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Characterization of Intracranial Neoplasms by CT and Intraoperative Sonography

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Twenty-one adult male patients with 24 intracranial neoplasms were studied with intraoperative sonography and preoperative computed tomography (CT). Both methods defined the lesions, but the characteristic appearances were different. Sonography was more effective than CT in determining whether a lesion was cystic, with or without septations, or solid. Most importantly, sonography was an intraoperative localizing tool, which required a surgically created cranial defect. CT excelled in defining the ancillary components of an intracranial neoplasm, such as surrounding edema and details evident with contrast enhancement, but it had no capability for intraoperative use.

Sonography and computed tomography (CT) are complementary methods in the diagnosis and localization of intracranial pathology. CT provides exquisite detail of intracranial derangement in the preoperative patient. Sonography is the definitive localizer of pathology during intracranial surgery after surgical cranial defects have opened an acoustic window. We reviewed 21 consecutive cases in which intraoperative sonography of intracranial neoplasms was used and correlated the findings with preoperative CT to see if any particular pattern or characterization could lead to the appropriate etiology of the tumor.

Materials and Methods

Twenty-one adult males with 24 intracranial neoplasms had intraoperative real-time sonographic examinations using an ATL NeuroSectOR unit with a 3, 5, or 7.5 MHz transducer. The technique has been described [1–4]. Most preoperative CT scans were obtained 1 week before surgery on a GE 8800 before and after administration of contrast material (150 ml of iothalamate meglumine 60%). Some of the CT scans were from outside hospitals and obtained with a variety of units.

Results

The appearances of intracranial neoplasms varied between CT and sonography. The two neoplasms that were of cerebrospinal fluid (CSF) density with smooth walls on contrast-enhanced CT scans were cystic on sonograms (fig. 1); both were cystic astrocytomas. Masses with low-density centers with an enhanced rim on CT scans were either cystic or solid on sonograms; these included adenocarcinoma, astrocytoma, and glioblastoma (fig. 2). High-density lesions on CT scans were always solid on sonograms. These included adenocarcinoma, oligodendroglioma, sellar adenoma, angioma, midbrain glioma, and astrocytoma. When the 24 neoplasms were subdivided according to their acoustic properties (table 1), no specific pattern was detected that correlated with histopathology. The two neoplasms with diffuse, multiple, cystic and solid components were primary neoplasms. Solid lesions with hypoechoic centers that were suggestive of central necrosis or hemorrhage on sonograms were seen in both primary and secondary neoplasms.

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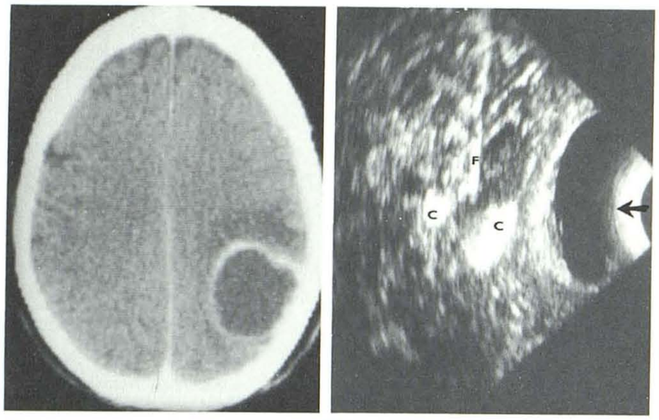

A B

Fig. 1.—Cystic astrocytoma. **A**, Contrast-enhanced CT scan. Smooth-walled low-density lesion with high-density enhanced rim. **B**, Intraoperative coronal sonogram using 3.5 MHz transducer confirms cystic nature of lesions (*arrow*). C = choroid; F = falx.

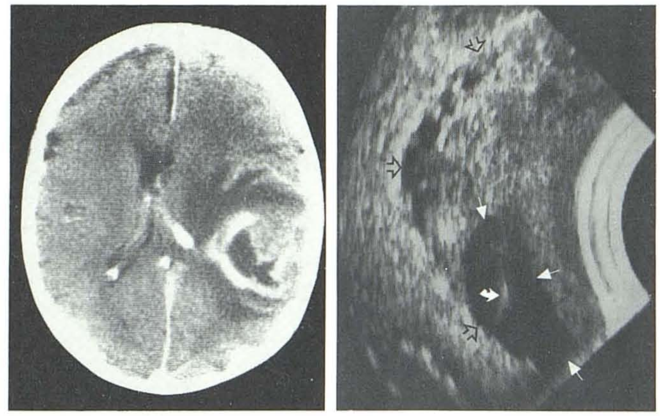

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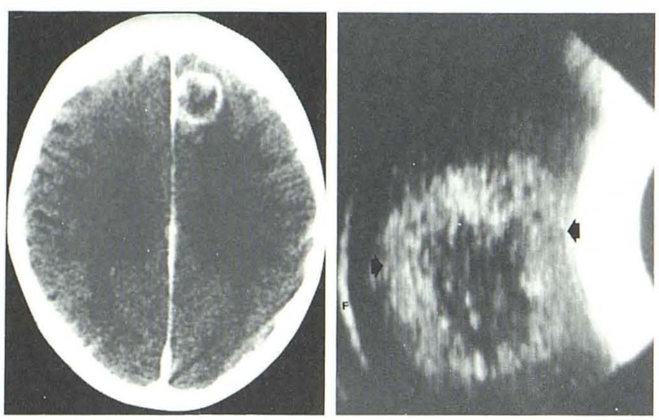
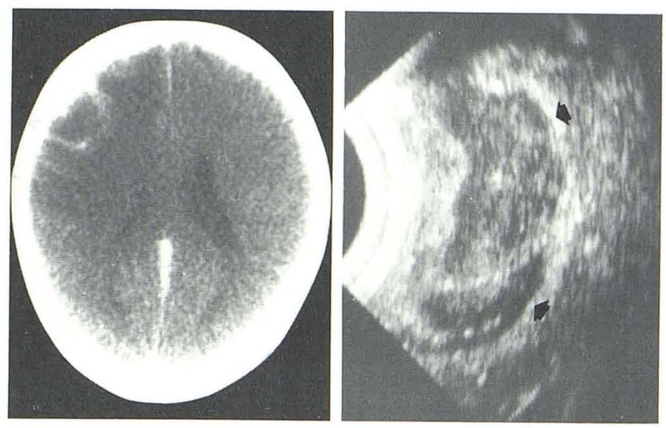
Fig. 3.—Astrocytoma. **A**, Contrast-enhanced CT demonstrates left parietal mass with both areas of high and CSF density. Mass has irregular enhanced rim of high density and wide area of surrounding decreased attenuation suggesting edema. **B**, Intraoperative axial sonogram using 7.5 MHz transducer demonstrates this astrocytoma as solid mass with smaller cystic component and lucent rim of fluid (*open arrows*). Needle tip (*curved arrow*) is in posterior cystic component (*straight white arrows*), which was proven to be cystic by aspiration and surgery. Prominent area of decreased attenuation on **A** is not really appreciated medial to well demarcated lesion on **B**.



A B

Fig. 2.—Glioblastoma. **A**, Contrast-enhanced CT shows left frontal mass with low-density center and thick enhanced rim of high density. **B**, Intraoperative axial sonogram using 7.5 MHz transducer demonstrates thick-walled solid mass with hypoechoic center (*arrows*). F = flax.



A B

Fig. 4.—Left frontal adenocarcinoma. **A**, Contrast-enhanced CT shows left frontal isodense mass with mildly enhanced rim. **B**, Intraoperative axial sonogram using 7.5 MHz transducer shows solid lesion with inferior rim of fluid (*arrows*).

TABLE 1: **Intraoperative Sonography of Neoplasms: Acoustic Properties**

Acoustic Property	No. of Neoplasms	
	Primary	Secondary
Solid	8	5
Cystic	2	2
Cystic and solid	2	0
Basically solid with hypoechoic center	2	3

Most tumors were solid on sonograms. Three solid neoplasms had curvilinear hypoechoic perimeters typical of fluid on sonograms. Two of these were metastatic tumors and one was a primary malignancy. One patient had a multiloculated cyst as part of a solid neoplasm on sonography (figs. 3 and 4). CT did not demonstrate the loculations. Two patients with metastatic foci in the brain had separate lesions that were solid and lesions that were cystic; on sonography, another had two similar metastatic lesions, solid with hypoechoic centers. On CT scans, the cystic lesions seen on sonograms appeared in one case as a mass of diminished attenuation and enhanced rim and in the other as a mass of both increased and decreased attenuation with an enhanced rim. The solid lesions also varied on CT. Two were high-density masses on CT; the other was of decreased attenuation with a mildly enhancing rim.

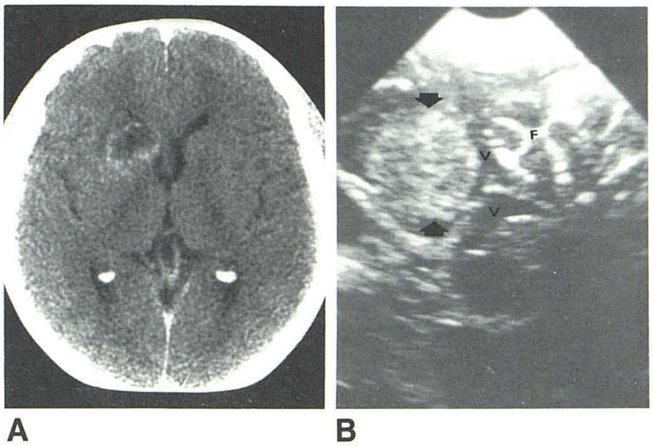


Fig. 5.—Right caudate astrocytoma. **A**, Contrast-enhanced CT shows mass of mildly decreased density with mildly enhanced rim. **B**, Intraoperative coronal sonogram using 5 MHz transducer shows discrete solid tumor compressing ventricles (V) (*arrows*). F = falx.

Discussion

Experience with intraoperative sonography in the delineation of intracranial neoplasms has shown that the character of the lesion may be assessed accurately as cystic, with or without septations; solid; or a combination of the two [1–12]. Both CT and sonography often demonstrated the neoplasms as discrete lesions well demarcated from the adjacent normal tissues. CT sometimes showed a wide area of decreased attenuation suggesting edema, which was not apparent on the sonograms (fig. 3). When CT demonstrated a lesion with smooth walls and attenuation coefficient similar to CSF, the appearance correlated with a sonographic assessment of a cyst (two cases). Sonography was sensitive in detecting multiple septations in a cystic tumor, which CT defined as a nonseptated single lesion of CSF density. Rubin and Dohrmann [1] had a similar experience. Both an isodense lesion and a mass of mild decreased density by CT were solid by sonography (figs. 4 and 5). Lesions that demonstrated both high and low attenuating characteristics on CT could be either solid or solid and cystic on sonography. Neither technique differentiated benign from malignant disease by appearance alone.

Enhancement on CT of parenchymal intracranial lesions is variable and ranges from none to a peripheral ring of increased attenuation to a diffuse or patchy increase in attenuation. Latchaw et al. [13] reported that CT absorption coefficients are misleading histologic indicators and not always reliable in the differentiation of cystic from solid lesions, benign from malignant, or neoplastic from nonneoplastic. In their experience, seven patients had grossly solid tumors that were of low density by CT, that is, the same attenuation as CSF. Handa et al. [14] studied 21 patients with low-density intracranial lesions on CT and concluded that differentiation of cyst from solid was difficult or impossible using that method alone. Tumors with low-density centers and an enhancing rim on CT may not have central fluid or necrosis. This appearance may represent a second compartment in which intravascular or interstitial contrast material may equilibrate at a slower rate [15]. By sonography, a solid tumor with a hypoechoic center, in our experience, represents central necrosis, cystic degeneration, or hemorrhage [1, 3, 16].

The morphologic nature of the neoplasm varies between sonography and CT. From the observation in two cases, cystic lesions were accurately predicted by CT when the presumed cystic region had CSF attenuation coefficients and smooth walls. This is not, however, a pathognomonic appearance, as demonstrated in the experience of others [13, 14]. Intraoperative sonography provides a more accurate appraisal of cystic collections. In our series, all cystic lesions were easily aspirated at the time of surgery, and were appropriately diagnosed by sonography. Our data correlate with those of Dohrmann and Rubin [1], who used intraoperative sonography to confirm cystic components of neoplasms. High-density lesions on CT were all solid on sonography.

While sonography and CT use different kinds of energy and involve different biophysical principles, the images produced are quite similar in defining boundaries, extent, and presence or absence of calcification. Both were accurate in their assessment of the relation of the tumor to the ventricles and the size of the ventricles.

Intraoperative sonography is a rapidly burgeoning field in neurosurgery. While sonography requires a surgically created cranial defect, it has the advantage that it can be used as an intraoperative tool for localization and for monitoring the completeness of surgical resection. Sonography can also help the surgeon avoid damage to important vascular structures whose location may be obscured by tumor. CT, on the other hand, defines the pathologic process and its extent throughout the cranium precisely, but cannot be relied on to accurately assess cystic versus solid components in a neoplasm. When cystic lesions are identified at surgery by sonography, aspiration of the fluid provides decompression for the patient and may facilitate resection. Further examination of the fluid may yield additional diagnostic information to the neurosurgeon. In addition, for patients with cyst formation and recurrent or residual tumors, symptoms of focal or diffuse intracranial hypertension may be improved by cyst aspiration.

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