Stereotaxic suboccipital transcerebellar biopsy of pontine mass lesions

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Twenty-six patients (16 male and 10 female) ranging in age from 5 to 68 years underwent suboccipital transcerebellar stereotaxic biopsy of mass lesions situated in the pons. Stereotaxic computerized tomography, magnetic resonance imaging, and angiographic data were obtained while the patient was positioned in an inverted custom stereotaxic head frame. The patients were then placed under general endotracheal anesthesia and positioned prone. Optimal trajectory planning utilized a transcerebellar route directed through the middle cerebellar peduncle, with target and entry points calculated to avoid vascular structures. No complications were encountered in the perioperative period when this technique was used. Histological diagnosis of the lesions revealed: astrocytomas in 14 patients, oligodendroglioma in one, ependymoma in one, arteriovenous malformations in two, radionecrosis in one, cryptococcal abscess in one, demyelinating disease in three, and infarctions in three. No consistent correlation could be made between radiographic characteristics and histological diagnoses.

Empiric treatment of brain-stem lesions without tissue diagnosis based upon the radiological and clinical findings may result in inappropriate therapy administration. Alternatively, open operative procedures to obtain tissue require a visible surface abnormality to guide biopsy, and carry the risks of a major surgical procedure in already compromised patients. For these reasons the authors consider a suboccipital transcerebellar stereotaxic biopsy to be the diagnostic procedure of choice in the assessment of pontine mass lesions.

Key Words : stereotaxic procedure • pons • biopsy • brain neoplasm

Lesions of the pons and brachium pontis have long represented a difficult diagnostic and surgical challenge. A presumptive diagnosis can often be made based upon characteristic computerized tomography (CT) and magnetic resonance (MR) imaging appearances; therefore, patients have been treated purely on the basis of radiographic findings in the absence of a diagnostic tissue specimen. The dangers of such a course are obvious; patients are frequently administered inappropriate therapy because their diagnoses were based upon clinical and radiographic impressions and not on histological grounds.

Surgical approaches to the pons have generally been one of the following: 1) the suboccipital approach via the fourth ventricle; 2) an approach through a retrosigmoid suboccipital craniectomy via the cerebellar pontine angle; 3) the subtemporal transtentorial technique; or 4) a CT-guided stereotaxic biopsy. The open conventional surgical methods carry inherent risks in compromised patients and are associated with a low diagnostic yield. Stereotaxic biopsy has been shown effective and consistent in obtaining diagnostic tissue samples whether through a transcortical frontal trajectory or by a suboccipital transcerebellar approach. There have only been three previously reported cases of pontine biopsies obtained by the suboccipital transcerebellar method. In this report, we present our experience with 26 cases of pontine mass lesions, both tumorous and non-neoplastic, biopsied through a suboccipital transcerebellar approach traversing the middle cerebellar peduncle.

Clinical Material and Methods

Twenty-six patients with pontine mass lesions underwent suboccipital transcerebellar stereotaxic biopsy at the Mayo Clinic between July, 1984, and February, 1988. All had undergone thorough preoperative clinical evaluation by a medical neurologist and, when indicated, appropriate neurodiagnostic studies were performed to exclude non-neoplastic etiologies. Their clinical profiles are presented in Table 1. There were 16 male and 10 female patients ranging in age from 5 to 68 years, with a mean age of 34 years.

Symptoms and Signs

The patients naturally presented with a plethora of symptoms and signs associated with the sensitive location of their lesions. The most common were cranial-nerve dysfunction, ataxia, upper motor-neuron signs,
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TABLE 1
Profile of 26 patients with pontine mass lesions diagnosed by suboccipital transcerebellar stereotaxic biopsy

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs) &amp; Sex</th>
<th>Symptoms &amp; Signs</th>
<th>CT Findings†</th>
<th>MR Findings‡</th>
<th>Side of Lesion</th>
<th>Pathology</th>
<th>Postop Treatment</th>
<th>Follow-up Duration</th>
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<td>RT</td>
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<td>RT</td>
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<td>T1, T2</td>
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<td>RT</td>
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* Abbreviations: CT = computerized tomography; MR = magnetic resonance imaging; CND = cranial-nerve dysfunction; UMN = upper motor-neuron signs; HP = hemiparesis; HA = headache; astro = astrocytoma; crypto = cryptocoeal; AVM = arteriovenous malformation; ependy = ependymoma; oligo = oligodendroglioma; RT = radiation therapy; AbTx = antibiotic therapy; CTx = chemotherapy.

† T1 and T2 represent weighting emphasis applied to MR. †t = prolonged relaxation time; ↓ = reduced relaxation time; ↔ = no change.

and hemiparesis. Additional infrequent findings included nystagmus, oscillopsia, headache, nausea, vomiting, and lethargy. The duration of symptoms ranged from 1 to 60 months, with an average of 11 months prior to the time of diagnosis.

**Diagnostic Investigations**

Computerized tomography was performed on all 26 patients with and without the administration of iodinated contrast material (Fig. 1). On noncontrast studies eight of the lesions were isodense, 12 were hypodense, and six were hyperdense. Nineteen of the 26 lesions enhanced with iodinated contrast agents. A cystic component was documented by CT in five lesions. Hydrocephalus was noted in three patients. Twenty-two patients underwent MR imaging (Fig. 1). All but one displayed prolonged relaxation time on T2-weighted images and 16 also produced prolongation on T1-weighted imaging. Vertebral angiography was performed on all cases for the purpose of planning an avascular biopsy trajectory. Only one of these studies was considered abnormal as it showed a subtly displaced right superior cerebellar vein.

**Operative Technique**

Utilizing the Kelly-Goerss stereotaxic system, stereotaxic CT scanning, MR imaging, and integrated vertebral angiography were performed under local anesthesia. The techniques have been detailed elsewhere.11-18 In brief, a custom CT-compatible stereotaxic head frame is attached in an inverted fashion to the patient's skull by carbon-fiber fixation pins which penetrate the outer table of the skull (Fig. 2). The length of the carbon-fiber pins represents a fixed reference measurement. Detachable micrometers are used to measure the relative length of the pins against the vertical support elements of the head holder. This system provides a mechanism by which the stereotaxic head holder can be removed and reapplied in precisely the same position for subsequent data acquisition or operative procedures performed at a later date.

After placement of the inverted stereotaxic CT-compatible head frame, the patient is transported to the angiography suite where selective transfemoral catheterization of the vertebral vessels is performed. An arteriographic reference system is attached to the stereotaxic head holder which creates four reference marks.
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FIG. 1. Representative contrast-enhanced radiographic studies of patients with pontine mass lesions subjected to biopsy using the stereotaxic suboccipital transcerebellar technique. Upper: Computerized tomography scans showing Case 26 with a cystic grade 3 astrocytoma (left), Case 5 with a cryptic arteriovenous malformation (center), and Case 3 with a cryptococcal abscess (right). Lower: Magnetic resonance images showing Case 6 with a grade 4 astrocytoma (left), Case 25 with infarction (center), and Case 4 with a demyelinating disease (right).

The arteriographic reference system is interfaced with the stereotaxic coordinate system by a method described previously. Following angiography the patient is taken to the CT scanning suite where the head holder is placed in a CT table-adaptation plate. The localization system consisting of nine carbon-fiber rods creates nine reference marks on each CT slice from which stereotaxic coordinates can be calculated. The previously administered angiographic contrast material serves as the contrast-enhancing agent for the stereotaxic CT scan. If MR data are deemed useful, the CT-compatible head frame is removed and in its place a carbon-fiber MR-compatible head frame is applied. The fiducial marks for the MR localization system are created by nine Lucite tubes filled with a solution of CuSO₄.

The localization studies may be performed on the day of surgery or sequentially over several days. Once data acquisition has been completed, the CT-compatible stereotaxic head holder is reapplied (or left on if no MR data have been accumulated and surgery is to be performed on the same day as data acquisition) after the patient has been placed under general anesthesia.

FIG. 2. Depiction of the inverted stereotaxic head frame placement.
The patient is then placed in a prone position with the stereotaxic head holder attached to the stereotaxic frame (Fig. 3).

The CT or MR slice that best demonstrates the lesion to be biopsied is selected. The localization markers are digitized manually or automatically by an intensity detection program. With the cursor and trackball, the surgeon selects a point within the lesion to be biopsied and inputs this target by means of the deposit key. The computer calculates the X, Y, and Z mechanical adjustments that will place the point on the CT scan within the focal point of the arc-quadrant stereotaxic frame. This point is also transposed to the angiographic data to allow the planning of an avascular trajectory (Fig. 4). Computer software accounts for patient rotation in this display since the arteriogram is performed with the patient supine and surgery is performed with the patient prone. The position of serial biopsy sites is then calculated from the trajectory angles thus developed and displayed on sequential CT or MR slices.

Once the X, Y, and Z adjustments are set on the stereotaxic frame in the operating suite, the scalp over the calculated entry point is prepared. A 7-mm incision is made in the scalp and a guide tube is inserted through the horizontal quadrant of the stereotaxic frame to rest on the outer table of the skull, which has been positioned according to arc and collar angles calculated by the computer program. Anteroposterior and lateral teleradiographs are obtained to confirm the position of the entry and target points. A ½-in. drill hole is made through the skull, and the dura mater is opened by a unipolar coagulating current applied to the stylet of an insulated cautery probe. The biopsy cannula is advanced to the target point and a 10-mm core biopsy is obtained. The position of the biopsy specimen is documented by anteroposterior and lateral teleradiography. Typically a single biopsy is harvested; however, if immediate frozen sections or smear preparations are nondiagnostic, further biopsies may be obtained. Once the biopsy procedure is complete, the cannula is slowly withdrawn and the scalp closed with a single vertical mattress suture.

Results

Adequate biopsy specimens were obtained in all 26 patients. Fourteen patients had astrocytomas which were graded according to Kernohan's classification system: grade 4 in two patients, grade 3 in six, grade 2 in five, and grade 1 in one. Two other patients had non-astrocytic gliomas: a grade 3 oligodendroglioma and an ependymoma. Ten patients were found to have nonneoplastic lesions. These included three patients in whom biopsies revealed demyelinating disease, three whose biopsies showed changes consistent with infarction, two with cryptic (angiographically occult) thrombosed arteriovenous malformations, one with a cryptococcal abscess, and one whose biopsy confirmed radiation necrosis. The diagnoses in the three cases of demyelination and the three cases of infarction have been confirmed in clinical follow-up studies.

There was no perioperative morbidity or mortality associated with any of the procedures. This was assessed at time of discharge from the hospital or 1 week postoperatively, whichever occurred first. The follow-up period has ranged from 1 to 44 months, with an average of 15 months. At the time of follow-up evaluation, 15 patients were alive and well, four with tumors reported
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...recent deterioration in their status, and seven had died due to their disease. All of the patients who had died or whose condition was deteriorating harbored glial tumors (Table 1).

Discussion

The diagnostic possibilities for mass lesions present within the pons include astrocytoma, oligodendroglioma, ependymoma, lymphoma, metastatic carcinoma, neuroepithelial cyst, vasculitis, arteriovenous malformation, spontaneous hematoma, infarction, infection, and demyelinating disease.4,8,9,12-15,19,24,28,30,33,36,37 With such a broad spectrum of potential pathology, it is obvious that treatment options must be individualized. In the past, patients with pontine masses have often been treated empirically with external beam irradiation and/or chemotherapy as a homogeneous group.7,25,39 This course of action has often led to inappropriate management. Two cases in our present series illustrate this point. One patient (Case 13) underwent radiation therapy for a presumed pontine glioma at 5 years of age and did well for 3 years before experiencing a relapse of symptoms. Biopsy at that time revealed demyelination changes but no evidence of neoplasm. At examination 3 ½ years after the biopsy, the patient has shown no further progression of her disease clinically or radiographically. The other patient (Case 22) underwent a ventricular shunting procedure at 5 years of age for presumed fourth ventricular outflow obstruction and a cranectomy at 10 years old, which reportedly revealed a low-grade astrocytoma. She then received radiation therapy. At the age of 20 years she presented with a cystic pontine lesion on CT and MR imaging. Additional radiation therapy and chemotherapy were contemplated; however, biopsy revealed radiation necrosis.

Tumor was also considered a strong possibility in the differential diagnosis in the remaining eight patients who were found to have non-neoplastic biopsies. Fortunately, the treatment of these patients was based upon the histological findings of stereotaxic biopsy. All have done well clinically in the follow-up period.

The certainty with which a diagnosis may be made upon a small biopsy specimen is always a matter of concern, particularly when one entertains the diagnosis of demyelination or infarction. Reigel4 stated that even when a biopsy has been considered inconclusive or tenuous it was not necessarily nondiagnostic. He and his coworkers5 found that many patients in whom biopsy did not show tumor had a stable neurological course. The avoidance of empiric treatment modalities which are associated with inherent morbidity is, in our opinion, preferable to establishing a specific diagnosis. The patients in our series with non-neoplastic diagnoses have had stable clinical courses consistent with the histological impressions.

The CT detection rate of brain-stem gliomas has been quoted as high as 96%. With the advent of MR imaging, the sensitivity of neurodiagnostic techniques is likely even higher than this impressive figure. However, the ability to determine the precise histological diagnosis by neurodiagnostic imaging is questionable, since many lesions have similar appearances (for example, abscess and high-grade glioma). This is illustrated by one of our patients (Case 3) who was found to have a cryptococcal abscess. A diagnosis of high-grade glioma was entertained on the basis of radiographic appearances, and empiric radiation therapy was contemplated. This patient subsequently recovered after receiving antibiotic therapy.

In the past, conventional surgical approaches to pontine lesions included a suboccipital craniectomy and direct approach to the pons, either through the floor of the fourth ventricle for midline lesions or retromastoid for ventral or laterally situated lesions.2,12,23,27,29,37 Subtemporal transtentorial approaches have also been recommended.1,10,23 These open procedures have been associated with mortality rates as high as 60%, especially when performed on already compromised patients.2,38

Another drawback of the conventional techniques involves the ability to identify the location of the lesion when it does not produce a visible surface abnormality.2,5 Typically, only limited exposure is attained and if no exophytic component is present, the diagnostic yield declines precipitously. Inversely, the risks of creating new neurological deficits when one must "search" for a lesion rise dramatically.

Stereotaxic techniques have consistently been demonstrated to be safe, reliable, and efficient in their application to supratentorial mass lesions.1,6-18,26,31 Until this decade, the pons was considered an inaccessible region for stereotaxis; however, Coffey and Lunsford dispelled this notion in 1985 when they reported 12 cases of stereotaxic brain-stem biopsies. In their series there were three pontine biopsies obtained via the suboccipital transcerebellar method. The nine remaining cases were situated above the pontomesencephalic junction and were approached by a transfrontal trajectory. Coffey and Lunsford emphasized the importance of avoiding blood vessels when utilizing these techniques. By interfacing the patient's angiographic data with CT- or MR-based stereotaxic coordinate data, a trajectory path is planned through an avascular corridor which traverses the middle cerebellar peduncle. Stereotaxic angiography provides information on cerebellar-surface and deep parenchymal tumor vessels which must be avoided. Angiography is advisable if biopsy instruments are to be inserted through a twist-drill hole in the skull as detailed above. However, the necessity of arteriography decreases if the surgeon is willing to make a burr hole and open the dura in order to be sure that no vessels lie beneath the entry point. At present, MR imaging does not yet possess the resolution necessary to detect vessels that could bleed if injured by a probe puncture of the dura. It has been stated that the majority of pontine lesions project to one side or the other,8,12 and this unique characteristic usually guides our trajectory planning. However, we have obtained several
biopsies from midline lesions without difficulty by approaching from the side of the more significant neurological symptomatology.

The development of safe CT- and MR-based stereotactic biopsy techniques is no substitute for sound clinical skill and judgment. The clinical course and nonsurgical diagnostic studies may firmly establish the diagnosis in many non-neoplastic pontine lesions. Stereotactic biopsy can safely provide tissue confirmation of the neoplastic nature of a pontine lesion thought to be a tumor before radiation or chemotherapy is recommended.

References

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Manuscript received March 29, 1988.