemopallidectomy. He determined the area for lesion by preoperative pneumoencephalography and intervened through a frontal burr hole. Busc used the same method through a temporal burr hole in 1956.

Cooper is now developing a method which causes a lesion by freezing. He uses liquid nitrogen injected through a special cannula. The temperature around the cannula is controlled by a special thermostatic device. A reversible lesion is produced by lowering the temperature to −10 C for 30 seconds. An irreversible lesion is produced if the temperature is lowered to −50 C and maintained for 3.5 second. One advantage to this technique is that it creates a complete lesion and avoids the risk of deep bleeding Further, it allows the surgeon to determine the degree of lesion desired.

Materials and Method

At Hacettepe Medical Center we have performed 24 chemothalamectomies, in 21 of which we used stereotaxic techniques. Our methods and equipment were similar to those of Cooper, with some modification. We first inflated the balloon of a catheter with urographin. The patient was always tested first for allergic reaction to iodine, since it is possible that the balloon may burst for some reason. The lesion itself was bought about using a 20 per cent solution of Moydil in absolute alcohol. Three coordinates were drawn on the head of the patient prior to the operation and these, with pneumoencephalography, located exactly the ventrolateral nucleus of the thalamus (Figure 1).

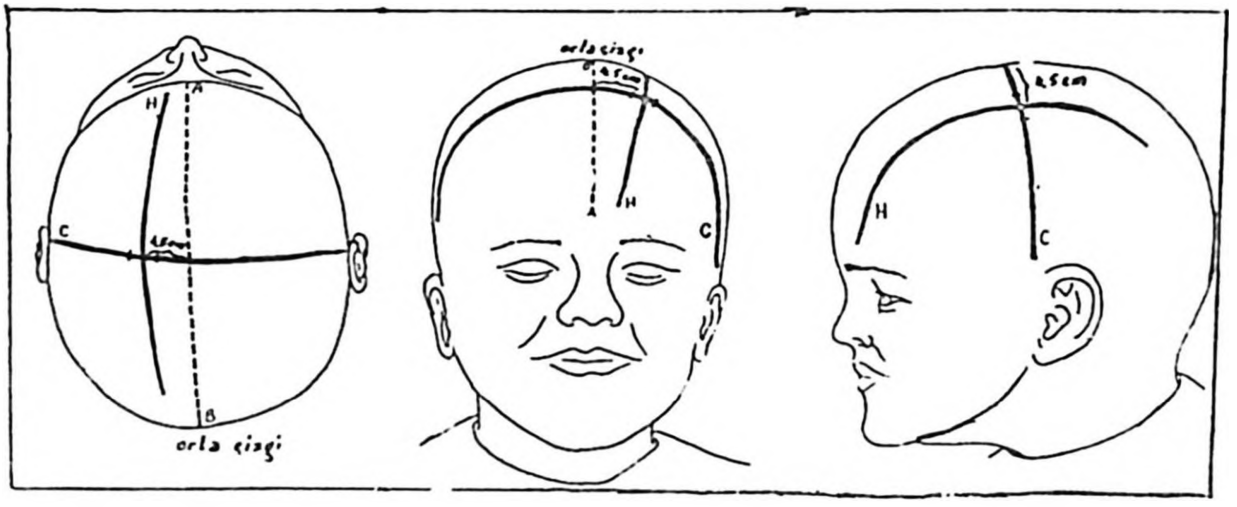


Figure 1. The dotted line, AB, is the midline; the line, C, crosses the midline at right angles and ends at the helix of the ears. The H line (Hacettepe Line) intersects the C line 4.5 cm off the midline and ends in the angulus oculi medialis in front.

The patient's head was shaved and copper wires were laid over the C and H lines. Thirty to thirty-five cc of sterile air were injected by lumbar puncture without removing any liquid, and then Antero-

Posterior and side views of the head were obtained by x-ray (Figure 2a and b). In the lateral x-ray, the C line can be seen to parallel the middle of the foramen of Monro and the recessus pineale; the H line in the Antero-Posterior views indicates the point at which lines drawn

Figure 2 a. Side view of the head showing the C and H lines as marked by copper wires.

Figure 2 b. Front view of the same patient.

from the lateral and lower ends of the lateral ventricle intersect at a right angle. This point corresponds to the ventrolateral nucleus of the thalamus (Figure 3).

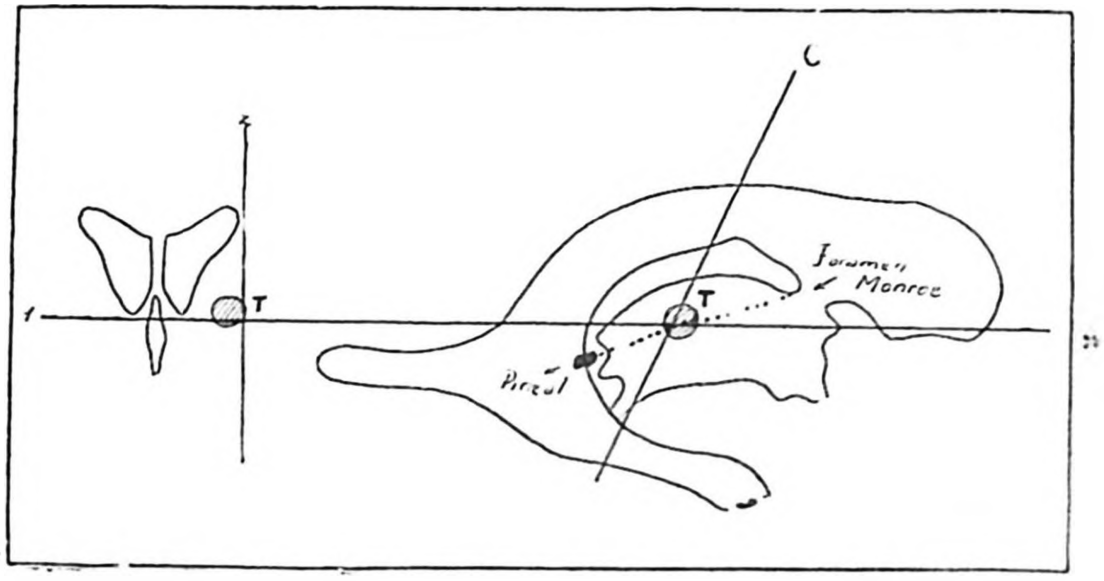
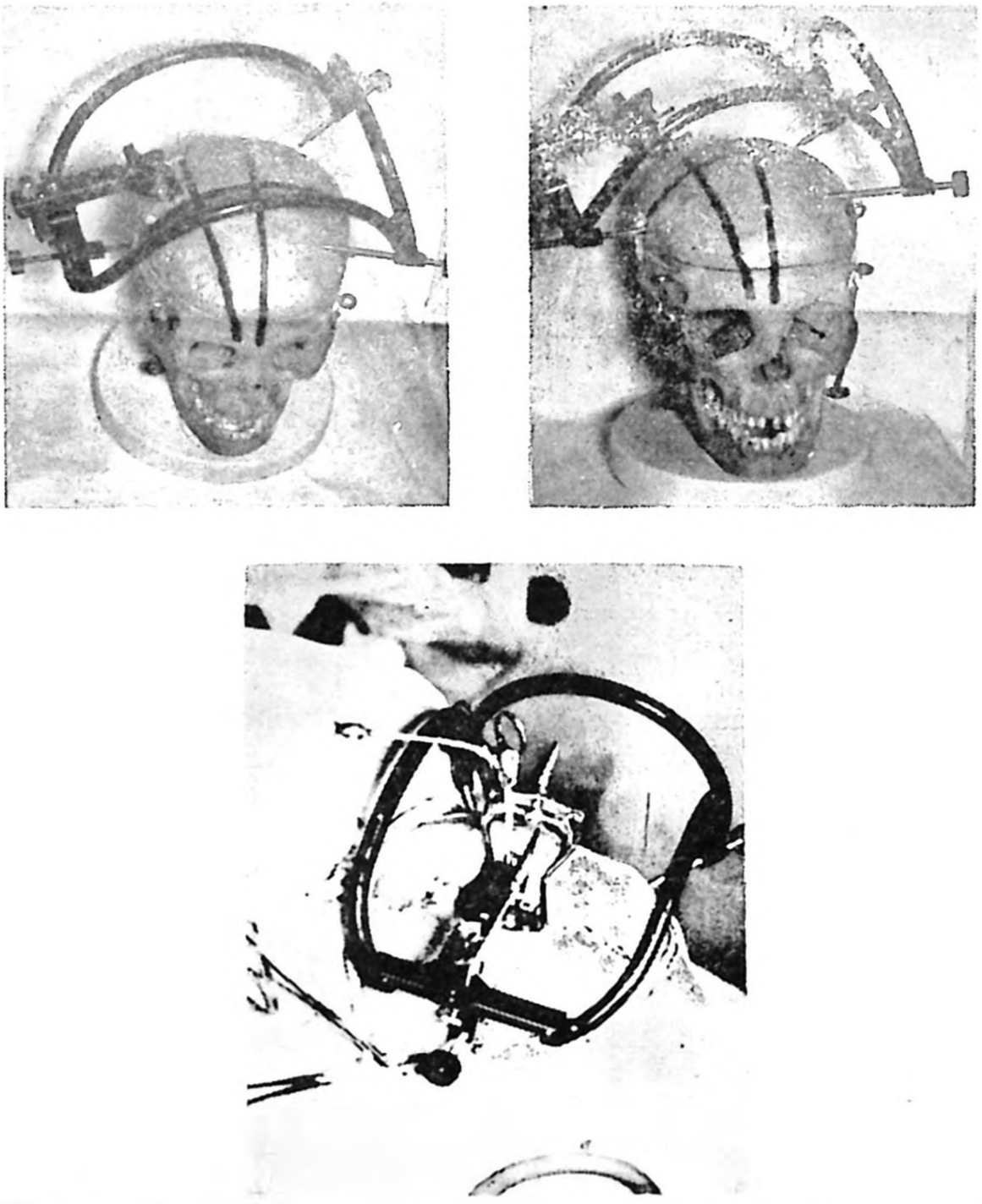


Figure 3. Points indicating the ventrolateral nucleus of the thalamus.

The basal ganglia guide consists of a metal section that can be fixed to the skull with three screws, and has a catheter attached to it which can move in any direction at any angle desired (Figures 4,5 and 6). The catheter Cooper used consists of a double channel poly-



Figures 4, 5, and 6. The basal ganglia indicator and its use in actual operation.

ethylene cannula, a tripod, and a cannula holder. One channel of the cannula is used to inflate the balloon and the other to inject absolute alcohol-mydil into the lesion area (Figure 7).

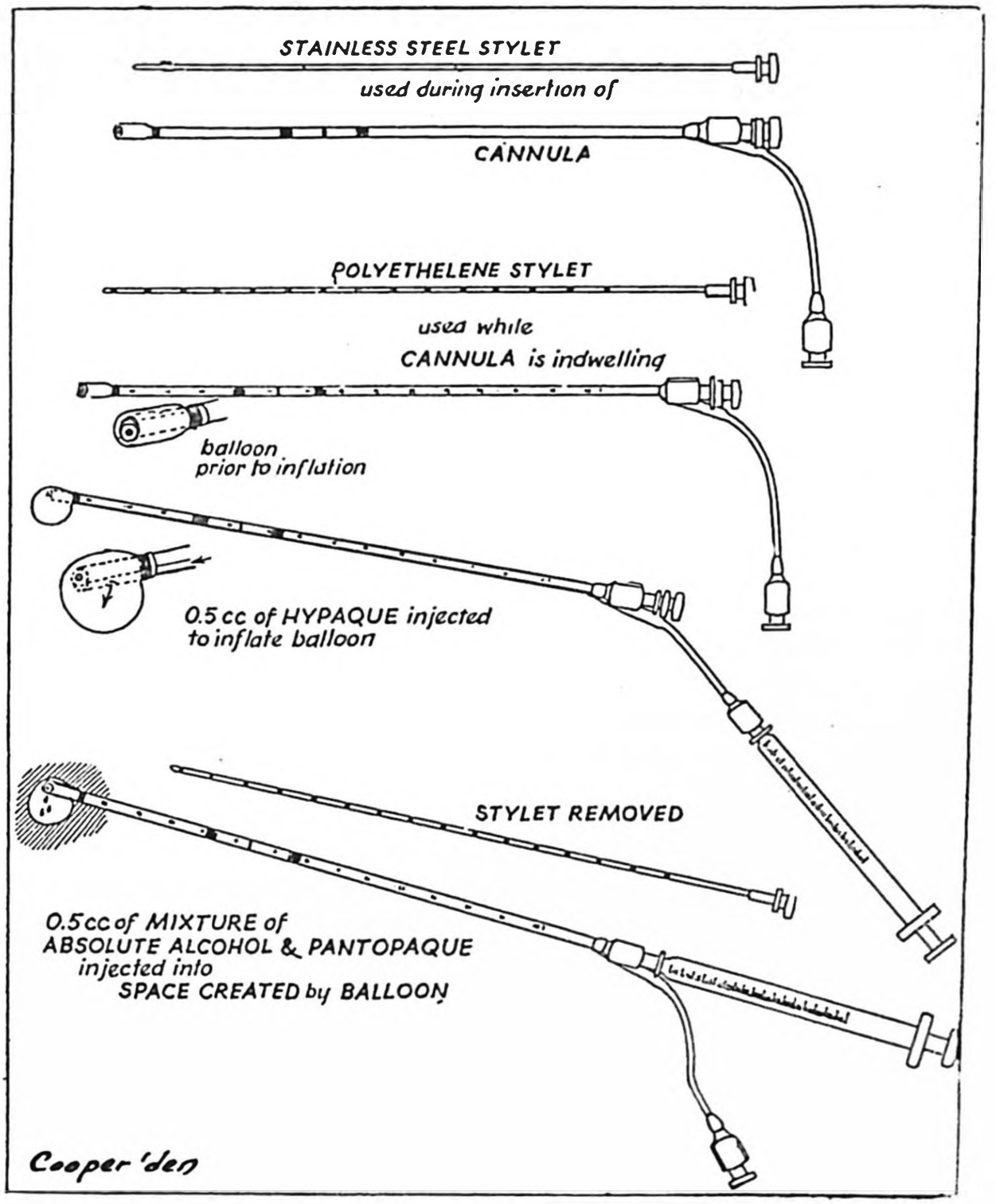


Figure 7. Diagram showing parts of the Cooper cannula (From Cooper).

Phases of the Operation

1. Pneumoencephalograms are made first to determine the lesion area.

2. If the condition of the patient allows, locala nesthesia is employed.

3. A frontal burr hole is made on the site to be opened, following skin incision at the point where the C and H lines cross each other. The dura is opened and a small area of the cortex is cauterized.

4. The basal ganglion guide is fixed to the head and the cannula is placed in its special position on the apparatus.

5. Under x-ray control, the cannula is inserted until it reaches the ventrolateral nucleus of the thalamus.

6. When the cannula reaches the desired point, the balloon is inflated with 0.5 cc of urographin which causes a reversible lesion. When the operation is being performed under local anesthesia, counterlateral tremors and rigidity should be closely watched. When a decrease in tremor and rigidity is noted the operation is halted and the cannula fixed to the skull. If there is no such positive sign, the balloon is deflated, and the cannula reversed and re-inserted.

7. The following day, x-rays of the skull are taken to ascertain whether or not the cannula has remained in place. If there has been no change in the position of the cannula, the balloon is emptied and 0.5 cc of the alcohol-myodil solution is injected through the second channel and an irreversible lesion is created. If one injection is sufficient to create the lesion, the catheter is removed. Injections can be repeated several times if necessary to create an irreversible lesion.

If x-rays indicate that the cannula has been dislodged, it is removed entirely and the patient is allowed to rest before a second intervention is attempted.

The symptoms of patients who underwent chemothalamectomy as described above are summarized in Table 1. The results are summarized in Table 2.

TABLE 1
SUMMARY OF PATIENTS WHO HAD CHEMOTHALAMECTOMY

Case no.	Age and Sex	Parkinson syndrome	Torsion spasm	Choreo-athetosis	Spas-modic torticulis	Chemothal-amectomy
1-S.A.	61, M	×	–	–	–	right side
2-A.A.	50, M	×	–	–	–	left side
3-H.Y.	55, F	×	–	–	–	left side
4-S.S.	62, M	×	–	–	–	right side
5-I.K.	41, M	×	–	–	–	right side
6-M.A.	12, M	–	×	–	–	left side
7-N.D.	54, M	×	–	–	–	right side
8-S.B.	12, M	–	–	×	–	right side and left side
9-Y.E.	11, M	–	–	×	–	left side
10-O.K.	17, M	–	–	×	–	left side
11-M.E.	17, M	–	×	–	–	right side
12-B.K.	53, F	×	–	–	–	left side
13-F.Ş.	61, M	×	–	–	–	left side
14-İ.E.	30, M	–	–	–	×	right side
15-N.A.	9, F	–	–	×	–	right side and left side
16-N.A.	8.5, F	–	–	×	–	right side
17-M.A.	50, M	×	–	–	–	left side
18-V.B.	56, M	×	–	–	–	left side
19-M.D.	55, M	×	–	–	–	right side
20-A.Ö.	55, F	×	–	–	–	right side
21-M.K.	32, M	×	–	–	–	left side

TABLE 2
SUMMARY OF RESULTS OF CHEMOTHALAMECTOMY

Degree of improvement	Parkinson syndrome 3 Females, 10 males	Torsion spasm 2 Males	Choreo-athetosis 2 Females 3 Males	Spasmodic torticulis 1 Male
None	1	1	1	–
Slight	4	–	4	–
Good	6	1	–	–
Death	2	–	–	1
TOTALS	13	2	5	1

Results

Several complications were encountered following the operations. 1. *Displacement of the Cooper cannula:* This complication arose particularly among those patients who had choreo-athetosis (case nos. 8,9,10,11, and 18). Continous movements of the head caused displacement of the cannula.

2. *Bursting of the balloon:* This may be due to a fault in fabrication and may be minimized by using a new cannula for each operation. We encountered this complication in three of our patients (case nos. 1,2, and 14).

3. *Motor Defects:* These may be caused by either a displacement of the cannula or insertion into the wrong area. In one of our cases (19), hemiplegia developed and changed to hemiparesis eight days later. Hemiparesis disappeared in two other patients (case nos. 9 and 13) six to 12 weeks after the operation. We were unable to evaluate another patient who did not return for follow-up examinations.

4. *Aphasia:* In five patients (case nos. 8,9,13,15, and 19), all of whom had right hemisphere dominance, aphasia developed during the first four days after the operation. Left-sided chemothalamectomy was performed on four of these patients, and the fifth patient was operated on from the right. In the three patients who returned for follow-up examinations (nos. 8,9, and 13) aphasia disappeared in the days following the operation.

5. *Lung Infection:* This complication appeared to be the result of aspiration of tracheo-bronchial secretion. We observed it in two patients (case nos. 1 and 18) following complete loss of consciousness.

6. *Somnolence:* We observed somnolence in arteriosclerotic patients with advanced parkinsonian symptoms (case nos. 1, 13, and 18). In two patients (1 and 18) somnolence developed into complete loss of consciousness. In the third case, somnolence disappeared one and a half months after the operation.

7. *Complete Unconsciousness:* This condition developed one to five days after the operatinon in two cases (nos. 1 and 14) in which the Cooper cannula had burst, and in another in which the cannula had shifted position (no. 18).

8. *Death:* Death occurred in three cases (nos. 1, 14, and 18) following complete loss of consciousness, Two of these patients were arteriosclerotic and the other died of complications following the bursting of the balloon. In the former, loss of consciousness and lung infection contributed to the deaths.

We did not observe psychological changes or convulsions as reported by others.

In summary, we can say that ten of our 21 patients suffered postoperative complications. Three of them died. Of the remaining seven, we were able to follow up five, and in all instances sequelae disappeared after some time.

Discussion

Careful selection of the patient plays an important role in the success of basal ganglia operations. Before recommending surgery, the following points should be carefully considered:

1. presence of predominant vegetative defects
2. moral weakness or pessimism
3. psychosis and/or organic mental defects
4. old age
5. arteriosclerosis
6. swallowing difficulty accompanied by pseudobulbar paralysis

In cases of parkinsonism, if the present symptoms of the disease can be controlled by drug therapy and do not bother the patient, an operation is inadvisable. At best the mortality rate is two per cent, according to Cooper. Patients having other parkonsonian symptoms along with strong bilateral tremors and rigidity, predominant vegetative defect, and/or arteriosclerosis; should not undergo this operation. With such patients the results are not sufficiently good to justify the risk involved. We obtained the most favorable results in those patients who had unilateral tremor, with rigidity and only slight motor impairment and no other symptoms (case nos. 3, 4, and 7). In these patients, it was noted that their age and the duration of their symptoms did not effect the results. Also, there were no postoperative complications in these cases.

As the symptoms of the disease intensify, the operation becomes less benefical. Although we obtained quite good results in three patients who had bilateral tremor, rigidity, typical gait pattern and mask-like facial expression (case nos. 12, 13, and 21), the results in two other cases were indifferent, and in one other there was no noticeable change. The complications that occurred in some of our patients are discribed above.

Patients with intense tremor, rigidity, and other symptoms of parkinsonism showed little impovement following the operation (cases 2 and 20).

Cooper developed a set of criteria, based on examinations of 2,000 patients, to aid in the selection of "candidates" for basal ganglia surgery. The "ideal candidate" is one having unilateral tremor and rigidity, and only slight motor impairment. The results are good in in 90 per cent of these patients, and the mortality rate is two per cent.

The "good candidate" is one having slight unilateral tremor and rigidity, who can move by himself, and is without vegetative defects or physiological symptoms. The probability of success with such patients is 80 per cent, and the mortality rate is two per cent. In this group, there is a possibility of neurologic sequelae in two per cent of the patients.

The "average candidate" is one having bilateral tremor and rigidity of equal intensity. These patients often have the other symptoms of parkinsonism as well (parkinson's facies, deep voice, excessive perspiration, and abnormal gait). Although complete recovery is not possible, in 80 per cent of the cases some symptoms do disappear.

The "doubtful or bad candidate" is one having high fever, excessive perspiration, dysphagia, urine retention, dysphonia, and oculogyric crises, in addition to bilateral and intense tremor and rigidity. These patients are largely bedridden, and the probability of the operation being a success is not good. The mortality rate, too, is high.

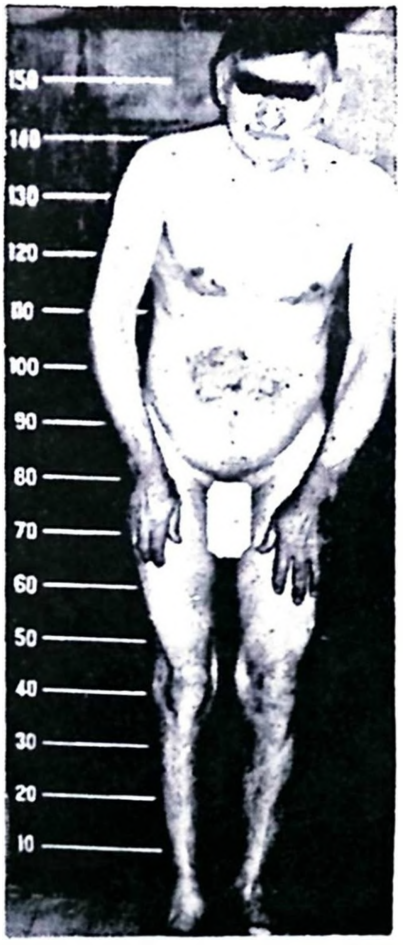


Figure 8. Patient with Parkinson's syndrome who benefitted from bilateral chemothal amectomy.

Additional precautionary measures or contraindications may be encountered on an individual basis. When bilateral chemothalamectomy is indicated, for instance, it is advisable to allow three months to elapse between operations in order to obtain the best results. If aphasia and dysphonia develop after the first operation, the second should be cancelled. A patient who benefited from bilateral chemothalamectomy is shown in Figure 8.

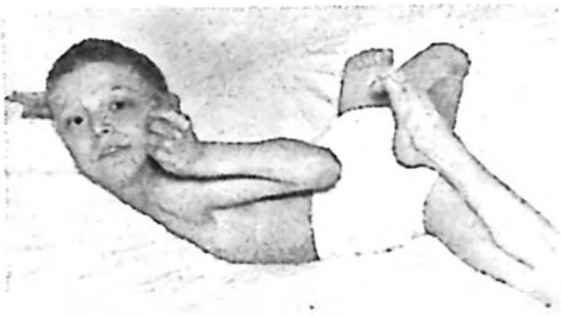
Although we obtained remarkable results in one of our patients with torsion spasms (case no. 6, Figures 9 and 10), complications arose in the other patient when the Cooper cannula became dislodged. X-ray examination revealed a calcified focus in the place where the cannula should have been, and it was felt that this calcification had caused the cannula to slip. The patient did not benefit from the operation and the planned second intervention was not performed. We are of the opinion, however, that chemothalamectomy generally gives good results in these cases.

Figure 9. Patient with torsion spasm prior to operation.

Figure 10. Same patient, after operation.

Four of the five patients with choreo-athetosis were only slightly improved by the operation (Figures 11 and 12). In our opinion the results do not justify the risks involved. This is especially true in those cases complicated by cortical atrophy or ventricular hypertrophy.

We had only one patient with spasmodic torticollis. Although he died a day after the operation, it was noted that the lesions had disappeared within a 30-hour period following the operation. In the surgical



Figures 11 and 12. Patient with choreo-athetosis, before and after the operation.

treatment of this disease, stereotaxic methods are used by many surgeons. Lauri Laitinen, in five patients with spasmodic torticollis, brought about lesions of the thalamus and the medial globus pallidus by stereotaxic methods. He further reported that the symptoms, which had disappeared after the operation, recurred two months later in four of his patients.

During the early attempts at surgical treatment of basal ganglia diseases, lesions were created in different areas of the brain. It was learned that surgery on the medial globus pallidus and its afferent carriers (fascilus lenticularis and ansa lenticularis) may eliminate tremor to a certain extent but has only a slight effect on rigidity. Lesions of the ventrolateral nucleus of the thalamus are effective in alleviating both tremors and rigidity. There are some indications that lesions of the substansia Nigra produce more positive results, but these reports are not yet complete. Lesions on the nucleus Caudatus and the putamen are not beneficial at all in alleviating parkinsonian symptoms. Recently, various techniques have been tried in different clinics. The essential thing is to make a lesion about 10 mm square in the preselected area of the brain, without damaging the surrounding tissue or creating conditions in which other complications might

arise. In some clinics this lesion is created in the ventrolateral nucleus of the thalamus. If the results are not satisfactory, lesions may be made in the medial globus Pallidus or the posterior leg of the capsula interna.

Norholm and Tygstrup performed autopsies on 12 patients who had died from a variety of causes following stereotaxic operations. They found that small and large lesions had been created in the capsula interna after chemothalamectomy in some cases. They also saw patients in whom lesions had been made in the ventrolateral nucleus of the thalamus with unsatisfactory results. Although none of these patients had motor defects, the best results seemed to come from lesions in the capsula interna.

As the anatomy, physiology, and physiopathology of the basal ganglia areas become better known, there will undoubtedly be an improvement in the neurosurgical techniques designed to treat basal ganglia diseases. At present surgical intervention is indicated, particularly in the treatment of parkinsonism, only when other less radical techniques have failed to alleviate the symptoms.

Summary

A discussion of neurosurgical treatment of basal ganglia diseases is presented, followed by a report and summary of the results of 24 chemothalamectomies performed on 21 patients at Hacettepe Medical Center.

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