Computerized tomography as a possible aid to histological grading of supratentorial gliomas

STANLEY TCHANG, M.D., GIUSEPPE SCOTTI, M.D., KAREL TERBRUGGE, M.D., DENIS MELANÇON, M.D., GARY BÉLANGER, M.D., CURT MILNER, M.D., AND ROMEO ETHIER, M.D.

Department of Radiology, Montreal Neurological Hospital, Montreal, Quebec, Canada

Computerized tomography (CT) is shown to be very helpful in demonstrating the presence and extent of supratentorial gliomas, particularly in combination with intravenous injection of contrast material. Certain specific density patterns were found to exist and enabled us to differentiate with confidence the low-grade gliomas from the glioblastomas. Overlapping did occur, however, as was to be expected, since histological proof was sometimes obtained by needle biopsy with its inherent doubt as to true tumor representation. Future CT techniques such as sequential scanning after intravenous injection of contrast material may further increase the usefulness of CT scans in the diagnosis and therapeutic approach to the patient with a suspected glioma.

KEY WORDS • supratentorial glioma • histological grading of gliomas • computerized tomography

The value of computerized tomography (CT) in the demonstration of intracranial neoplasms has been widely demonstrated. The accuracy of CT in detecting and outlining cerebral tumors is significantly improved after intravenous injection of contrast material. Several authors have recently attempted to differentiate major groups of tumors such as gliomas, meningiomas, and metastasis on the basis of CT appearance. However, no systematic attempt has yet been made to find a possible correlation between the CT appearance and the histological grade of malignancy of the gliomas. New and Scott described certain differentiating features in CT of the glioblastomas with respect to the low-grade gliomas, but no definite conclusion was reached.

Different grades of malignancy in supratentorial gliomas may require different surgical and therapeutic approaches, and therefore the possibility of predicting preoperatively the histological diagnosis is of great practical importance. A retrospective analysis of 56 cases of supratentorial gliomas of different histological grade was undertaken in an attempt to establish certain differentiating features on the CT scan in the different groups of gliomas.

Materials and Methods

We reviewed the plain CT scan and the scan after intravenous injection of contrast material (IV-CT) in 56 patients with a histologically proven supratentorial glioma. All scans were done at the Montreal Neuro-
TABLE 1

Ventricular distortion or displacement in supratentorial gliomas

<table>
<thead>
<tr>
<th>Distortion</th>
<th>Low Grade</th>
<th>Anaplastic</th>
<th>Glioblastoma</th>
</tr>
</thead>
<tbody>
<tr>
<td>marked</td>
<td>0</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>moderate</td>
<td>3</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>slight</td>
<td>5</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>none</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>12</td>
<td>13</td>
<td>31</td>
</tr>
</tbody>
</table>

logical Institute with an EMI head scanner, using a 160 × 160-matrix and a 13-mm collimator.* Histological diagnosis was obtained from sections of the tumor removed partially or completely in 36 patients, from needle biopsy in 15 patients, and on post-mortem examination in five patients.

Tumors were graded histologically according to a three-stage classification:

Group A = Low-grade gliomas, corresponding to Kernohan’s Grade 1

Group B = Anaplastic gliomas, including Kernohan’s Grades 2 and 3

Group C = Glioblastoma multiforme (Kernohan’s Grade 4).

There were 12 patients in Group A, 13 in Group B, and 31 in Group C. The grading of malignancy was restricted to the three main groups, representing the biological activity of the cells rather than their stem origin, such as astrocytes, oligodendrocytes, and ependymal cells.

All CT scans were reviewed and note was taken of the absorption coefficients of the lesion in the plain CT examination. The density of the tumor was considered to be either decreased, increased, or normal with respect to the surrounding brain parenchyma. The IV-CT scan was obtained after rapid intravenous injection of 1.9 cc of 60% Hypaque/kg body weight, followed by a slow intravenous infusion, and the scan was completed within 30 minutes after the bolus injection.* The pattern of abnormal enhancement after intravenous injection of contrast material was classified as marked, slight, or absent. In the presence of significant enhancement, a further subdivision into heterogeneous and homogeneous enhancement was made. The presence of mass effect as shown by ventricular distortion or displacement was also tabulated (Table 1).

Results

The most common appearance of all types of gliomas on plain CT scan is a decreased-density lesion (Table 2). This was the case in nine low-grade gliomas (Fig. 1), 10 anaplastic gliomas (Fig. 2), and 29 glioblastomas multiforme (Figs. 3 and 4). The appearance of the

*EMI computerized tomography scanner manufactured by EMI Tronics, Inc., 3605 Woodhead Drive, Northbrook, Illinois.

Fig. 1. Low-grade glioma. Left: Plain CT scan shows pattern of decreased density with regular margins in the left central area. Right: No significant changes are observed in scan after intravenous injection of contrast material.

Fig. 2. Anaplastic glioma. Left: Plain CT scan. The large area with decreased density occupying the left frontal lobe, herniating underneath the falx, and producing severe mass effect on the frontal horns was part of the tumor. Right: On the IV-CT scan only a limited part of the tumor is enhanced.
Grading tumors by CT scan

Fig. 3. Glioblastoma. Left: Plain CT scan shows area of decreased density in the right insula and temporal lobe, with somewhat regular margins. Right: On the IV-CT scan, enhancement shows a thick ring outlining the extent of the tumor.

Fig. 5. Anaplastic glioma. Left: Plain CT scan shows the irregular increased density of a lesion due to calcification in the right frontal lobe. A less extensive area of decreased density is seen on the left. Right: On the IV-CT scan homogeneous enhancement is present almost exclusively on the left side.

area of decreased density, however, was often different in the three groups.

The low-density lesion in the low-grade gliomas is often well defined and regular in shape. The area of decreased density may represent either the solid tumor or a cystic component of the neoplasm. Edema surrounding the low-grade glioma is usually scarce or absent. In the glioblastomas the area of low density is often more irregular in shape and poorly defined. A finger-like appearance of the low-density area is often present and caused by the edema in the subcortical white matter (Figs. 3 and 4).

Areas of increased density were present in three low-grade gliomas and in three anaplastic gliomas due to calcifications within the tumor (Fig. 5). The only glioblastoma that showed an area of increased density (Fig. 6) was found at operation to contain a patch of hemorrhage. One glioblastoma was of a density similar to the surrounding brain.

The patterns of enhancement on the IV-CT scan in the different groups are shown in Table 3. No enhancement was present in seven of the 12 low-grade gliomas (58%), and in four of the 13 anaplastic gliomas (30%), while only two of 31 glioblastomas (6.5%) showed no evidence of enhancement. When
TABLE 2

<table>
<thead>
<tr>
<th>Density</th>
<th>Low Grade</th>
<th>Anaplastic</th>
<th>Glioblastoma</th>
</tr>
</thead>
<tbody>
<tr>
<td>decreased</td>
<td>9</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td>increased</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>normal</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The lesion represents, at least in some proven cases, cavitation and necrosis within the tumor. This appearance is best shown on the scans completed within 30 minutes after intravenous injection of contrast material. The configuration of the “ring” is often irregular and the margins are frequently unequal in thickness. All glioblastomas showed a mass effect while four low-grade gliomas and one anaplastic glioma did not (Table 1).

Discussion

The purpose of our analysis was to try to find a possible correlation between the CT appearance and the grade of malignancy of the gliomas. No attempt has been made to include in the discussion the problems of differentiating the CT appearance of gliomas from infarcts, abscesses, solitary metastasis, and more rarely resolving hematomas.

The fact that in 15 patients the histological diagnosis was obtained by needle biopsy represents a limitation in accuracy, since it is well known that different parts of the same tumor may carry different degrees of malignancy. This limitation may be responsible for some of the disparities observed. The majority of the gliomas presented as decreased-density lesions with the exception of the low-grade and anaplastic gliomas that

Fig. 7. Low-grade glioma. Left: Plain CT scan. The large area of decreased density in the left frontal lobe was found at surgery to be a cystic astrocytoma. Right: The mural nodule is seen on the scan enhanced by contrast material.

enhancement occurred in the low-grade gliomas it was often only slight and limited to part of the tumor. A mural nodule was recognized in one case (Fig. 7) and one other case showed homogeneous enhancement of the low-grade glioma. In the anaplastic gliomas the appearance of the enhancement was often variable without specific features. One case showed a marked homogeneous enhancement, simulating a meningioma (Fig. 8). Glioblastoma multiforme showed most frequently on the IV-CT scan as an area of heterogeneous enhancement in “ring-like” fashion. The low-density area in the center of the lesion represents, at least in some proven cases, cavitation and necrosis within the tumor. This appearance is best shown on the scans completed within 30 minutes after intravenous injection of contrast material. The configuration of the “ring” is often irregular and the margins are frequently unequal in thickness. All glioblastomas showed a mass effect while four low-grade gliomas and one anaplastic glioma did not (Table 1).

Fig. 8. Anaplastic glioma. Left: Plain CT scan shows extensive area of decreased density mainly due to edema. The finger-like appearance is the result of sparing of cortical layers. Right: On the IV-CT scan the enhancement is homogeneous involving all the tumor and mimicking the appearance of meningiomas.

TABLE 3

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Low Grade</th>
<th>Anaplastic</th>
<th>Glioblastoma</th>
</tr>
</thead>
<tbody>
<tr>
<td>marked</td>
<td>1</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>nonhomogeneous</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>homogeneous</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>slight</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>none</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The purpose of our analysis was to try to find a possible correlation between the CT appearance and the grade of malignancy of the gliomas. No attempt has been made to include in the discussion the problems of differentiating the CT appearance of gliomas from infarcts, abscesses, solitary metastasis, and more rarely resolving hematomas.

The fact that in 15 patients the histological diagnosis was obtained by needle biopsy represents a limitation in accuracy, since it is well known that different parts of the same tumor may carry different degrees of malignancy. This limitation may be responsible for some of the disparities observed. The majority of the gliomas presented as decreased-density lesions with the exception of the low-grade and anaplastic gliomas that

Fig. 7. Low-grade glioma. Left: Plain CT scan. The large area of decreased density in the left frontal lobe was found at surgery to be a cystic astrocytoma. Right: The mural nodule is seen on the scan enhanced by contrast material.

enhancement occurred in the low-grade gliomas it was often only slight and limited to part of the tumor. A mural nodule was recognized in one case (Fig. 7) and one other case showed homogeneous enhancement of the low-grade glioma. In the anaplastic gliomas the appearance of the enhancement was often variable without specific features. One case showed a marked homogeneous enhancement, simulating a meningioma (Fig. 8). Glioblastoma multiforme showed most frequently on the IV-CT scan as an area of heterogeneous enhancement in “ring-like” fashion. The low-density area in the center of

Enhancement pattern of computerized tomography with intravenous contrast material in supratentorial gliomas.

Fig. 8. Anaplastic glioma. Left: Plain CT scan shows extensive area of decreased density mainly due to edema. The finger-like appearance is the result of sparing of cortical layers. Right: On the IV-CT scan the enhancement is homogeneous involving all the tumor and mimicking the appearance of meningiomas.
Grading tumors by CT scan

contained calcifications. The well defined, rounded, low-density lesion of the low-grade glioma, however, is distinctly different in appearance from the poorly defined low-density lesion in glioblastoma. The shape of the latter is often a finger-like configuration representing the edema in the subcortical white matter frequently associated with this type of glioma. However, the plain CT appearance of the gliomas was often non-specific for the three different groups.

The enhancement in the neoplasm on the CT scan after intravenous injection of contrast material is thought to be due to increased tumor vascularity and disruption of the blood-brain barrier. The IV-CT scan is definitely required to better visualize the tumor itself and to separate it from the surrounding edema. The appearance of the enhancement pattern on the IV-CT scan may be highly characteristic and enable us to predict the grade of malignancy of the glioma with confidence.

Enhancement in a ring-like fashion with thick irregular margins surrounding a central area of low density was never present in a low-grade glioma and is virtually diagnostic of a glioblastoma. Homogeneous enhancement of the lesion may occur in each group and is therefore a nonspecific finding. The enhanced mural nodule in the wall of a cyst with decreased density is quite suggestive of a low-grade glioma. Complete absence of enhancement may occur in each group, particularly in very cellular and avascular lesions.

When the degree of enhancement of a glioma is compared to the angiographic appearance of the tumor, only partial correlation is found. Angiographic evidence of tumor vascularity always corresponded to enhancement on CT but this also occurred in some cases without any demonstration of tumor vessels.

References

6. Huckman MS: Clinical experience with the intravenous infusion of iodinated contrast material as an adjunct to computerized tomography. Surg Neurol 4:297-318, 1975

This paper was presented at the 39th Annual Meeting of the Canadian Association of Radiologists, June 12-17, 1976, in Quebec City, Canada.

Present address for Dr. Tchang: Department of Diagnostic Radiology, University Hospital, Saskatoon, Saskatchewan, S7N OW8, Canada.

Address reprint requests to: Romeo Ethier, M.D., Radiology Department, Montreal Neurological Institute, 3801 University Street, Montreal, Quebec, Canada.