Intraoperative sonography of meningiomas.

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Intraoperative Sonography of Meningiomas

Four meningiomas were scanned during surgery using a commercially available, real-time sector sonographic scanner. Each lesion was extremely well defined, and its effects on the surrounding brain were easily characterized by surrounding edema and displaced ventricles. In one case, sonography demonstrated the nonresectability of a portion of the tumor because of involvement of the superior sagittal sinus. This preliminary experience suggests sonographic imaging may be useful during the resection of meningiomas.

There has been some interest in intraoperative sonographic localization of brain tumors in the past [1–4]. However, these one-dimensional displays could only determine the depth of the lesion and crudely evaluate its echogenicity. The internal characteristics, the boundaries, and the effects of a lesion on normal structures were almost impossible to evaluate. We have been using real-time, two-dimensional, gray scale sonographic scanning intraoperatively to define intracranial pathology [5, 6]. These scans can give quite accurate representations of both normal and pathologic anatomy. The value of this technique is in reducing the time and risks involved in surgical resection. The scanner produces instantaneous images that can be evaluated immediately, assisting the surgeon in planning the best approach. Four patients with meningiomas who underwent intraoperative scans to define and localize the lesions offered instructive experiences.

Materials and Methods

An ATL (Advanced Technology Laboratories, Bellevue, WA 98007) rotating sector scanner was used with either a 3 MHz long internal focus or a 5 MHz medium internal focus transducer. Because all of the craniotomies were near to the tumor, the 5 MHz transducer could easily display the lesion itself. However, to demonstrate the relation of a tumor to structures in the far field (e.g., the opposite hemisphere), the 3 MHz transducer was used.

The transducer head was tightly wrapped with a sterile transparent drape. Acoustic coupling gel was applied to the transducer face before it was inserted into the drape to assure good contact. The surgeon then placed the transducer head and drape onto the dural surface. Sterile saline was dripped onto the dura as a coupling agent. All of these scans were performed through the dura after a craniotomy.

Case Reports

Case 1

An 83-year-old woman presented with tonic-clonic seizures on the right. Computed tomography (CT) demonstrated a left parietal meningioma abutting the falk (fig. 1A). Intraoperative sonography also demonstrated the lesion. It was parasagittal and was
Fig. 2.—A, Enhanced CT scan. Right sphenoid wing meningioma (M). Mass surrounded by collar of edema (solid arrows). Midline shifted to left (open arrow). Lateral ventricles (V) compressed and displaced to left. B, Transaxial sonographic section corresponding approximately to CT image. Tumor (M) with compression of left ventricle (V) and shift of midline (open arrow). Small amount of edema (solid arrow). Choroid plexus (CP) identified in ventricles. C, Slightly more cephalad section than B. Large collar of edema (arrows) surrounds margin of tumor (M). Acoustic shadow (S) projects from calcification within mass.

abutting the superior sagittal sinus (fig. 1B). This finding indicated that the tumor could not be completely resected. The pathologic finding was meningotheliomatous meningioma.

Case 2

A 41-year-old woman had a single generalized seizure; the neurologic examination was unremarkable. CT demonstrated a sphenoid wing meningioma (fig. 2A). Intraoperative sonography demonstrated the neoplasm, confirmed the deviation of the midline structures and the lateral ventricles to the left (fig. 2B), and displayed the surrounding edema and calcification within the mass (fig. 2C). There was a 10 day interval between the initial CT scan and the sonogram, during which time the amount of edema seemed to have decreased. The edema reduction could be attributed to preoperative steroid therapy and the intraoperative administration of mannitol. The pathologic finding was meningotheliomatous meningioma.

Case 3

A 59-year-old man had a renal mass and the gradual onset of personality change and emotional lability. A CT scan of the brain revealed a bifrontal meningioma (fig. 3A). At operation, a well encapsulated tumor was noted to arise from the falk and extend to the corpus callosum. The sonogram showed the mass arising from the falk (fig. 3B); it was possible to determine the precise size of
Fig. 3.—A, Enhanced CT scan. Large bifrontal meningioma (M). Anterior horns of lateral ventricles (V) compressed, right frontal horn (arrow) more so than left. B, Transaxial sonogram corresponds approximately to CT image. Large bifrontal tumor (M) with compressed frontal horns of lateral ventricles (arrows). Choroid plexus (CP) in bodies of lateral ventricles.

Fig. 4.—A, CT scan. Bifrontal meningioma (M). Mass mainly on left side. Bodies of lateral ventricles (V) labeled. B, Sagittal sonogram from left of midline. Front of head on left side of image. Meningioma (M) compresses anterior horn of left lateral ventricle (V). Margins of tumor very well defined. Left anterior temporal horn (T), floor of frontal fossa (arrow).

the neoplasm as well as the distance from the neoplasm to the lateral ventricles. The anterior horns of the lateral ventricles were seen to be compressed by the tumor as in the CT scan. The pathologic finding was transitional meningioma.

Case 4
A 45-year-old man had frontal headaches for 6 months, and papilledema was noted on physical examination. CT showed a midline frontal mass presumably originating from the falx (fig. 4A). Sonography demonstrated the relation of the tumor to the frontal and temporal horns of the lateral ventricles and to the floor of the frontal fossa (fig. 4B). The sonogram was a sagittal section as opposed to the transaxial orientation of the CT section. Such an image could have been produced by reformatting the CT scan, but the sonogram was produced instantaneously at surgery. The pathologic finding was meningotheliomatous meningioma.

Discussion
Intraoperative demonstration of the relation of brain tumors to the normal anatomic structures around them is valuable information for the neurosurgeon. Intraoperative sonography defines margins of tumors, determines potential resectability of tumors, and helps select portions of tumors for biopsy. Meningiomas have been demonstrated previously [2-4, 7] by intraoperative A-mode one-dimensional displays that revealed small amounts of information by current standards. In all of our cases, real-time sonography demonstrated the lesions as well as the respective CT scans did. Yet, sonography is a direct surgical tool because it can be used to evaluate the brain during an operation.

The sonographic characteristics of these four lesions were quite constant. They were all homogeneous with increased echogenicity and well defined margins. It was possible that the marked echogenicity was caused by the increased amounts of collagen in these tumors over normal brain [8]. The well defined margin between each tumor and normal brain probably represented the surrounding capsule.

The histologic characteristics of these tumors corresponded to the relatively uniform texture suggested by the sonographic images. All the meningiomas had similar cel-
lular density, similar amounts of collagen, and similar numbers of blood vessels; all had sparse psammoma body formation. A focal calcification in case 2 was manifest as an acoustic shadow (fig. 2C).

Using sonography, it was possible for the neurosurgeon to recognize, during surgery, important characteristics of lesions that could influence the course of therapy. In case 1, sonography demonstrated that the entire tumor could not be resected due to involvement of the superior sagittal sinus (fig. 1B). The CT scan of case 2 demonstrated marked edema surrounding the tumor (fig. 2A). This was also seen on the sonogram as an area of low echogenicity (fig. 2C). Sonography demonstrated the beneficial effects of steroids and mannitol in decreasing the edema. In other cases, the combination of a well defined capsule encompassing an echogenic tumor with surrounding edema could facilitate the identification and location of meningiomas and their extension into the surrounding brain. These characteristics might allow detection of residual tumor during surgery and assess completeness of resection.

In these cases, there was a marked difference between the echogenicity of these meningiomas and normal brain substance. This seems to be true of some other primary and secondary intracranial neoplasms as well [5–7, 9, 10]. This improves definition of the margins of brain tumors preoperatively, intraoperatively, and sometimes postoperatively. Further, in intracranial tumors with these differences in echogenicity, biopsies may be carried out under sonographic guidance [6].

REFERENCES