In 1954, a paper was given before the Harvey Cushing Society on the total removal of intramedullary tumors. A technique was described and a three-dimensional motion picture was presented, showing details of surgery and a follow-up on a patient who was walking quite well 2 weeks after her operation. Six cases were presented in the original study. Follow-up on this group is included here, together with the results on 4 additional patients operated upon for intramedullary tumors of the spinal cord. Reports of total removal have been few and the results were partial recoveries. Without removal, paralysis and reduction of life expectancy are inevitable.

In the 10 cases in which total removal was feasible 9 tumors were ependymomas and 1 was a teratoma (Fig. 1). In no case has there been evidence of recurrence, although after 3 to 7 years there has been slight regression in 3 cases, suspected as being caused by gliosis, since follow-up myelograms have been negative (Fig. 2). Roentgen-ray therapy has not been used. Doubtless, ependymomas of the cord will be encountered that are more cellular, invade the cord, and cannot be removed totally, but none has been encountered in the last 15 years. The astrocytomas, other gliomas, and lipomas are not suitable for this type of surgical attack.

The technique is not remarkable, but does depend on the use of the two-point coagulation forceps—a miniature model of which is now used for work on the cord. Emphasis is placed on gentleness, an “elastic” feel of the tissues and the maintenance of a dry field throughout. Vessels leading into the tumor from its point of origin in or near the central canal must be coagulated under saline irrigation and cut with plastic surgical scissors. Strong magnifying glasses worn by the operator help in seeing the detail of his careful dissection along the planes of cleavage. Dissection should never be continued unless one is sure of the line between cord and tumor. Additional instruments needed are shown in Fig. 3.

Results of Surgery

Except for 3 of 10 patients, all were made worse temporarily by operation at least for a few days—3 for over a year: 2 of these now walk quite well, while the third retains a spastic gait and is the only patient made seriously worse by operation. A myelogram 1 year after operation was negative. As can be seen from Table 1, 6 or 50 per cent are rated above 85 per cent, walking quite well with little or no spasticity 2 to 21 years after operation (Fig. 4). Two are unable to walk without a cane or crutches. One of these was almost totally paralyzed at the time of operation and is improved, but the other still was able to walk with moderate spasticity and really needs a cane. Two patients have died, 1 from pneumonia 6 days after operation (1942) and the other 4 months after operation; both had had previous laminectomies elsewhere. Only 1 of 2 other patients who had laminectomies before coming to us can be classified as having an excellent result.

Summary

1. A follow-up study on 10 intramedullary tumors of the spinal cord, including 9 ependymomas and 1 teratoma, reveals that all 8
living patients are able to walk (6 of them almost perfectly). The remaining 2 are ambulatory, 1 with Canadian crutches and 1 needs at least a cane.

2. Tumors of this type, as indicated in 1954, are potentially enucleable with careful technique.

3. With no evidence of recurrence in 2 to 21 years, it is felt that many of these lesions must be curable.
Intramedullary Tumors of Spinal Cord

TABLE 1
Totally removed intramedullary tumors—follow-up

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1. C.N.</td>
<td>41</td>
<td>F</td>
<td>60</td>
<td>C7-T6</td>
<td>E7</td>
<td>0</td>
<td>90</td>
<td>21</td>
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<tr>
<td>2. L.C. McA.</td>
<td>46</td>
<td>F</td>
<td>40</td>
<td>C7-T4</td>
<td>E3</td>
<td>1</td>
<td>0</td>
<td>D</td>
</tr>
<tr>
<td>3. T.McG.</td>
<td>39</td>
<td>M</td>
<td>70</td>
<td>C6-T1</td>
<td>E3</td>
<td>0</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>4. M.M.</td>
<td>36</td>
<td>F</td>
<td>80</td>
<td>C3-C7</td>
<td>E3</td>
<td>0</td>
<td>85</td>
<td>8</td>
</tr>
<tr>
<td>5. L.H.</td>
<td>48</td>
<td>F</td>
<td>100</td>
<td>C3-T2</td>
<td>E3</td>
<td>0</td>
<td>100</td>
<td>8</td>
</tr>
<tr>
<td>6. F.G.</td>
<td>42</td>
<td>F</td>
<td>25</td>
<td>C5-T2</td>
<td>E4</td>
<td>1</td>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>7. L.P.</td>
<td>35</td>
<td>F</td>
<td>50</td>
<td>C3-C6</td>
<td>E4</td>
<td>0</td>
<td>85</td>
<td>7</td>
</tr>
<tr>
<td>8. J.F.</td>
<td>5</td>
<td>F</td>
<td>20</td>
<td>C4-C7</td>
<td>T4</td>
<td>2</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>9. E.K.</td>
<td>37</td>
<td>F</td>
<td>100</td>
<td>T5-T7</td>
<td>E2</td>
<td>0</td>
<td>85</td>
<td>3</td>
</tr>
<tr>
<td>10. R.B.</td>
<td>26</td>
<td>M</td>
<td>10</td>
<td>C5-T4</td>
<td>E6</td>
<td>2</td>
<td>0</td>
<td>1/3D</td>
</tr>
</tbody>
</table>

* Condition:
80–100% = gait normal
50–80% = walks without assistance
30–50% = walks with cane or crutches
20–30% = walks with support

† E = ependymoma
T = teratoma

Fig. 3. Additional instruments needed for surgery of intramedullary tumors: magnifying glasses; standard and fine-tip two-point coagulation forceps; and dissectors.

Fig. 4. Reproduced from motion-picture strip: hopping or walking. Cases 1, 4, 5, 8 and 9: 21, 8, 8, 5, and 3 years after operation.
4. Slight regression of neurological status in 2 to 7 years is thought to be caused by glial changes, since myelography has been negative in 3 cases in which this was noted.

5. Results of early operation are better; nevertheless, no attempt at complete removal should be continued at any time unless planes of cleavage are demarcated clearly.

6. There is no evidence that infiltrating gliomas or lipomas can be removed completely.

7. Roentgen-ray therapy is not indicated after total removal.

References

Discussion

Dr. George S. Baker: I think the discussion should be a true discussion and not another paper. I therefore would like to compliment Dr. Greenwood, and I think all of you in the group would join me in noting that he has been rewarded, particularly in the case of the little girl he described last, by removing a tumor that had completely separated the elements of the spinal cord. It is true that a well-encapsulated tumor in the spinal cord, with careful dissection and care as to the circulation to the cord, can be removed with gratifying results.

As Dr. Greenwood mentioned, the ependymomas and the epidermoid-teratoma groups are perhaps the most amenable to removal. However, in reviewing some of our series over a number of years, we found that there was 1 patient who had had an ependymoma for more than 25 years, in whom it was possible only to split the cord and decompress the area over the tumor: the ependymoma was thought to be too adherent to the surrounding cord to permit removal. This patient has remained in good condition for 25 years, with little worsening of spinal-cord function.

Another patient, who had an astrocytoma of the cord, survived for more than 40 years. It is possible that as a result of decompression of the cord some of these tumors become inactive and do not penetrate longitudinally.

In the case of astrocytomas, it is perhaps of note pathologically that they do not appear to reach the stage of malignancy in the spinal cord that they do in the brain; at least that is the present thinking on this subject. For a malignant tumor of the spinal cord, radical resection, including resection of the cord itself, has been attempted, but to date very little benefit to the patient has been noted. I have a few slides of 3 patients on whom I operated in 1940 which more or less complement what Dr. Greenwood has shown you.

[Slide] This is a typical case of a dermoid, and I think it is recognizable to everyone. The tumor was removed entirely. Function of the bladder has been maintained in a normal fashion for more than 22 years.

[Slide] This is the typical picture, such as that shown by Dr. Greenwood, in which the cord has been split and a sausage-like tumor has been taken out completely. The man has been farming now for more than 20 years since the operation.

[Slide] The drawing illustrates the usual appearance of the swelling of the cord, together with the circulation of the cord. When the spinal cord is operated on, it is necessary to preserve as much of the circulation as possible before the tumor is enucleated.

I must not close without reminding you all that Dr. Gil Horrax had a most interesting case involving an ependymoma which began in the region of the foramen magnum and extended all the way to the conus; the tumor was removed totally in three operations. You can see that radical surgery sometimes is rewarding if the tumor is benign and can be removed.

Dr. James G. Greenwood, Jr.: I want to thank George for his discussion. In the original paper we do refer to his work and, of course, to Dr. Horrax's. Some of these patients will go 25 years, and in most of them, I think, we could be justified in simply splitting the cord, particularly if the patient has few symptoms. With the largest tumors, symptom-free, you can come back when symptoms develop and still be able to do something about them.

Joe Evans asked me about dysesthiasis. They have not been a problem. We have had very few severe neurological findings either before or after operation in most cases. About half of the patients have had dysesthiasis which have not been particularly disturbing.

One patient that I forgot (the patient the operation definitely made somewhat worse) did complain of dysesthiasis. If they have residual spasticity, they may complain quite a bit of this.