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Computed Tomographic and Sonographic Characterizations of Central Nervous System Masses

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We present our experience with 15 central nervous system masses evaluated preoperatively with computed tomography and by intraoperative sonography. Cysts were seen as sharply circumscribed, thin-walled masses, near water density by computed tomography, and echo-free by sonography. Inflammatory masses were well demarcated by tomography with areas of edema and ring enhancement but were poorly marginated and variable in appearance by sonography. Primary brain tumors presented as round, solid or complex masses best evaluated by intraoperative sonography in those cases where poor contrast enhancement resulted in limited characterization of the mass by computed tomography. Our experience suggests a very high degree of correlation between these two imaging methods. Therefore, sonography serves as an excellent study for the localization and characterization of central nervous system masses during surgery.

The versatility and portable capability of sonographic equipment has made ultrasound examinations possible during surgery. Although sonography has been used during a variety of surgical procedures, by far its greatest impact has been in neurosurgical procedures (1-4).

The many applications of intraoperative sonography (IOS) during neurosurgical procedures include localization of spinal and intracranial masses, assistance during biopsy of lesions or placement of shunt catheters, and planning the surgical approach to lesions (1-4).

We have used IOS during neurosurgical procedures since May of 1983 and believe that our interpretation of sonographic findings attains a greater specificity in the characterization of central nervous system (CNS) processes as experience is gained. With this in mind, we analyzed the findings of IOS examinations of our first 15 patients and compared the preoperative computed tomographic (CT) appearance of these CNS processes with the characteristics noted by IOS. Our purpose was to learn of possible clues, as seen by IOS, that would enable us to predict the nature of an underlying process before performance of biopsy or surgical excision.

Materials and Methods

Our series consisted of 15 neurosurgical patients who underwent IOS examinations between May of 1983 and February of 1984. The youngest patient was three months old and the eldest 79 years. There were eight females and seven males.

The topographic distribution of these lesions included the brain (n = 12) and the spinal cord (n = 3). Preoperative CT indicated a syrinx n one patient, but findings of IOS revealed a normal spinal cord.

Twelve brain lesions were supratentorial (intraaxial, n = 9; extraaxial, n = 3). The single primary brain tumor was an astrocytoma grade III of the left frontal lobe. Three cortical tumors were metastases from the colon (n = 1) or from unknown primary malignancies (n = 2). One staphylococcal abscess and one actinomycotic abscess were found. There were two cysts.

There were three supratentorial extraaxial processes: a meningioma, a dermatofibrosarcoma, and a middle cranial fossa arachnoid cyst. A grade II astrocytoma of the cerebellum in a 5-year-old boy was studied. Three IOS examinations of the spinal cord were performed; a nerve-root schwannoma, a syrinx, and a normal spinal cord were found.

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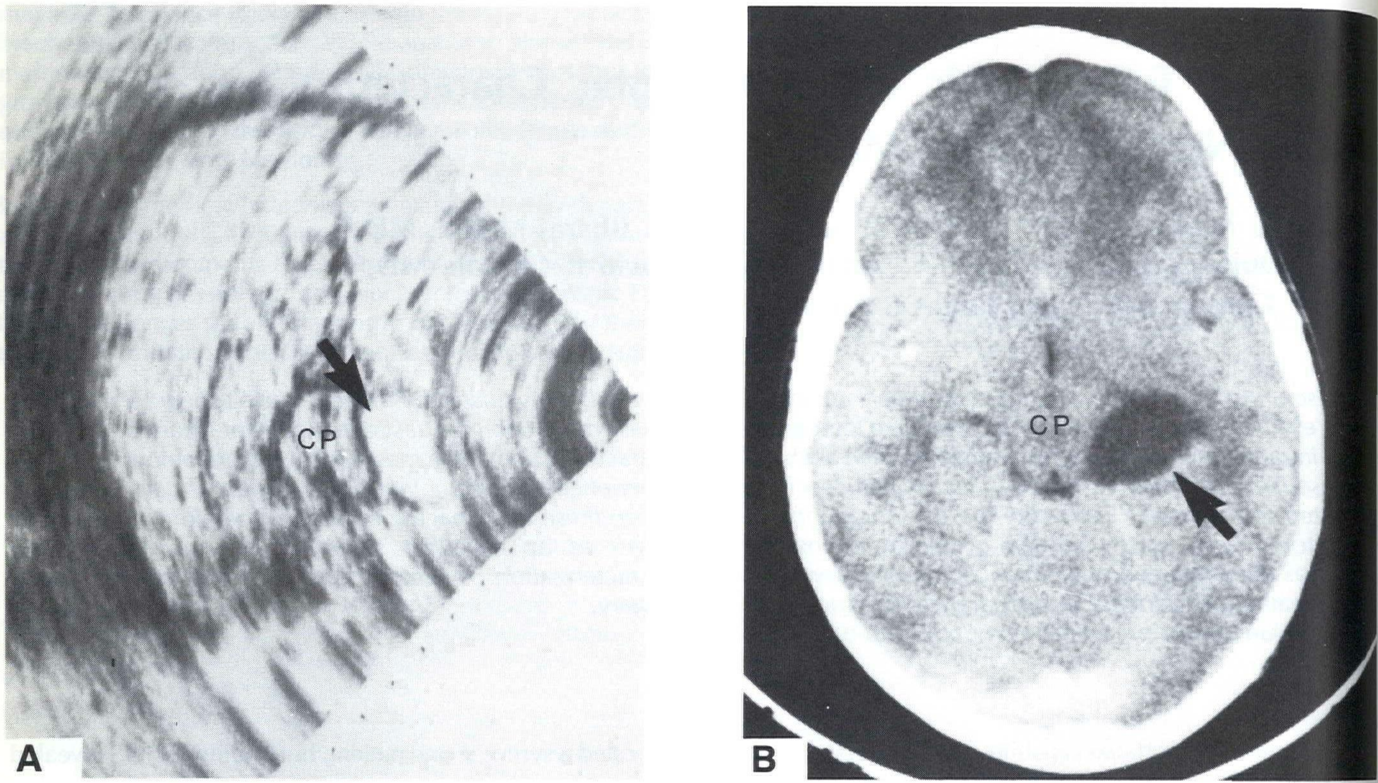

Fig 1
Axial sonogram (A) demonstrates 2-cm sharply circumscribed echo-free mass (arrow) adjacent to cerebral peduncles (CP). Enhanced CT study (B) reveals 2-cm nonenhanced lesion (arrow) adjacent to CP.

All studies were performed using a Philips SDU 3000 portable, real-time sector scanner. Imaging of the brain was performed using a round-face, 5-MHz medium-focus transducer. Studies of the spinal cord were performed using a flat-face, high-resolution, 7-MHz superficial parts transducer. Filtration of the ultrasound beam allowed us to increase or decrease transducer frequency during imaging to improve penetration and resolving ability according to specific needs.

Sterile aqueous gel was applied to the face of the transducer, which was then placed into a sterile plastic drape. The drape was secured with sterile rubberbands. Sterile tape secured the plastic around the cable of the transducer. Imaging was performed directly over the surgical field, with or without an intact dura, using sterile saline as a couplant.

Results

CT and IOS characterizations of most CNS processes were in agreement. Often one modality was superior in demonstrating certain findings.

The three cystic masses in this series had characteristic findings revealed by both studies. CT showed sharply circumscribed, thin-walled lesions of a density near that of water, and IOS showed them to be echo free. No adjacent edema was present (Fig 1).

Two cortical brain abscesses exhibited ring enhancement on contrast CT studies and were noted to be sharply circumscribed. On IOS, these inflammatory processes were irregular in shape and had no definable borders. The actinomycotic abscess was homogeneously hyperechoic (Fig 2), and the staphylococcal abscess was a complex mass with a 1-cm necrotic center.

Three of the four cortical neoplasms were due to metastatic disease. The single primary brain tumor was seen on postinfusion CT studies as a nonenhancing neoplasm (the preoperative characteristics of the mass were unknown). Two closely adjacent yet separate masses were identified by IOS.

The largest mass measured 6 cm and was located in the left frontoparietal region. Intense echogenic edema surrounded both lesions. The three metastatic brain lesions exhibited disproportionately large areas of edema for the relatively small size of the metastatic deposits (Fig 3).

The two supratentorial extraaxial neoplasms imaged during surgery included a meningioma and a dermatofibrosarcoma. IOS showed a definable peripheral rim surrounding the meningioma; however, pathological analysis of the tumor did not reveal a tumor capsule. This rim likely represented the attachment of the mass to the adjacent flax cerebri. The meningioma was ovoid in shape and of medium-to-high

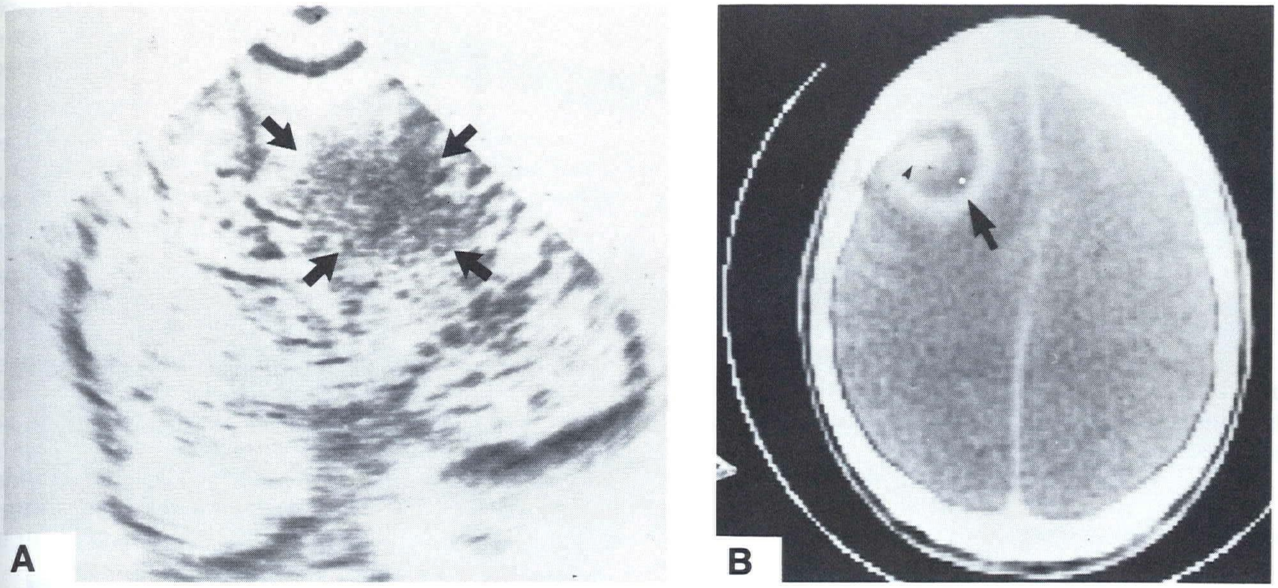

Fig 2
Coronal sonogram (A) reveals 4-cm hyperechoic mass (arrows) with indistinct borders. (Reproduced with permission from Henry Ford Hosp Med J 1984;32:73.) Axial enhanced CT scan (B) reveals low-density mass with peripheral ring enhancement (arrow) containing 2-cm necrotic center (arrowhead) filled with contrast material. (Reproduced with permission from Henry Ford Hosp Med J 1984;32:73.)

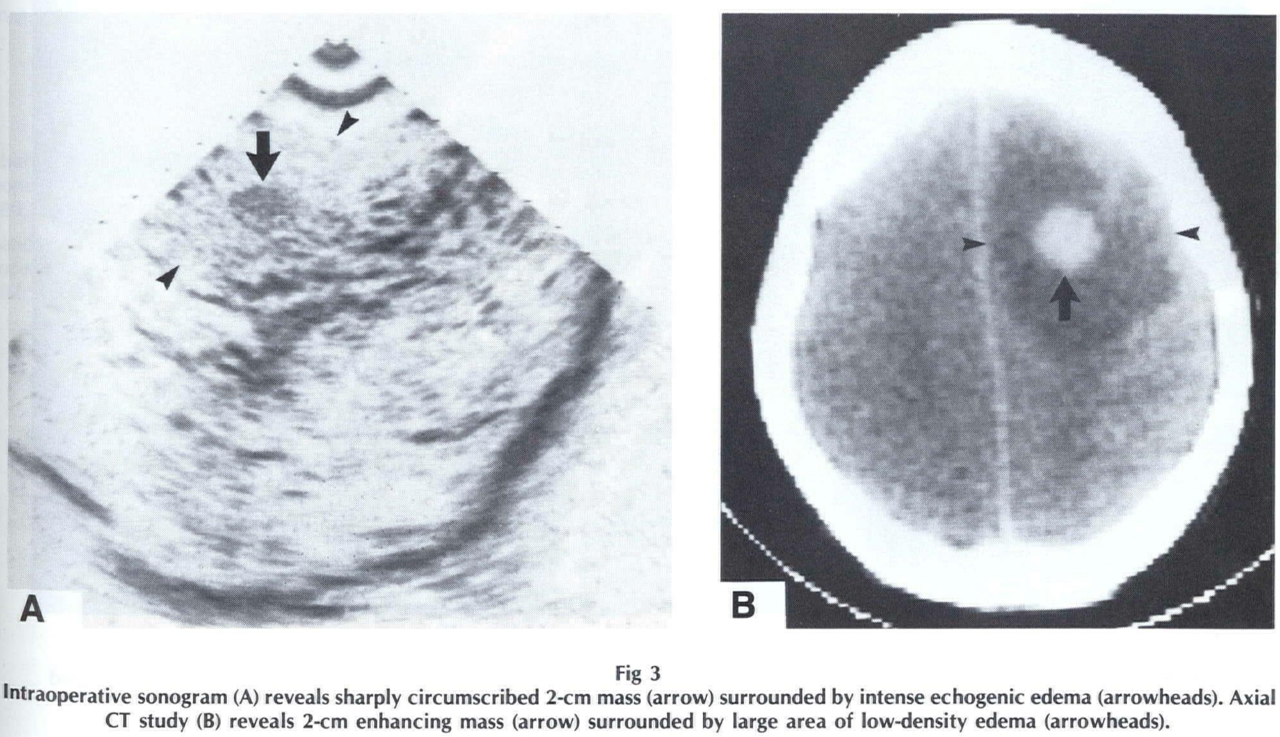

Fig 3
Intraoperative sonogram (A) reveals sharply circumscribed 2-cm mass (arrow) surrounded by intense echogenic edema (arrowheads). Axial CT study (B) reveals 2-cm enhancing mass (arrow) surrounded by large area of low-density edema (arrowheads).

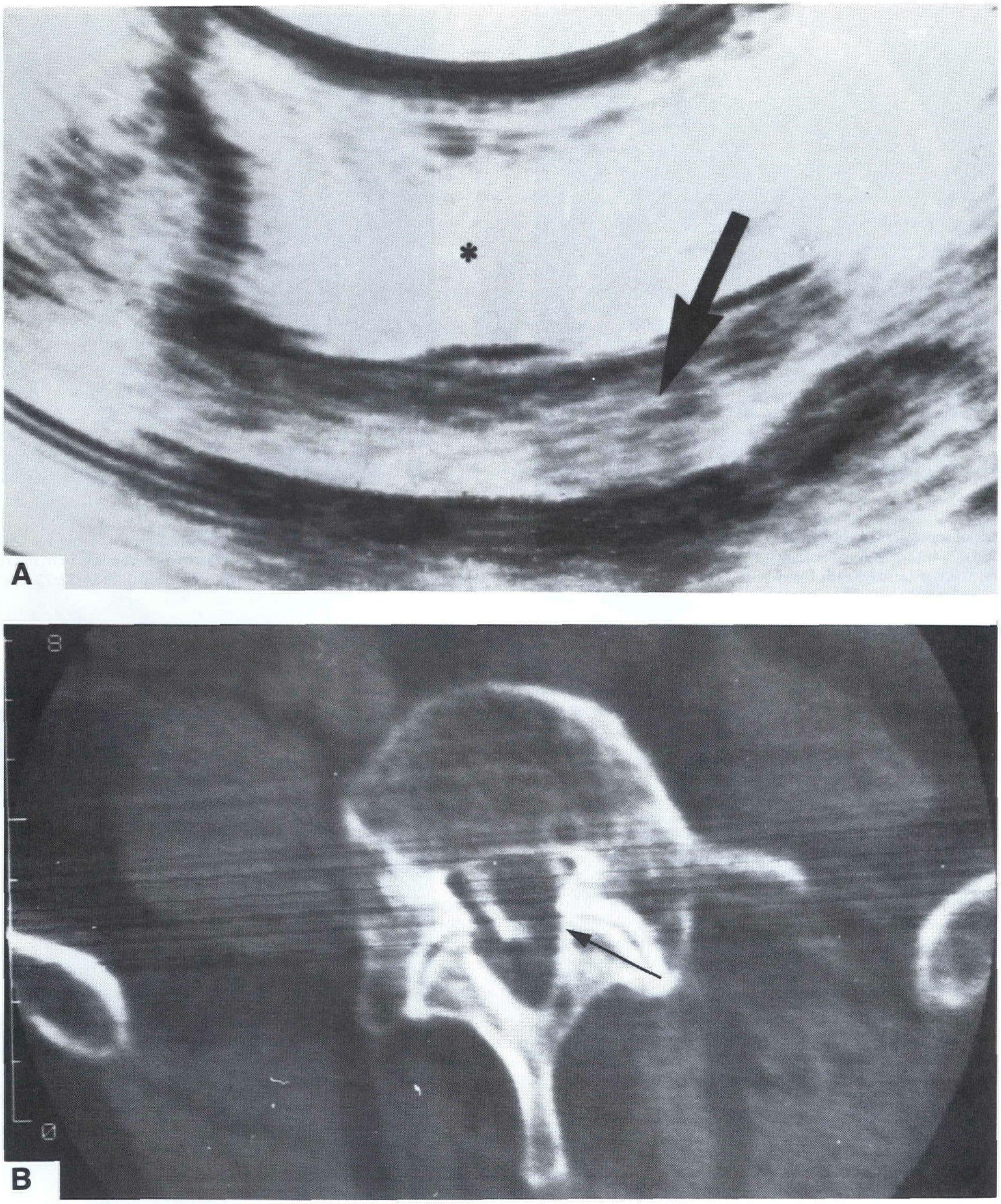

Fig 4
Intraoperative sonogram (A) reveals 2-cm solid mass (arrow) within nerve root of cauda equina. CT scan of spine (B) obtained after administration of metrizamide revealed dural defect caused by solid mass (arrow).

echogenicity. The rare dermatofibrosarcoma was a case of recurrent disease along the straight sinus. This tumor was echogenic with irregular shape and margins.

A grade II astrocytoma of the cerebellum is included in this series. CT and IOS findings showed that the mass was complex. CT showed enhancing rims that separated the cystic spaces of the mass, and IOS showed echogenic septa that compartmentalized the lesion.

The single spinal tumor, a schwannoma of the cauda equina, was solid in appearance by both imaging methods (Fig 4). The other two examinations were of a syrinx of the thoracic spine in a patient who had myelomeningocele and of a normal cervical spine in a patient whose CT findings indicated syrinx. The case of syrinx presented as an expanded spinal canal with compressed neural tissue peripherally. CT was not able to delineate this process preoperatively due to an extreme degree of scoliosis of the spine, and IOS was of great value in management of this patient.

Discussion

This series of 15 cases offers insufficient data to derive conclusions regarding the characterization of CNS masses as seen by CT and IOS. We are encouraged by our initial experience and feel that the two imaging methods are complementary in the characterization of CNS masses.

The physical principles governing each modality are different, and limitations inherent to one imaging method are circumvented by the abilities of the other imaging technique. CT is limited if the use of iodinated contrast material does not contribute to the characterization of a lesion; therefore, hypovascular masses cannot be characterized by CT, and discrimination between these masses and other processes such as infarcts is not possible.

IOS, being totally independent of physiological function and blood supply, has the ability to image all processes, offering a complete delineation of the lesion and discriminating it from surrounding edema.

In the series of 44 patients reported by Enzmann et al (4), wherein findings of CT were compared with those of IOS, the belief was that the entire extent of tumors was best portrayed by IOS. We agree with this observation and feel that CT is limited by partial volume averaging, ie, loss of definition of tissue planes.

Of interest is the disproportionate edema (relative to the size of the lesion) seen with metastatic brain disease. Enzmann et al (4) made this observation. We have observed similar findings in cases of metastatic brain disease.

In summary, IOS appears to be an excellent tool in the localization and characterization of CNS processes.

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