A clinical analysis of 88 consecutive neurosurgical cases of metastatic tumour involving the central nervous system is presented. The primary and secondary sites of growth are compared with reference to the relative frequency of the anatomical location. The pathological types are noted, and the general methods of treatment are outlined.

### PRIMARY SITES OF GROWTH

The primary sites of growth listed in order of frequency of appearance in the series are given below:

<table>
<thead>
<tr>
<th>Tissue Type</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung and Bronchus</td>
<td>20</td>
</tr>
<tr>
<td>Breast</td>
<td>14</td>
</tr>
<tr>
<td>Kidney</td>
<td>4</td>
</tr>
<tr>
<td>Thyroid</td>
<td>3</td>
</tr>
<tr>
<td>Rectum</td>
<td>3</td>
</tr>
<tr>
<td>Prostate</td>
<td>3</td>
</tr>
<tr>
<td>Spine (multiple myeloma)</td>
<td>2</td>
</tr>
<tr>
<td>Ovary</td>
<td>1</td>
</tr>
<tr>
<td>Bladder</td>
<td>1</td>
</tr>
<tr>
<td>Uterus</td>
<td>1</td>
</tr>
<tr>
<td>Colon</td>
<td>1</td>
</tr>
<tr>
<td>Cervix</td>
<td>1</td>
</tr>
<tr>
<td>Adrenal</td>
<td>1</td>
</tr>
<tr>
<td>Nasal Mucosa</td>
<td>1</td>
</tr>
<tr>
<td>Parotid</td>
<td>1</td>
</tr>
<tr>
<td>Pancreas</td>
<td>1</td>
</tr>
<tr>
<td>Testicle</td>
<td>1</td>
</tr>
<tr>
<td>Doubtful</td>
<td>29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
</tr>
</tbody>
</table>

As noted above, no accurate definition of the primary location was made in the last 29 cases. However, the lesions in the central nervous system were carcinomata. Failure to accomplish localization of the primary was due to incomplete clinical studies, or incomplete autopsy examination.
In the lung and bronchus there were 8 adenocarcinomata, 5 cases of spindle cell carcinoma and 4 squamous cell carcinomata. Three cases were not analyzed as to cell type.

In the breast there were 7 adenocarcinomata, 2 carcinoma solidum, 3 scirrhous carcinoma, and 2 undiagnosed by cellular type.

In the thyroid there were 2 cases of adenocarcinoma, and 1 case unspecified.

Those of the G-U tract are listed as follows:

- Uterus—Adenocarcinoma.
- Cervix—Squamous epithelial carcinoma.
- Ovary—Carcinoma simplex.
- Testicle—Teratoma.
- Kidney—3 hypernephroma, 1 alveolar adenocarcinoma.
- Prostate—3 adenocarcinoma.
- Urinary bladder—1 transitional cell carcinoma.

Those of the G-I tract showed the following cell types:

- Pancreas—Adenocarcinoma.
- Colon—Adenocarcinoma.
- Rectum—3 adenocarcinoma.

The parotid gland showed 1 adenocarcinoma. The adrenal cell type was not specified. There was 1 mucous cell carcinoma arising from the nasal mucosa.

The predominant histopathological type in this series is adenocarcinoma.

SECONDARY SITES OF GROWTH

Tumours arising from the lung and bronchus metastasized to the following parts of the central nervous system, in order of frequency: to the cerebrum, 11; to the cerebellum, 5; to the vertebral column, 1. Two cases showed metastasis to both cerebrum and cerebellum, and 1 case showed metastases to the skull and spine.

There were 12 tumours arising in the right lung or bronchi. These showed metastases to both the right and left sides of the brain and to the vertebral column, as follows: right cerebrum, 5; right cerebellum, 1; left cerebrum, 1; left cerebellum, 2; vertebral column, 2. One tumour in the right upper lobe showed metastases to the right cerebellar hemisphere at operation and to the left cerebrum at autopsy.

Six tumours arising from the left lung or bronchi, showed secondary foci as follows: metastases to the right cerebrum, 1; to the right cerebellum 1; to the left cerebrum, 3. One tumour from the left upper lobe showed metastases to both the right cerebrum and right cerebellum at operation. One from the left lower bronchus showed metastases to both sides of the skull, and to the bodies of T7 and 8 and the pedicles of T10 and 12.
METASTATIC CARCINOMA OF CENTRAL NERVOUS SYSTEM

From origins in the breast, the following metastases occurred: to the cerebrum, 9; to the cerebellum, 1; to the meninges, 1; to the pons, 1; to the pituitary, 1; generalized to the cerebrum and longitudinal sinus, 1. From the right breast these neoplasms spread as follows: to the left cerebrum, 2; to the right cerebrum, 1; to the left cerebellum, 1; to the left temporal meninges, 1; to the pons, 1; to the pituitary, 1. The left breast showed metastases with the following locations: to the right cerebrum, 3; to the left cerebrum, 2; generalized, 1. One case of adenocarcinoma in the right breast of a male metastasized to the pituitary.

There were 3 cases of metastases from the thyroid, all to the thoracic spine (T3, T3 and T6–9 respectively).

From the genito-urinary system secondary lesions were noted as follows: from the bladder (1 case) to the spine (T6–9); from the prostate (3 cases) to the cervical and to the thoracic spine respectively; from the cervix uteri to the lumbar and sacral vertebrae, at L3–4–5 and S1. (An adenocarcinoma of the uterus showed no clearly defined metastatic lesion, but cerebral thromboses were noted.) From the ovary (1 case) to the spine (T3); from the left testicle to the left temporal and left cerebellar areas. The peri-renal tumours metastasized as follows: from both kidneys (1 case) to the thoracic spine (approximately T6); from the right kidney (2 cases) both to the left cerebellum; from the right kidney (1 case) to the left frontal area. The adrenal tumour metastasized to the 2nd and 3rd lumbar vertebrae.

In the gastro-intestinal group, the pancreatic lesion metastasized to the 1st and 2nd lumbar spine. The carcinoma of the rectum showed secondary lesions in the right cerebellar hemisphere, with extension to the right middle fossa and the right frontal meninges. The carcinoma of the colon also metastasized to the right cerebellar hemisphere.

The tumour of the left parotid metastasized to the left middle fossa. The mucosal carcinoma of the nose developed a left frontal cerebral lesion.

There were 2 cases of multiple myeloma. One arising from the 5th thoracic vertebra showed metastases to the skull, the ribs and the right femur, and the other, whose primary lesions were discovered in the 2nd and 3rd cervical vertebrae, showed multiple metastatic lesions in all bones.

Summary of Secondary Sites of Growth. (1) In the cases of carcinoma of the lung or bronchus and breast, there was no apparent correlation in the above information, of side of primary focus to side of metastasis. Thus, it cannot be stated (at least from observation of these cases) that a tumour arising in one or the other lung field would metastasize to one or the other cerebral hemisphere. However, from a clinical point of view the predominance of metastatic spread from the lung field was to the cerebral hemisphere as opposed to the cerebellum or spine. This was true of both bronchogenic carcinoma and carcinoma of the breast.

(2) Primary carcinoma arising from the thyroid, bladder, prostate, cervix, ovary, adrenal gland, kidney (1 case with bilateral involvement) and pancreas metastasized to the spinal column. In 1 case of primary carcinoma
of the right kidney, metastasis occurred to the left frontal lobe and in the 2 other instances to the left cerebellar hemisphere. From the left testicle spread occurred to the left temporal lobe and the left cerebellum. One tumour of the colon and 1 of the rectum metastasized to the right cerebellar hemisphere. Growth from the nasal mucosa on the left side metastasized to the left frontal lobe, and from the left parotid lesion to the left middle fossa.

**TABLE 1**

*Age and sex incidence*

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung</td>
<td>17</td>
<td>3</td>
<td>47.3</td>
</tr>
<tr>
<td>Breast</td>
<td>1</td>
<td>15</td>
<td>52.0</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Bladder</td>
<td>1</td>
<td></td>
<td>68</td>
</tr>
<tr>
<td>Uterus</td>
<td></td>
<td>1</td>
<td>56</td>
</tr>
<tr>
<td>Ovary</td>
<td></td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Colon</td>
<td></td>
<td>1</td>
<td>56</td>
</tr>
<tr>
<td>Spine</td>
<td>2</td>
<td></td>
<td>50.5</td>
</tr>
<tr>
<td>Testicle</td>
<td>1</td>
<td></td>
<td>47</td>
</tr>
<tr>
<td>Kidney</td>
<td>4</td>
<td></td>
<td>46.5</td>
</tr>
<tr>
<td>Prostate</td>
<td>3</td>
<td></td>
<td>71</td>
</tr>
<tr>
<td>Cervix</td>
<td></td>
<td>1</td>
<td>58</td>
</tr>
<tr>
<td>Adrenal</td>
<td>1</td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>Parotid</td>
<td>1</td>
<td></td>
<td>62</td>
</tr>
<tr>
<td>Pancreas</td>
<td>1</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>Rectum</td>
<td>2</td>
<td>1</td>
<td>50.5</td>
</tr>
<tr>
<td>Nasal Mucosa</td>
<td></td>
<td>1</td>
<td>39</td>
</tr>
</tbody>
</table>

|                | 34   | 25     | 51.8 |

In this series (Table 1) the ratio of males to females was 3 to 2. This excludes a group of 29 cases in which the primary lesion was not definitely identified as to location or type. The average age was 51.8 years. In tumours of the bronchus or lung 17 males were affected as compared with 3 females, whereas in tumours of the breast 1 male was affected as compared with 13 females. All the tumours of the thyroid were in females and all the tumours of the urinary tract were in males. The ratio of males to females in tumours of the genito-urinary tract was 3 to 1, and the tumour of the adrenal was in a male.

**FAMILY HISTORY OF CARCINOMA**

Information available in the cases under discussion is not adequate to allow a conclusion on the incidence of carcinoma in patients’ relatives. However, there is evidence of carcinoma in the families of a few widely scattered cases.

**DOUBTFUL PRIMARY FOCCI**

Twenty-nine cases in the series are considered separately, because information as to the exact location of the primary tumour is not available. This deficiency exists because adequate clinical data were lacking or because in
certain cases in which the patients died after a brief hospital course, autopsies were not granted. The cases are briefly summarized for their general interest.

There are 8 cases of spinal metastases. Examination of the surgical specimens in these cases did not suggest the primary focus except in 1 instance of metastasis to the 9th thoracic vertebra, which resembled a hypernephroma. One patient with metastasis to the body of the 6th thoracic vertebra, is known to have had a mass in the left breast, which was not biopsied in this hospital. One with metastasis to the lower cervical spine was re-admitted a year later with ascites. No biopsy was obtained, but a presumptive clinical and radiographical diagnosis of carcinoma of the large bowel was obtained. Fifteen showed metastases to the cerebral hemisphere and examination of the surgical specimen in each of these showed that a large proportion were epithelial in type and some were adenocarcinomata. One tumour which metastasized to the right occipital lobe resembled a carcinoma of the bowel. Three cases showed secondary lesions in the cerebellar hemisphere. Examination of the pathological specimen in one of these suggested ovarian carcinoma, and in another, adenocarcinoma resembling bronchogenic origin.

REMARKS ON THE TREATMENT OF METASTATIC CARCINOMA IN NEUROLOGICAL SURGERY

Metastatic carcinoma as a therapeutic problem in neurological surgery presents the necessity of the alleviation of increased intracranial pressure, the relief of pain and the prevention of paraplegia.

Cerebral Metastasis. In cases where the intracranial metastasis is single, removal should be considered for the relief of the intense headache apart from any improvement of neurological signs. Pneumonecctomy for primary carcinoma of the lung by Dr. C. A. McIntosh resulted in a patient returning to work for 2 years. A secondary growth was then removed from the right temporal lobe. Patient left hospital in 2 weeks, ambulatory and well.

On the Treatment of Pain. The treatment of pain is possible through the employment of definitive surgical techniques. In the majority of patients cordotomy will relieve pain from the trunk and lower limbs, and is the method of choice if there is no compression of the spinal cord or nerve roots at the vertebral level. When the procedure is carried out with care and accuracy, there need be no disturbance of bladder function. The operation may be done unilaterally with an interval before carrying out section of the other side. Though generally considered to be more hazardous there are cases where it may be desirable to do both sides at the same operation, and the authors believe that it can be done bilaterally in one procedure without disturbance or alteration of bladder function or sphincter control. At the discretion of the operator the section can be made in the dorsal or upper cervical region. The selection, of course, is dependent largely upon the level of the pain source, taking into consideration afferents passing by way of the sympathetic system. After laminectomy and exposure of the cord, the dentate
ligament is identified, gently picked up and a fine knife inserted 2 mm. ante-
rior to it and parallel to the fiber tracts in the desired direction through the 
anterolateral segment of the cord. It is turned at right angles and drawn 
out laterally.

In cases where spinal exploration and decompression are undertaken it 
has been the custom of the authors to make extradural spinal root sections 
at the level of the growth both to relieve and prevent pain. The number of 
roots selected for sectioning, usually 2 on each side, is judged by the amount 
of involvement and the proximity of growth to the roots. In all cases ex-
plored and decompressed by the authors in the last few years extradural root 
section has been employed and the pain, which is frequently bandlike, was 
relieved at once. In these cases cordotomy is generally not necessary.

In cases requiring a very high level of sensory anesthesia for relief of pain, 
high cervical cordotomy may be employed but it seems too difficult to be 
certain of obtaining a satisfactorily high level, for example, above the 6th 
dermatome. The writers have employed a combined procedure in this rare 
type of case, illustrated as follows:

Case 1. Posterior root section of the 2nd to the 6th cervical roots inclusive on 
the ipsilateral side and high cordotomy at the C2–3 level on the opposite side was 
performed. It was possible in this case to bring the sensory level of the cordotomy 
up to meet the loss in the hand from the root section. The junction occurred at the 
3rd digit. It was interesting to note the difference in type of sensory loss in the two 
areas. Pain and temperature sense was lost over all spinal sensory dermatomes on 
the right side from C2 and below, while over the index finger and thumb slight loss 
of 2-point discrimination was added. A 3 mm. spread of a caliper was appreciated 
normally over the volar surface of the distal phalanges of the 3rd, 4th and 5th 
digits as compared to a gap of 4 mm. over the index finger and thumb. There was no 
loss of power except that already present due to rather massive oedema from lymph-
phatic obstruction and though there was some difficulty in manoeuvring the arm, 
sense of position was grossly intact. Sensation to touch was preserved over the hand 
approximately to the elbow. Above the elbow on the lateral side of the arm (C6 
and up) touch was not felt. Section of the upper 6 (2–6) posterior roots did not ap-
ppear to disturb function greatly probably because the small muscles of the hand 
derive innervation from roots C8 and D1 and the afferents no doubt correspond.

It is not the purpose to discuss the question of methods of treatment of 
pain in the region supplied by the 5th and the 9th cranial nerves and upper 
cervical supply. Most cases seen by the writers have involved principally the 
trigeminal distribution. For these, alcoholic injection of the maxillary and 
mandibular branches seemed to be reasonably satisfactory and simple. 
Otherwise one must resort to root sections by any of the usual methods. 
Intramedullary trigeminal tractotomy has been advocated by a few.

CONCERNING THE TREATMENT OF PARALYSIS

When paralysis occurs or is imminent, spinal decompression by laminec-
tomy and partial removal of the neoplasm is indicated to prevent progres-
sion. A paraplegic patient with metastases will pose a difficult nursing problem because, in addition to the complex care which the patient with carcinoma or primary malignant disease of the spine requires the treatment necessitated by disturbance of function of the urinary bladder and anal sphincter would be included. Occasionally with decompression and removal of tumour disappearance of paraplegia will occur. It should be stressed that laminectomy is not only of temporary benefit but in some instances may appreciably increase the life expectancy of the patient as well as contribute materially to his comfort during that time. In illustration, the case of a patient who is listed in the above series is cited.

Case 2. Five separate operative procedures were carried out on this woman. The 1st of these, which included intradural posterior root section (D7, 8, 9, right) gave complete relief of paralysis and pain for 8 months. The 2nd operation (mostly blood cyst, very little tumour found), after 8 months, also relieved the paralysis completely and gave her an almost equivalent pain-free interval. The 3rd, 12 months later, which included extradural root section (D7, 8, left), and the 4th operation, after another 9 months, again cleared up the paralysis and relieved the pain. On the 5th admission, 3 months later, for recurrence of the growth partial removal was repeated also with further root section. The patient succumbed at the end of this procedure.

This patient experienced more than 2½ years of reasonably comfortable life. She was provided with a brace when walking. Without laminectomy in the first instance, followed by the other procedures, her illness would have been complicated by paraplegia, much more pain and the related problems of bladder and sphincter disturbance.

SUMMARY

1. Eighty-five clinical cases of carcinoma with metastasis to the central nervous system are reviewed, with some suggestions as to treatment.
2. The majority of patients with carcinoma of the bronchus (lung) or breast sought neurosurgical consultation or treatment as a result of metastases to the cerebral hemispheres.
3. The tumours of the thyroid, bladder, prostate, cervix, adrenal, pancreas and kidney (1 case) exhibited clinical symptoms and signs from metastases to the spinal column.
4. The average age incidence for the series was 51.8 years.
5. The ratio of males to females was 3 to 2 in the general series. In the tumours of the lung, 16 males were affected as compared with 3 females; while in tumours of the breast, 1 male was affected as compared with 13 females.
6. Neurosurgical treatment should be directed toward the relief of: (a) intracranial pressure; (b) pain; (c) paraplegia.
7. The removal of a solitary intracerebral metastasis in selected cases may be attended with satisfactory relief of symptoms.
8. The authors have found it desirable and wish to point out the value
of simultaneous extradural section of spinal roots which are, and which are apt to be, compressed in cases justifying a decompressive laminectomy for impending paraplegia with partial removal of neoplasm. This procedure generally obviates the necessity for cordotomy.

9. In the special instance of diffuse pain of the upper extremity that does not respond to roentgen therapy, a posterior root section (C2–C6) combined with cervical cordotomy has given satisfactory relief.

10. It seems desirable to relieve spinal compression by decompressive laminectomy to prevent or minimize paralysis. Five such operations were performed in 1 patient over a period of 3 years with satisfactory result.