THE FREQUENCY OF INTRACRANIAL AND INTRASPINAL NEOPLASMS IN THE RESIDENT POPULATION OF ROCHESTER, MINNESOTA

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The purpose of this paper is to report the incidence, prevalence, and death ratio for various neoplasms affecting the central nervous system in the resident population of Rochester, Minnesota, for the 10-year period 1945 to 1954, inclusive.

It is desirable to have such statistics for various populations. Such information might disclose differences in frequency by race, geographic area or characteristics of population and would be of value in planning for research and needs of medical care. Epidemiologic studies in areas with appreciable variances in incidence might provide relevant clues to etiology.

Most previous reports dealing with the frequency of neoplasms affecting the central nervous system have been based on the personal experience of practising neurosurgeons or upon selected necropsy series or proportionate rates of hospital admissions. These data, although of value in describing clinical or pathologic experiences, do not necessarily provide a true picture of the incidence of neoplasms or of their frequency by type in the total population.

Surgical series are more likely to be representative of operable neoplasms rather than of all neoplasms in the population; operability, in turn, is influenced by such characteristics as age and general health of the patient and by the presumed type or accessibility of the lesion. The interest and reputation of the surgeon may influence the nature of his series; the relatively high proportion of pituitary tumors in Cushing's series of intracranial neoplasms is an often cited example of this type of bias. The admission policy of a hospital, such as age, sex or racial limitations, or its emphasis on neurosurgical problems may present another form of bias that prevents accurate generalizations from its data.

Series of cases seen at necropsy may likewise be unrepresentative because of the frequency of special interests in research in neoplastic conditions and because of the greater effort expended by the resident staff in obtaining permission for necropsy in cases of puzzling or relatively uncom-


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mon disorders. The rate of 2 per cent mentioned by Merritt as the proportionate rate of necropsy for brain tumors contrasts with the death ratio of 0.5 per cent of the deaths in the United States for the years 1952 to 1954, inclusive, that were certified as caused by neoplasms of the nervous system.

Recently a series of monographs on the incidence of cancer in specified populations has been published describing the results of extensive surveys in 10 metropolitan areas in the United States and in urban and rural Iowa. In these studies, an attempt was made to register all diagnosed cases of cancer, including neoplasms of the central nervous system, for a preceding calendar year. Similar data were obtained for Connecticut in a long-term study of cancer-registry reports. Comparisons have been made of the cancer rates, geographically, by age, sex and race; some of the results of these studies relating to the central nervous system will be compared with the results in Rochester, Minnesota, to be presented here.

Most surveys dealing with tumors of the central nervous system are limited to primary neoplasms. In a few instances, however, data have been presented on the relative frequency of primary and metastatic neoplasms observed at operation or necropsy. Since operations on the brain or cord are less likely to be undertaken in the face of recognized metastatic disease, the metastatic lesions are probably underestimated in the surgical series.

The Selection of Rochester, Minnesota. It is the impression of the author that the excellent and in many respects unique facilities for medical care concentrated within the organization of the Mayo Clinic are able to provide unusually complete statistics for many serious disorders including neoplasms of the central nervous system for the community’s 30,000 residents. A substantial proportion of the local residents are examined during life at one of the facilities of the Mayo Clinic or after death by the pathologists of the clinic.

It is assumed in this study that all residents of the community in whom neoplasm of the central nervous system was suspected or diagnosed during 1945 to 1954, inclusive, were observed at one of the facilities of the clinic and that data on these patients were included in the clinic’s unified record system.

The rates presented in this report are based on the diagnosed cases among local residents and must still be considered minimal; that is, less than the

*Almost half of the residents of the city are examined each year by the Mayo Clinic physicians at the clinic, in one of the local hospitals, or at home for emergency house calls. The Mayo Clinic record system, at the time of the study, included the reports for all hospital and other medical diagnostic facilities within the city, with the exception of the State Mental Hospital and the few general practitioners in the community. These physicians in private practice refer practically all patients with disorders of any serious nature to the large staff of specialists at the clinic. Neurologic consultations are routinely arranged for all patients who are examined in other sections of the clinic and suspected of having any serious disease of the nervous system. The clinic’s diagnostic file consists of diagnoses made in all Sections and includes surgical and necropsy reports from the Section of Pathologic Anatomy. The diagnoses made by each clinical consultant during the patient’s period of registry are cross-indexed by means of a system using IBM punch cards and tabulating devices. It is a relatively simple task to obtain the records of all resident patients for practically any clinical disorder.
“true” prevalence or incidence rates for symptomatic neoplasms in this population. The discrepancy for primary neoplasms is probably small and would be caused by failure of some persons to seek medical care after onset of symptoms or the possibility of misdiagnosis among those who have been examined. The study covers a 10-year period so that time is an adjunct in obtaining a high degree of definitive diagnoses; on the other hand, the resident population is small and the rates for the relatively infrequent disorders included here are subject to appreciable effect from chance fluctuation.

METHOD

The records were reviewed for all patients who were residents* of the city and in whom any primary or metastatic intracranial or intraspinal neoplasm was diagnosed during the 10-year period, 1945 to 1954, inclusive. Data for the statistical analysis, including age, sex, race, type of tumor, date of first Mayo Clinic diagnosis, and course of illness were then abstracted. The cases were divided into several principal groups and then subdivided by histologic type. Appropriate rates and ratios were computed.

The principal groups included metastatic neoplasms to the brain and spinal cord, primary neoplasms affecting the spinal cord, pituitary neoplasms and primary neoplasms of the brain. The primary tumors of the brain were classified as “certain” when confirmed histologically and “probable” when the diagnosis was strongly suspected on clinical grounds but not confirmed histologically.

Both incidence and prevalence rates were determined. By incidence rate is meant the number of newly diagnosed cases occurring during a specific period (usually a year) per unit of population (usually per 100,000 population). Only the cases newly diagnosed at the Mayo Clinic during the 10-year period were included here. The average annual incidence rate per 100,000 population for the 10 years was determined as follows:

Average annual incidence rate per 100,000 population equals

\[
\frac{\text{no. of resident cases diagnosed at Mayo Clinic during 10-year period}}{10 \text{ years} \times \text{population of Rochester, Minnesota (in 1950)}} \times 100,000
\]

For age-specific rates, the number of cases in a specified age group and the population of that age group were used. The rates were adjusted on the basis of the age distribution of the total population of the United States in 1950 to provide greater comparability with rates obtained from other statistical surveys. Furthermore, an approximation of the number of cases that can be expected in the population of the United States is readily calculated by applying this age-adjusted rate to the population of the United States.

Prevalence rate ordinarily refers to the number of patients living at a

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* “Resident” includes only those individuals whose domicile was within the city limits of Rochester, Minnesota, for at least one year during the study period; all persons who were known to have moved to Rochester to facilitate treatment of a condition diagnosed prior to taking up residence were excluded.
specified time per unit of population; however, to simplify comparisons with the cancer surveys by Dorn and others, their definition of prevalence as "the number of patients living at any time during a specified year per unit of population" was adopted here. In this study, the prevalence rate per 100,000 population was determined for the year 1954.

RESULTS

During the 10-year period, 50 cases of intracranial neoplasm were recorded for the resident population (Table 1). Fifty-four per cent of the patients had primary tumors of the brain, 14 per cent had pituitary tumors, and the rest had metastatic tumors to the brain.

There were 12 cases of intraspinal neoplasm. Eight (67 per cent) were diagnosed as primary tumors and 4 (33 per cent) were metastatic. Two of the latter were also metastatic to the brain.

Prevalence Rates. During the calendar year 1954, 22 of the patients with a diagnosis of intracranial or intraspinal neoplasm were alive. Their number and the age-adjusted rates for each site are shown in Table 2. (None of these happened to be a patient in whom there were both intraspinal and intracranial metastatic lesions.)

If these data can be applied to the other populations of the United States, about 46 persons per 100,000 population have primary intracranial neoplasms and 13 per 100,000 population have primary neoplasms of the spinal cord or roots in any one recent year. On this basis, about 77,000 persons in the United States were affected with primary intracranial tumors and about 22,000 had primary tumors of the spinal cord or roots in 1956. Since all the Rochester rates reported here are based on a small population, they must be interpreted with caution when applied to other populations, such as those of the rest of the United States. Consideration must be given to the effect of chance variation.*

Incidence Rates by Age and Sex. In Table 3, the age-adjusted incidence rates by sex and by type of neoplasm are presented; in Table 4, the rates are shown by age.

Incidence rates are higher for females except in cases of pituitary tumors in this series. According to these rates, each year 9.2 persons per 100,000 population develop a primary intracranial neoplasm and each year 17.3 persons per 100,000 population develop a neoplasm affecting the central nervous system. To look at this another way; if one could apply these rates to other populations in the United States, one might expect the following number of neoplasms to be diagnosed in a city of 1,000,000 population per year:

* If it can be assumed that the United States is randomly represented by the Rochester data, there are 19 chances in 20 (95 per cent confidence interval) that the true prevalence rate for intracranial neoplasms was between 25.0 and 77.6 per 100,000 population and that between 42,000 and 130,000 persons were so affected. Similarly, the true prevalence rate for primary intraspinal tumors is between 3.4 and 33.6 per 100,000 population, so that the number with this disorder probably fell between 6,000 and 56,000 persons.
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Primary tumors of the brain: 77 cases
Pituitary neoplasms: 15 cases
Primary neoplasms of the spinal cord: 25 cases
Intracranial metastasis to central nervous system: 50 cases
Intraspinal metastasis: 6 cases

Total number of cases per year: 173 (95 Per Cent Confidence Interval: 124-221)

TABLE 1
Intracranial neoplasms diagnosed at the Mayo Clinic in Rochester, Minnesota, resident population, 1945 to 1954, inclusive

<table>
<thead>
<tr>
<th>Type of Neoplasm</th>
<th>Number of Patients</th>
<th>Per Cent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary brain, certain*</td>
<td>22</td>
<td>44</td>
</tr>
<tr>
<td>Primary brain, probable*</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Metastatic lesions to brain</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Pituitary</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

* “Primary brain, certain,” refers to histologically confirmed neoplasms; “primary brain, probable,” refers to cases for which there is strong clinical or surgical evidence of a primary neoplasm of the brain which has not been histologically confirmed.

TABLE 2
Prevalence* and age-adjusted prevalence† rates per 100,000 population for neoplasms affecting the central nervous system, by site, for Rochester, Minnesota, population, 1954

<table>
<thead>
<tr>
<th>Type of Neoplasm</th>
<th>Number of Patients</th>
<th>Age-adjusted Rate per 100,000 Population‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary brain, certain</td>
<td>8</td>
<td>24.7</td>
</tr>
<tr>
<td>Primary brain, probable</td>
<td>4</td>
<td>12.4 (46.0)</td>
</tr>
<tr>
<td>Pituitary</td>
<td>3</td>
<td>8.9</td>
</tr>
<tr>
<td>Intracranial metastasis</td>
<td>3</td>
<td>9.7</td>
</tr>
<tr>
<td>Primary spinal cord</td>
<td>4</td>
<td>12.9</td>
</tr>
<tr>
<td>All types</td>
<td>22</td>
<td>68.6</td>
</tr>
</tbody>
</table>

* Prevalence obtained by accepting all patients who were residents and alive in Rochester, Minnesota, at some time during 1954.
† Rate adjusted for age on the total population of the United States, 1950.
None of the patients with a diagnosis of intraspinal metastasis was alive during 1954.
‡ Ninety-five per cent confidence limits of the age-adjusted rates were computed.
If the primary tumors of the brain and the pituitary tumors are combined, the prevalence rate for the intracranial neoplasms is 46.0 per 100,000 population. The 95 per cent confidence limits for these intracranial neoplasms are 35.0 and 77.6 per 100,000 population.
A similar confidence interval per 100,000 population for the primary neoplasms of the spinal cord is between 3.4 and 33.6 per 100,000 population, the interval for intracranial metastatic lesions is between 1.9 and 28.8. For all neoplasms affecting the central nervous system, the confidence interval is between 42.2 and 105.4 per 100,000 population. (No adjustment was made for the relatively minor effect of age standardization in the computation of the confidence limits.)
For the United States, it is expected that there are, on this basis, about 15,000 new primary intracranial neoplasms annually and about 29,000 new cases of neoplasm affecting the central nervous system.*

In view of the small number of cases in some of the categories, the age-

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TABLE 4

Incidence and average annual incidence rates for newly diagnosed intracranial and intraspinal neoplasms in Rochester, Minnesota, resident population, 1945 to 1954, inclusive, by age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>1950 Population</th>
<th>Primary Brain Tumor, Certain and Probable</th>
<th>Intraspinal* and Intracranial Metastasis</th>
<th>Primary Intraspinal Neoplasm</th>
<th>Pituitary</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.  Rate†</td>
<td>No.  Rate†</td>
<td>No.  Rate†</td>
<td>No.  Rate†</td>
<td>No.  Rate†</td>
<td>No.  Rate†</td>
</tr>
<tr>
<td>0-24</td>
<td>11,391 3.26</td>
<td>0 0.9</td>
<td>1 0.9</td>
<td>1 0.9</td>
<td>5 4.4</td>
<td></td>
</tr>
<tr>
<td>25-44</td>
<td>8,899 7.9</td>
<td>3 3.4</td>
<td>4 4.5</td>
<td>1 1.1</td>
<td>15 16.9</td>
<td></td>
</tr>
<tr>
<td>45-64</td>
<td>6,579 12.2</td>
<td>13 19.8</td>
<td>2 3.0</td>
<td>0 0</td>
<td>22 35.0</td>
<td></td>
</tr>
<tr>
<td>65 plus</td>
<td>2,942 23.8</td>
<td>2 6.8</td>
<td>1 3.4</td>
<td>3 10.2</td>
<td>13 44.2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29,811 8.4</td>
<td>18 6.0</td>
<td>8 2.7</td>
<td>5 1.7</td>
<td>56 18.8</td>
<td></td>
</tr>
</tbody>
</table>

Age adjusted rate‡: 7.7 5.6 2.5 1.5 17.3

95% Confidence interval: 4.9-11.6 3.2-9.0 1.2-5.3 0.5-3.9 12.4-22.1

* Two of the 18 patients in this group had intraspinal lesions only—one patient in each of the last two age groups.
† Average annual rate per 100,000 population.
‡ Rate adjusted for age on the total population of the United States, 1950.
specific incidence rates are shown for the sexes combined. Fig. 1 illustrates these rates for all the neoplasms, for primary tumors of the brain ("certain" and "probable" cases) and for the intracranial metastatic lesions.

The rate increases steadily with age for primary neoplasms of the brain and for the total group while that for the metastatic group reaches a peak in the 45- to 64-year age group.

**Death Ratio.** During the 10-year period, there were approximately 2,100 deaths from all causes among the residents of this city. In this same period, there were 37 deaths from intracranial and intraspinal neoplasms; in Table 5,

**TABLE 5**

*Death ratio for intracranial and intraspinal neoplasms, Rochester, Minnesota, resident population, 1945 to 1954, inclusive*

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number</th>
<th>Ratio per 1,000 deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary intracranial neoplasms</td>
<td>16</td>
<td>7.6</td>
</tr>
<tr>
<td>Pituitary neoplasms</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Intracranial and intraspinal metastatic lesions</td>
<td>17</td>
<td>8.1</td>
</tr>
<tr>
<td>Primary spinal neoplasms</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>37</strong></td>
<td><strong>17.6</strong></td>
</tr>
</tbody>
</table>
the number and proportion of all deaths from these causes are listed. About 1 per cent of all deaths were caused by primary intracranial neoplasms (brain, meningeal and pituitary) and about 1.8 per cent of all deaths were caused by primary and metastatic intracranial and intraspinal neoplasms combined.

Type of Tumors. (1) Primary Intracranial. There was histologic confirmation in 22 of the 27 diagnosed cases. Eight were astrocytomas (1, grade 2; others, grade 3 or 4); 8 were meningiomas; 2 were acoustic neurofibromas; and there was 1 each of parasellar chordoma, myxofibrosarcoma, hemangioma, and retinoblastoma with cerebral extension.

(2) Pituitary. There were 7 cases (5 M, 2 F). One elderly male with acromegaly was found to have an acidophilic adenoma at necropsy 12 years after symptoms were first noted. In all the other cases, the diagnosis was chromophobe adenoma.

(3) Primary Intraspinal. In 7 of the 8 cases the diagnosis was confirmed histologically; in the other case a diagnosis of a lesion of the cauda equina was based on clinical and roentgenologic evidence alone. Of the 7 tumors confirmed histologically, 3 were neurofibromas, 2 were meningiomas, and 2 were ependymomas.

(4) Metastatic Intracranial and Intraspinal. There were 16 patients with metastatic intracranial lesions; 2 of these also had intraspinal metastatic lesions. Two other patients had intraspinal metastatic lesions alone. Of the 18 primary neoplasms reported, 6 were of the breast, 6 were of the lung and the remaining 6 were of various other tissues.

COMPARISONS OF INCIDENCE IN ROCHESTER, MINNESOTA, WITH THAT REPORTED IN OTHER SURVEYS

The incidence of intracranial and intraspinal neoplasms in Rochester, Minnesota, is compared with that of cancer surveys in Connecticut, Iowa, and 10 metropolitan areas in the United States. These collectively will be referred to as the “other areas.” The studies in Iowa and the 10 cities were essentially a measure of the cases of cancer diagnosed or observed during a 1-year period. The Connecticut survey covered the period 1935 to 1951, but is probably most complete for primary tumors of the brain for the period 1947 to 1951. Case reports were obtained from death certificates and all medical sources reporting under a voluntary reporting procedure.

In addition to differences in the methods of collection of cases and the periods covered in the surveys, there are also differences in methods of classification of neoplasms. In Table 6, an attempt has been made to present comparisons for various primary sites in the nervous system. “Primary brain” is probably the only one that is reasonably comparable in the different studies. The very low incidence of pituitary tumors in the Connecticut report suggests that some may have been included with the primary neoplasms of the brain. The rates for “other nervous system neoplasms” in Connecticut (including spinal cord, sympathetic and peripheral nerves),
TABLE 6

In incidence and age-adjusted incidence rates per 100,000 population for intracranial and intraspinal neoplasms for various communities and states, by sex and type

<table>
<thead>
<tr>
<th>Area</th>
<th>Primary Brain</th>
<th>Primary Spinal Cord</th>
<th>Pituitary Total</th>
<th>Other Nervous System Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
</tr>
<tr>
<td>A) Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roch. (Minn.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1945-54</td>
<td>27</td>
<td>7</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Iowa, rural</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>45</td>
<td>29</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Iowa, urban</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>66</td>
<td>46</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Ten cities, 1947–49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>white</td>
<td>637</td>
<td>387</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>nonwhite</td>
<td>59</td>
<td>29</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Connecticut, 1947–51</td>
<td>382</td>
<td>213</td>
<td>169</td>
<td></td>
</tr>
<tr>
<td>Connecticut, 1941–46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B) Rate per 100,000 population (average annual)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roch. (Minn.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1945–54</td>
<td>7.7</td>
<td>5.4</td>
<td>9.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Iowa, rural</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>3.3</td>
<td>4.1</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Iowa, urban</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>5.1</td>
<td>7.4</td>
<td>3.0</td>
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<tr>
<td>Ten cities, 1947–49</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>white</td>
<td>5.1</td>
<td>6.3</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>nonwhite</td>
<td>3.0</td>
<td>3.0</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Connecticut, 1947–51</td>
<td>3.6</td>
<td>4.1</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Connecticut, 1941–46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Specified as other central nervous system.

in Iowa and the 10 cities are lower than the rate for primary neoplasm of the spinal cord alone in Rochester.

The rates for primary brain, primary spinal and pituitary tumors for both sexes combined are somewhat higher in Rochester, Minnesota, than in the other areas. This is probably because of the more complete method of collecting cases in Rochester rather than to any geographic difference in the frequency of the neoplasms. Most of the rates for each sex are also presented in Table 6; the differences noted here will be discussed later.

In Fig. 2 there is a comparison of primary tumors for both sexes combined
for Rochester, Minnesota, and the other areas. The age-specific rates for the other areas are similar to one another and all decrease in the age group 65 years and over. In Rochester, Minnesota, on the other hand, the rate is highest in the oldest age group. It is believed that the diagnosis of brain neoplasms in the older age groups is more complete and more accurate in Rochester, Minnesota, than in the other areas. One important factor in this respect is that about two-thirds of deceased residents are examined at necropsy! It was noted that among the instances at which the first diagnosis of neoplasm was made at necropsy, there were a few patients in whom a

Clinical diagnosis of vascular accident was superseded by a necropsy diagnosis of a primary tumor of the brain. The relatively high proportion of the total population in this community in whom a histologic diagnosis is made at operation or at necropsy is believed to account for greater accuracy of diagnosis of intracranial disease and also may account for the increasing incidence rate of primary tumors of the brain with age, contrary to the experience in the other areas and to the experience of others reporting series of surgical cases.

**COMMENT**

This report is believed to be the most nearly complete population survey of intracranial and intraspinal tumors available to date. Although the 10-year period represented by the study provides 300,000 “person years” of
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experience, the resident population is somewhat small to yield relatively stable rates and ratios for uncommon disorders such as those included in this report. The rates by sex, age and type of neoplasm may well be subject to appreciable chance fluctuations. Nevertheless, it is the writer’s opinion that the best method of detecting possible associations of geographic, social or racial incidence is to carry out systematic population surveys of which the present study, in conjunction with other recent population surveys⁷ might be considered a prototype.

Willis¹⁴ has described the deficiency of the statistics in general hospital series as follows: “The relative frequencies of various tumors in the clinical and necropsy records of a general hospital are not the true relative frequencies, but are influenced by many extraneous factors.” Comparisons of surgical series are particularly subject to the hazards of nonuniformity in method and the following examples are presented to illustrate the need for restraint in concluding that differences in such series demonstrate geographic or population influences. In discussing the relative frequency of different types of intracranial tumors, Wilson and Bruce¹⁵ compared Cushing’s series with those of Olivecrona in Sweden and several British authors and suggested “they (pituitary tumors) must be far more common in the United States of America than elsewhere,” whereas “metastatic growths occur more often (in the British experience) than in the American or Scandinavian series.” Cushing’s unusual interest and ability in pituitary surgery and his relative, if not absolute, exclusion of cases of metastatic lesions resulted in a series which, first, was not necessarily representative of all brain tumors in the population of the United States and second, should not be compared without qualification to the series of other surgeons.

Earle and associates³ in their intensive review of brain tumors at the University of Texas Hospital in Galveston, noted a higher proportion of white to Negro patients. Since the ratio was greater than that of the beds allotted to the Negro patients, they suggested that the disproportion might be ascribed to a difference in racial susceptibility for brain neoplasm. There may, indeed, be racial differences as suggested by the higher relative frequency of whites over nonwhites in necropsy series.¹⁰,¹¹ However, this cannot be definitely concluded in the absence of population surveys that are equally thorough for all segments of the population and that take into consideration variations in the age and race distribution and the relative frequency of other causes of death as well.

Primary intracranial tumors accounted for about 1 per cent of all deaths in the Rochester, Minnesota, population, and symptomatic metastatic lesions of the central nervous system were present in almost 1 per cent of all fatal cases. Primary tumors of the spinal cord were generally successfully removed and, therefore, were rarely reported as a cause of death.

The proportion of deaths caused by brain neoplasms in this community was about twice that reported in the national mortality statistics. Although necropsy data may not accurately portray the various causes of death in a
population, it is interesting that brain neoplasms were noted in 1.3 per cent of all necropsies in the series of Newbill and Anderson in New Orleans and in 1 per cent of all necropsies in the extensive collection by Steiner for the Los Angeles County Hospital.

The incidence and prevalence rates for Rochester, Minnesota, were higher for both intracranial and intraspinal neoplasms than those reported in the course of other community surveys for cancer. This is believed to be attributable to the superior medical reporting available in Rochester, Minnesota, rather than to any true difference in frequency in the different communities.

One of the more interesting results of this study is the apparent discrepancy in the age distribution of the primary neoplasms of the brain as compared with that reported from all other sources. Cushing’s surgical series as well as those of other investigators usually show the highest incidence about or below age 45 years, and Merritt summarizes most of the clinical reports with “in general, intracranial tumors occur predominantly in early life or in middle life.” However, these are clinical series of cases and are not rates, that is, they are not related to the population at risk at a given age.

Age-specific incidence rates have been computed in only a few instances. In the surveys in the other communities the rates were found to diminish in the oldest age groups. In the extensive necropsy series reported by Marsh, the highest incidence of gliomas was in the 60- to 70-year age group. In the present study, the rates increased with age and it is suggested that this was caused by the relatively accurate clinical and pathologic diagnoses in the older population in Rochester, Minnesota.

In a few elderly residents of Rochester in whom a clinical diagnosis of cerebral vascular accident was made, a neoplasm was demonstrated at necropsy and the corrected diagnosis was incorporated into the unified record system. This study demonstrates the value of a unified record system and a high community necropsy rate in community surveys of morbidity and mortality.

The observation of an increase in the rate for brain neoplasms with age may have little practical value in so far as the surgical management of the elderly patient is concerned but it may have important implications in so far as future consideration of the pathogenesis of the brain-tumor group is concerned. For most forms of cancer the incidence rate continues to rise beyond age 60 years, and the same has been noted for the primary neoplasms of the brain in the present study.

No special inquiry was made with respect to the family history of patients; routine histories in the charts did not reveal familial cases. Present evidence, including the genetic study of Harvald and Hauge does not disclose any simple hereditary factor responsible for gliomas.

According to Merritt, “the frequency of intracranial tumors is approximately equal in the two sexes, but the statistics of some authors would in-
dicate that the incidence in the male sex is slightly greater than in the female. In the other community surveys, the age-adjusted rates for primary tumors of the brain were higher in males, whereas in the present study the rate is higher in females.

In Steiner's extensive necropsy series at the Los Angeles County Hospital, primary tumors of the brain were noted 1.67 times as often in white females as in white males. In the Charity Hospital necropsy series of Newbill and Anderson the ratios for primary tumors of the brain were twice as high in white females as in white males. In view of the small numbers in the present study, future population surveys will have to be depended upon to clarify the question of any susceptibility for either sex.

Almost all tumors diagnosed as primary neoplasms of the brain in this series were confirmed histologically. Meningiomas comprised a somewhat higher proportion of the total (8 out of 22) than in other reported series, in which they generally account for about 15 per cent of the cases. It is of interest that among the brain tumors observed at necropsy of residents and nonresidents of Rochester, Minnesota, at the Mayo Clinic from 1939 to 1954, 300 (10 per cent of the total) were asymptomatic and among these 300, 100 (33.3 per cent) were meningiomas.

Metastatic tumors comprise about one-third of all the diagnosed tumors of the brain in the present study. This is considerably higher than the 1 to 8 per cent reported in neurosurgical series but is lower than the 62.7 per cent reported in chronic disease hospitals providing terminal care for patients with any type of malignancy. In the present study, it is likely that there is more underreporting of metastatic cerebral cancer than of the primary neoplasms of the brain. The metastatic cases were included only when involvement of the central nervous system was specified on the diagnostic face sheet of the patient's record. In most instances signs of cerebral dysfunction, focal seizures or localized paresis had developed; in several cases, the cerebral metastasis was observed and recorded for the first time at necropsy. It is the author's opinion that if all brain neoplasms in a population were correctly diagnosed and tabulated about 35 to 50 per cent would be metastatic.

SUMMARY AND CONCLUSIONS

1. Incidence and prevalence rates and death ratios were computed for intracranial and intraspinal neoplasms for the resident population of Rochester, Minnesota, for the 10-year period 1945 to 1954, inclusive. The records of the Mayo Clinic were the source of data for the diagnosed cases; these records included the reports of the local hospitals and pathologic laboratories associated with the clinic. It is believed that the survey includes the large majority, if not all, of local residents with diagnosed neoplasms affecting the central nervous system.

2. There were 50 cases of intracranial neoplasm. Twenty-seven of the tumors (54 per cent) were primary neoplasms of the brain and meninges, 7 (14 per cent) were pituitary tumors, and the other 16 (32 per cent) were
metastatic tumors. Twenty-two of the 27 primary tumors of the brain were histologically confirmed: 8 were gliomas, 8 were meningiomas, and the other 6 were of miscellaneous types. Six of the 7 pituitary neoplasms were histologically confirmed: 1 was an acidophilic adenoma and the others were chromophobe adenomas.

3. There were 12 cases of intraspinal neoplasm. Seven of the tumors were histologically confirmed primary neoplasms, 1 was clinically suspected, and 4 were metastatic to the spinal column with signs of cord compression.

4. The prevalence rate based on those patients alive in 1954 was 46 per 100,000 population for primary intracranial neoplasms and 13 per 100,000 population for primary neoplasms affecting the spinal cord. If these rates are applicable to the total population in the United States in 1956, there were about 77,000 persons with symptomatic primary intracranial tumors and 22,000 with symptomatic tumors of the spinal cord or roots in the United States that year. The 95 per cent confidence intervals for these estimates are also presented.

5. Average annual incidence rates (that is, the number of newly diagnosed cases each year) were 9.2 per 100,000 population for primary intracranial neoplasms and 2.5 per 100,000 population for primary neoplasms affecting the spinal cord. On this basis, there should be about 15,000 new primary intracranial neoplasms and about 4,200 new neoplasms of the spinal cord and roots annually in the United States.

6. About 1 per cent of all deaths in the resident population were caused by primary intracranial neoplasms; metastatic tumor to the brain caused about the same percentage of deaths. In only one instance was a primary intraspinal tumor associated with the death of the patient; in the others, the tumor was successfully removed surgically.

7. Incidence and prevalence rates were found to be higher in females for primary neoplasms of the brain and meninges and for metastatic tumors. The rate for pituitary tumors was higher in males, and there was no appreciable difference by sex for primary tumors affecting the spinal cord.

8. The age-specific rates for primary tumors of the brain increased with advancing age; in most other studies reviewed here the rates are said to diminish after 45 years of age.

9. Although the resident population is somewhat small to yield stable rates for subgroups by age, sex and type of tumor, the survey is believed to provide a more accurate picture of the frequency of neoplasms of the central nervous system than heretofore available, because of the high level of the diagnostic services in the community, the unified record system at the Mayo Clinic, and the high proportion of histologically confirmed cases from surgical and necropsy studies.

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