IN Voluntary MOVEMENT DISORDERS FOLLOWING BASAL GANGLIA SURGERY IN MAN*

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During the course of a series of more than 850 consecutive basal ganglia operations (7, 8, 9) for involuntary movement disorders, 21 patients developed a postoperative dyskinesia differing from that which had been relieved by the surgery. The operatively-induced involuntary movements took the form of a ballismus, chorea or athetosis, alone or in combination. They varied in intensity from mild to severe, and in duration from a single day to 5 months.

Two of the patients who underwent anterior choroidal artery ligation developed transient contralateral choreiform movements which cleared spontaneously within 7 days. In both of these cases, parkinsonian tremor and rigidity were relieved and have not recurred in more than 5 years since surgery.

Only one patient (Case No. 198) in the entire series of over 500 chemopallidectomies manifested a dyskinesia post-operatively:

He is a 34 year-old bilateral parkinsonian who presented a chorea of the right upper extremity the first day after left chemopallidectomy was performed. The abnormal movements disappeared within 24 hours and the patient was discharged after 3 weeks with complete remission of tremor and rigidity on the operated side.

All of the other patients who developed involuntary movements were operated upon during the evolution of the target areas situated more posteriorly: pallidofugal complex and ventrolateral thalamus, especially the latter. Eleven of these patients developed a contralateral dyskinesia following initial surgery. In one case, however, a 34 year-old woman (case No. 435) with dystonia musculorum deformans who had a right chemothalamectomy, a transient athetosis appeared on the ipsilateral side.

Thus far, in the group of patients which were reoperated on the same side because of incomplete results initially, there are no examples of consequent hyperkinesis.

Eight patients who had previously undergone unilateral chemosurgery developed abnormal involuntary movements after placement of a lesion in the opposite hemisphere. Included in this bilateral series are the 2 patients previously mentioned:

The patient with parkinsonism (case No. 198) returned one year later (still

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without tremor or rigidity on the right) for right chemothalamectomy. Two
days after surgery he showed an ipsilateral or right-sided athetosis restricted to
the hand. This is the same limb as was previously involved following left thala­
mectomy. The movements subsided and vanished after 3 days, and the patient
was discharged 2 weeks postoperatively with complete relief of rigidity bi­
laterally, no tremor on the right, slight recurrence of tremor on the left.

The dystonic woman (case No. 435) underwent subsequent left chemothala­
mectomy, again with the appearance of an ipsilateral (left) athetotic tremor
for a short period of time.

These 2 cases illustrate the complexity of the problem. However, this report
will deal only with the occurrence of contralateral dyskinesia following initial
chemosurgery. Evaluation of the anatomico-physiologic correlates in the bi­
laterally-operated patients, and/or those who developed ipsilateral involuntary
kinetic syndromes, will require more intensive analysis.

METHOD

The technic (10, 11) of basal ganglia surgery in hyperkinetic disorders, its development
and aims (11, 12) and recent modifications (3, 9) have been previously described.
Essentially, the operation consists of placement, through a burr hole, of a small balloon­
cannula into the specific surgical target within the basal ganglia. The procedure is per­
formed under X-Ray control with frequent checks in reference to a preoperative pneumo­encephalogram. Distention of the balloon at the needle tip in the correct area produces
immediate alleviation of tremor and rigidity in the contralateral half of the body. Within
24 hours the balloon is deflated as a mixture of absolute alcohol and Pantopaque (19) is
instilled via the double-lumened cannula. Usually 0.4 cc of alcohol mixed with 0.1 cc of
Pantopaque is injected 2 or 3 times prior to removal of the cannula. On subsequent skull
X-Rays in the true AP and trans-lateral positions, the location of the intracerebral lesion is
identified by the radiopaque dye.

Estimation of the anatomical structure(s) implicated by this visible lesion has been
shown to be accurate (4). Such radiographic-anatomic correlation forms a basis for the
present study.

A total of 10 patients developed contralateral dyskinesia in the restricted group having
initial procedures in the manner described. Two of these will be omitted from our analysis
since they showed evidence of mild bleeding in the lesion site. The remaining 8 patients are
evaluated in terms of clinical picture pre- and post-operatively, and measurements of the
effective lesion as shown in the radiographs.

All 8 of the patients are right-handed, white, males with parkinsonism.

CASE REPORTS

Case. 1 History: L. R. (Case #371), 50 years old, was admitted to the Neurosurgical
Service at St. Barnabas Hospital on June 3, 1957. Onset of parkinsonism was 10 years previ­
ously. He presented with 3+ plastic rigidity on his left side, 1+ cogwheel phenomenon on
the right. Tremor was 2-3+ on the left compared to 1+ on the right. He had a right chemo­
thalamectomy on June 6 with complete disappearance of tremor and rigidity on the left
side of his body. Initial injection was postponed when it was found that the cannula was
loosely fixed to the scalp and had pushed in, displacing the balloon to a more medial and
deeper position. It was withdrawn 10 mm and fixed. On June 12, 0.2 cc absolute alcohol
and 0.1 cc Pantopaque were instilled. This was followed after several hours by the appear­
ance of intermittent choreo-athetotic movements of the relieved left hand. No further
injections were given, it being decided not to inflict a therapeutic-sized lesion. The move­
ments gradually remitted and had ceased entirely when the cannula was removed June 18. Patient was discharged June 26 with slight recurrence of tremor on the left and a trace of cogwheelism; however, improvement was sufficient so that reoperation was not warranted.

Case 2. History: F. S. (Case 372), aged 35 years, entered the hospital with a history of parkinsonism since 1946, reportedly worse following a bout of “flu” in 1950. Tremor and rigidity were 3+ bilaterally, slightly more pronounced on the left. Right thalamectomy was performed June 10, 1958 with the appearance of left-sided hemiballismus later the same

![Fig. 1. 0.5 cm brain sections of F. S. (case 2) who died of carcinoma of the pancreas. Flattening and distortion of the right hemisphere occurred during brain fixation. Upper section shows the advancing needle tract. Middle section depicts the full lesion in the sub-thalamus, lateral to the red nucleus, above the substantia nigra. The posterior limit of the lesion may be seen in the last section.](image-url)
day. The following morning 1 per cent procaine was injected via the indwelling cannula without alteration of the movements. Balloon manipulations during the succeeding days were without response. The cannula was removed June 16. The ballismus regressed to choreiform activity in the next 2 weeks but persisted thereafter in slowly diminishing intensity. Following prolonged illness, the patient expired 5 months later of carcinoma of the pancreas, still exhibiting mild chorea (fig. 1).

**Case 3. History:** C. T. (Case $500$), 51 years old, was a victim of post-encephalitic parkinsonism for 34 years prior to admission. He was bedridden with flexion-contractures of all limbs; he had severe dysphagia and was unable to speak due to pseudobulbar palsy. Tremor was 2-3+ and rigidity 3+, cog and plastic, bilaterally. He represents one of the severest cases selected for surgery in the entire series. Right chemothalamectomy was done on March 3, 1958 with excellent result: the left extremities became loose, tremor stopped, and 2 hours after the operation the patient spoke audibly for the first time in 10 years! A total of 0.5 cc alcohol with 0.2 cc Pantopaque was injected by the second postoperative day and the needle removed. On March 11, the patient developed a mild, intermittent choreo-athetotic restricted to his left side. This subsided slowly and was gone after 10 days. The patient was discharged April 1 very much improved, talking, eating solids, up in a wheelchair which he was able to handle himself. There was no tremor or rigidity of the left extremities.

**Case 4. History:** A. T. (Case $491$), 47 year-old Army officer, had influenza at the age of 9 years and left unilateral parkinsonism for 6 years; 4+ tremor and 2+ rigidity were found on admission. Right chemothalamectomy was performed on Feb. 20, 1958 with the first injection of 0.3 cc alcohol and 0.1 cc dye given the same day. A like injection was made the following morning. Mild, choreo-athetotic movements of the left upper extremity appeared within a few hours. The cannula was removed after check X-Rays revealed deep and medial migration. The movement decreased spontaneously, were gone after 2 days. The patient was discharged on the fourth postoperative day completely free of rigidity and involuntary activity of any sort (fig. 2).

**Case 5. History:** E. T. (Case $508$), aged 53 years, entered the hospital with parkinsonism of 20 years’ duration. Tremor was 2+ on the right, 1-2+ on the left. Rigidity: 2+ plastic, 3+ cog on the right; 4+ plastic on the left with flexion deformities. Right chemothalamectomy was done March 10, 1958. The first injection was given the next morning. On the afternoon of March 11, choreo-athetosis of the left upper extremity was apparent. Check films showed some medial drift of the cannula. Final injection was made the following day and the cannula removed. After 2 days the chorea was very mild and only occasionally noted; by March 17 it was completely gone. At the time of discharge from St. Barnabas, there remained a minimal residual plasticity on the left but without tremor.

**Case 6. History:** M. Y. (Case $519$), is a 49 year-old attorney who had influenza in 1918 and parkinsonism for 7 years. Left-sided signs were somewhat predominant with 3+ tremor, 1+ plastic and 3+ cogwheel rigidity. On April 11, 1958 the patient underwent right chemothalamectomy. On April 12, following alcohol injection, a mild athetosis restricted to the left fingers was seen. There was no change in the succeeding 2 days and the cannula was removed. The movements slowly remitted over the following 10 days so that, on discharge April 25, there remained no athetosis with the complete absence of tremor and rigidity on the left side.

**Case 7. History:** E. K. (Case $540$), a 64 year-old patient with postencephalitic parkinsonism was admitted with an 18 year history of slowly progressive symptomatology. Tremor and cogwheelism were 3+ bilaterally. Right chemothalamectomy on May 27, 1958 was followed the same day by the appearance of left hand athetosis. Three alcohol injections were given during the next 2 days. The athetosis remained mild, showed occasionally some choreiform tendencies, and disappeared entirely after 48 hours. On discharge, the patient was free of rigidity on his left, but maintained perhaps 30 per cent of tremor residual.

**Case 8. History:** L. C. (Case $552$) 42, had parkinsonism for 15 years. Preoperatively, tremor was 3+ on the right, 1+ on the left. Cogwheel rigidity was 2+ on the right with
Fig. 2. AP and lateral radiographs of patient A. T. (case 4) showing a deep and medial position of a portion of dye. The upper aspect of the dumbbell-shaped lesion is in the preferred target area. Operative films showed an initially deep location of the cannula tip corrected during surgery for the final balloon placement. The alcohol-dye mixture of the second injection migrated into the original needle tract.
only a trace on the left. On June 12, 1958 left chemothalamectomy was performed. Balloon position after surgery was deep and required adjustment. First injection was made June 13. A right-sided chorea appeared the following day, progressing to ballismus. Local procaine injection was of no effect on the movements which spontaneously subsided after a week and were gone within a month. This patient also exhibited a mild, right hemiparesis postoperatively which remitted to a trace hyperreflexia. Tremor or rigidity of the right extremities did not recur.

ANATOMIC ANALYSIS OF LESIONS

In each of the cases, measurement of the lesion was done on the first films taken subsequent to the onset of the dyskinesia. In most instances insufficient air remained in the ventricular system by this time so that superimposition of these X-Rays on the operative pneumoencephalogram was necessary. This was possible because of standardization of X-Ray technic; however, minimal amounts of rotation were sometimes encountered and appropriate extrapolations executed.

The dimensions of the 8 lesions responsible for the abnormal movements in these patients are seen in Table 1. Measurements on the lateral roentgenograms

<table>
<thead>
<tr>
<th>Patient</th>
<th>Foramen-Pineal Distance</th>
<th>Height Above (+) or Below (−) F-P Line to Depth Below It</th>
<th>Behind Foramen of Monro</th>
<th>Lateral to Midline</th>
<th>Anterior (+) or Posterior (−) to Pineal</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. R. Case #371</td>
<td>31</td>
<td>−2 to −12</td>
<td>9 to 22</td>
<td>7 to 17</td>
<td>+9 to +22</td>
</tr>
<tr>
<td>F. S. Case #372</td>
<td>28</td>
<td>+1 to −11</td>
<td>12 to 30</td>
<td>4 to 16</td>
<td>−2 to +16</td>
</tr>
<tr>
<td>C. T. Case #500</td>
<td>28</td>
<td>+5 to −9</td>
<td>11 to 23</td>
<td>8 to 21</td>
<td>+5 to +17</td>
</tr>
<tr>
<td>A. T. Case #491</td>
<td>28</td>
<td>+4 to −12</td>
<td>12 to 22</td>
<td>10 to 17</td>
<td>+6 to +16</td>
</tr>
<tr>
<td>E. T. Case #508</td>
<td>31</td>
<td>−4 to −16</td>
<td>11 to 26</td>
<td>5 to 16</td>
<td>+5 to +20</td>
</tr>
<tr>
<td>M. Y. Case #519</td>
<td>27</td>
<td>+5 to −5</td>
<td>15 to 25</td>
<td>7 to 19</td>
<td>+2 to +12</td>
</tr>
<tr>
<td>E. K. Case #540</td>
<td>29</td>
<td>+4 to −7</td>
<td>9 to 22</td>
<td>3 to 15</td>
<td>+7 to +20</td>
</tr>
<tr>
<td>L. C. Case #552</td>
<td>30</td>
<td>+3 to −8</td>
<td>14 to 24</td>
<td>10 to 24</td>
<td>+6 to +16</td>
</tr>
</tbody>
</table>

| Average Length: 29 | Minimum Extents: −4 to −5; Maximum: +5 to to −16; Average: +2.3 to −10 | Minimum Extents: 15 to 22; Maximum: 9 to 30; Average: 11.6 to 24.3 | Minimum Extents: 10 to 15; Maximum: 3 to 24; Average: 6.8 to 18.1 | Minimum Extents: +9 to +12; Maximum: −2 to +22; Average: +4.8 to +17.4 |

TABLE 1

Diameters of Lesions in mm.
TABLE 2

Dimensions of Corpus Luysi in mm.

<table>
<thead>
<tr>
<th></th>
<th>Anterior to Pineal</th>
<th>Inferior to Pineal</th>
<th>Lateral to Pineal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum ranges</td>
<td>7 to 19</td>
<td>2 to 11</td>
<td>4 to 17</td>
</tr>
<tr>
<td>Minimum</td>
<td>11 to 15</td>
<td>7 to 7</td>
<td>8 to 9</td>
</tr>
<tr>
<td>Average</td>
<td>9 to 17</td>
<td>4.5 to 9</td>
<td>6 to 13</td>
</tr>
</tbody>
</table>

Fig. 3. Average foramen of Monro-pineal baseline drawn to graphic scale. The ventricular outline is provided for orientation. Superimposed are composite outlines of the average and minimum diameters of the lesions measured (table 1). Further, corresponding dimensions of the corpus Luysi are similarly represented (table 2).

were made in reference to the posterior-superior limit of the foramen of Monro and the projected foramen-pineal line. Measurements in the sagittal plane are along this line, while depth of a lesion is calculated as a perpendicular to the foramen-pineal line. The third dimension, distance from the midline, is taken from the AP view.

From the first, in patients in whom dyskinesia presented as a surgical complication and who possessed X-Rays with identifiable lesions, it became apparent that the subthalamus was involved and probably the corpus Luysi. In Table 2 measurements of the subthalamic nucleus of Luys are extrapolated from "Atlas of Stereoeencephalotomy" (21) to correspond with our use of the anterior portion of the pineal gland.

We calculate the error in any of the individual measurements contributing to the total statistical assessment to be ±2 mm. It is of significance, therefore, that the average lesion completely encompasses the average anatomical location of the subthalamic nucleus, and the tiny area of destruction common to
all 8 of the cases lies within 1 mm of the minimal, consistent site of the corpus Luysi. This is diagrammatically illustrated in Figure 3.

DISCUSSION

The relation of hemiballismus, as well as choreoathetosis, to lesions in the corpus Luysi has been well-documented (1, 2, 5, 6, 13–16, 18, 20, 22, 23).

We have noted that every corpus Luysi lesion does not have perceptible dyskinesia as an inviolable sequel. Balthasar (1) felt this to be true, especially in cases of extensive destruction with concomitant pyramidal implication. However, several patients with lesions radiographically identical to those presented in this report, neither developed involuntary movements nor showed signs of pyramidal tract deficit. Quantitative differences of destroyed nuclei in these patients cannot, of course, be estimated at present.

A somatotopic relation between distribution of the hyperkinetic response and a particular portion of Luys’ body was concluded by von Sántha (20) following serial section studies. He attributed involvement of the face to a lesion in the anterior pole of the nucleus, arm and trunk projections from the middle portion, with the lower extremity corresponding to the caudal pole. Our measurements tend, at first glance, to support this theory which Martin (14) and Juba and Rakonitz (13) also favored. The average lesion in our 8 cases covered only the middle and posterior portions of the maximum possible extents of the corpus Luysi. However, only one of these patients had involuntary facial movements (case 8) and his lesion was posterior to the average. Other patients who certainly had involvement of the rostral corpus did not have facial manifestations. Moreover, there is no correlation between any of the individual lesions and the site of movements which did appear, including 5 of the 8 in this study which were restricted entirely to the upper extremities. This is in agreement with the findings of Carpenter and Carpenter (6). These authors also pointed out a lateral predilection of hemiballism: 68 per cent of reported cases involved the extremities on the left. Our statistics are similar (64 per cent of postoperative dyskinesias having initial right chemosurgery contralaterally), although 7 of the 8 cases presented here showed left-sided movements. Fifty-five per cent of our entire dyskinetic series followed right hemisphere surgery. This contrasts with the fact that less than half (46 per cent) of all operations were on the right.

As regards types of movements, 4 were of moderate intensity and choreoathetotic in character, 2 were mild and almost purely athetotic, and 2 were ballistic. Lesions in the athetoids tended to be not as deep as the others but the series is too small to afford more than a suggestion of localization.

Meyers (17) has described the existence of two schools of thought: “those who believe hemiballismus is a distinct entity from chorea and athetosis, and those who believe that all three of these hyperkinesias are mere quantitative deviants of the same phenomenon.” We observed that the earliest show of dyskinesia was frequently athetosis, or sometimes heralded by occasional, small-range twitching of the fingers in patients who went on to develop severe choreo-
ballismus within 24 to 48 hours. In addition, patients whose movements were most severe had involvement of more than one limb; less intense activity tended to be mono-choreiform, while the mildest appeared as a distal mono-athetosis.

Conservative management has been found to be the most rewarding policy in these postoperative movement disorders. Nineteen of the 21 patients in the total dyskinetic group recovered completely. One patient left the hospital with a slight mono-chorea as a result of subthalamic hemorrhage immediately after surgery. The other patient (case 2) has already been discussed (fig. 1).

In an effort to avoid the adjacent internal capsule, the neurosurgeon performing chemothalamectomy will be tempted to direct the cannula medialward. If the narrow, curving limits of the inferior ventrolateral thalamus are superseded, the problem of dyskinesia may transiently detract from the concurrent alleviation of tremor and rigidity.

SUMMARY AND CONCLUSIONS

In 850 consecutive basal ganglia operations, 21 patients developed involuntary movement disorders (athetosis, chorea, ballismus) differing from preoperative dyskinesis. These are reviewed briefly and case histories are presented of 8 patients, all of whom sustained contralateral dyskinesia following initial chemothalamectomy. Lesions produced in these patients by injection of alcohol and radiopaque dye were measured on postoperative X-Rays and tabulated. Comparison with known neuroanatomical dimensions shows the effective lesion to involve the corpus Luysi. This is in general support of classic post mortem findings and experimental studies of the subthalamus, which are reviewed. Some neurophysiologic aspects are discussed.

REFERENCES

17. ——: Discussion following paper by Mettler and Carpenter (see Reference No. 15).