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# Spinal Cord Tumor Imaging with CT and Sonography

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The diagnosis, localization, and characterization of spinal cord tumors can be difficult even in this modern era of computed tomography (CT). Although magnetic resonance imaging offers the potential for accurate spinal cord imaging, at present myelography and CT with intravenous or intrathecal contrast material are the mainstays in the diagnosis and localization of spinal cord tumors. The preoperative information from these studies, however, is often incomplete.

Intraoperative sonography during neurosurgical procedures is receiving increased attention precisely because of its utility in identifying, localizing, and characterizing lesions. It could be a useful adjunct in spinal cord tumor imaging. The application of neurosonography to intraoperative spinal cord imaging has been limited, in part because of instrumentation [1]. Instrumentation, however, is continually evolving with resultant progressive improvement in sonograms. Newer probe designs are removing barriers to accurate spinal cord imaging; our report describes such a new probe. Intraoperative, transdural sonography of the spinal cord offers another clinically useful application of this diagnostic technique.

## Case Report

A 36-year-old man had motor and sensory findings suggestive of a cervical cord tumor. The initial investigation by myelography revealed enlargement of the cervical cord. A metrizamide CT scan (8 ml of 170 mg I/ml solution) revealed an enlarged cord extending from C2 to C6 (figs. 1A–1C). Minimal contrast material was detected within the cord itself at about the C3–C4 level; this suggested a possible cystic component to the tumor (fig. 1B). Delayed scans were not obtained. The somewhat low density of the cord also suggested a cystic component, but CT density values are not totally reliable in making this determination. No well defined tumor margins could be localized. CT was performed using double the normal dose (4 ml/kg) of a 50% iodinated contrast medium administered intravenously. An enlarged cervical spinal cord was revealed with inhomogeneous, multiple nodular areas of abnormal contrast enhancement and interspersed areas of low density (figs. 1D–1F). A cystic tumor could not be differentiated from an inhomogeneously enhancing tumor with areas of necrosis. This abnormal, heterogeneous density of the spinal cord was present from about C2–C6.

Intraoperative sonography was performed to localize and characterize the tumor for surgical resection using a standoff 10 MHz transducer (Diasonics). The face of the transducer measured 10 × 26 mm. This type of probe permitted transdural imaging without suffering significant near-field artifacts. Sagittal and coronal views of the cord were obtained from C1 to C6 (fig. 2). The ependymoma was multicystic in character, correlating with the heterogeneous texture and low density seen on the intravenous contrast CT scan. The areas of enhancement seen on CT corresponded to the echogenic islands of tissue scattered between the multiple, various-size cysts (figs. 2A, 2B, and 2E). The caudal part of the tumor was more solid compared with the upper part (figs. 2C and 2F). The tumor itself was hyperechoic relative to normal spinal cord. In the solid part of the tumor, the increase in echoes was homogeneous (figs. 2C and 2F). The transition of the tumor to normal spinal cord at the caudal end was seen, but it was not clearly delineated (fig. 2D). Reappearance of the nondisplaced central spinal canal was a good marker for return to normal cord. This central canal could be seen well within normal cord below the tumor.

The entire ependymoma was removed surgically with the patient showing improvement in leg weakness and spasticity and in arm dexterity. The surgical findings confirmed the sonographic findings of multiple cysts and the gradual transition zone at the caudal tumor margin. This latter finding was caused by fibrosis that resulted from a previous surgical procedure.

## Discussion

The utility of intraoperative sonography is becoming increasingly recognized by neurologic surgeons and radiologists [1–11]. Most applications to date have been intracranial [2–11]. New technologic developments, however, continue to improve image quality and expand the versatility of the technique, such as imaging through a burr hole [2]. These instrument improvements now make spinal cord imaging more feasible. The advantages attributable to intracranial, intraoperative sonography are particularly useful for spinal cord imaging, since preoperative myelography and spinal CT (intrathecal administration of contrast material) rarely give precise information regarding tumor location or character. To date the intravenously enhanced spinal CT scan has not received much attention for spinal cord tumor imaging. This is in contradistinction to the high success rate of tumor

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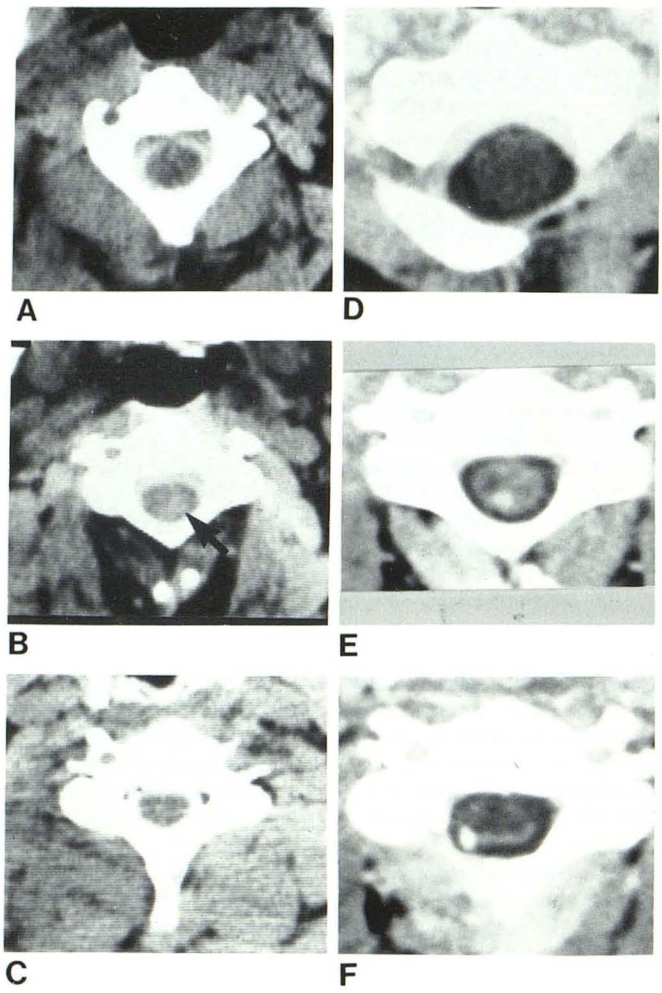


Fig. 1.—**A–C**, Spinal CT about 4–5 hr after instillation of metrizamide. Cord enlargement. **A**, C2 level. **B**, C4 level. Subtle increase in cord density (*arrow*) suggests cystic structure within cord. **C,** C5 level. Cord of near-normal size. **D–F**, CT after double-dose intravenous contrast enhancement. Inhomogeneous enhancement of cord. **D**, C2 level. No enhancement. Cord appears to be of low density. **E**, C4 level. Inhomogeneous contrast enhancement with nodule posteriorly on right. Several low-density regions within cord. **F**, Similar findings at C5 level, again with large part of cord being of irregular low density, suggesting multiloculated cysts; brightly enhancing tumor nodule was seen posteriorly on right. Heterogeneous tumor suggested by contrast-enhanced CT combined with metrizamide CT appearance suggested possibility of associated cysts.

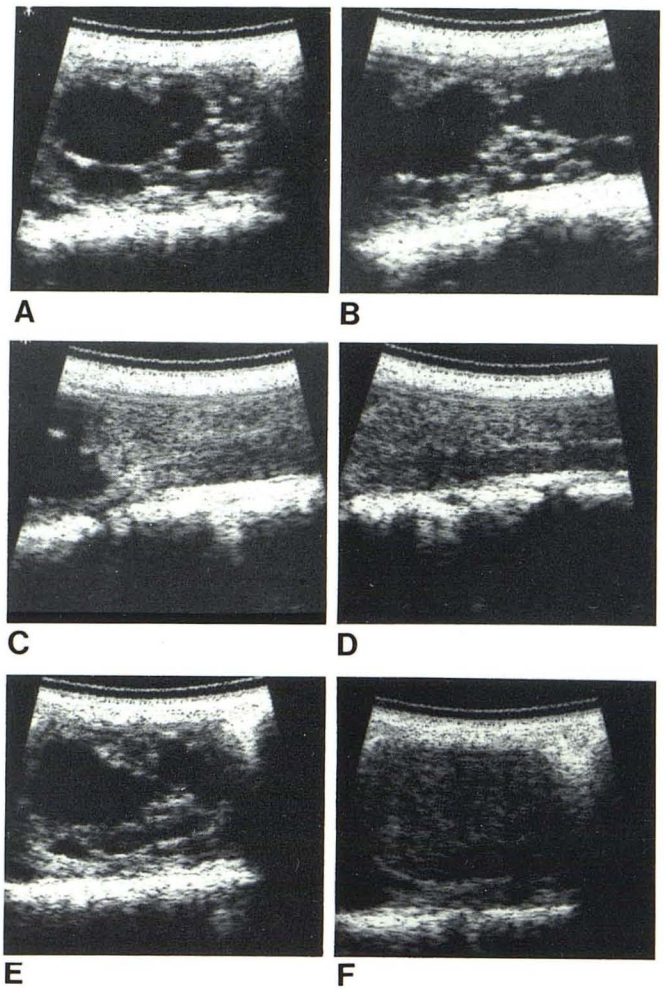


Fig. 2.—Sagittal transdural sonograms of ependymoma at various levels. C4 (**A**) and C5 (**B**). Multiple, well defined cysts of irregular shape and variable size correspond closely to low density in figs. 1D–1F and irregular density in figs. 1A–1C. **C**, Lower border of tumor characterized by more homogeneously echogenic area, with gradual transition to more normal, less echogenic spinal cord. There is appearance (or reappearance) of central spinal canal, which does not appear to be displaced. Obscuration of this structure was useful in delineating caudal tumor margin. Transverse sonograms confirmed cystic (**E**) and solid (**F**) nature of ependymoma and showed degree of cord enlargement well.

detection seen with the intracranial CT scan. Nevertheless, as our case shows, spinal CT using a high-resolution scanner and double-dose intravenous contrast material can provide useful information about tumor location and morphology. The concept of an abnormal blood-brain barrier defect resulting in contrast enhancement of intracranial gliomas (and ependymomas) is also applicable to the spinal cord. Given continued improvement in the resolution of CT scanners, the double-dose technique will be useful in the diagnosis and localization of spinal cord tumors.

The intraoperative images of the ependymoma in our patient were of high quality and correlated closely with the CT and surgical findings. The cystic nature of the lesion was best appreciated by sonography, and the upper and lower margins of the tumor were localized better by sonography than by CT. As with intracranial tumors, the spinal cord variety was also hyperechoic relative to adjacent normal neural tissue. Disruption of the normal central canal was an important finding that helped to define tumor margin. One could extrapolate from this patient's findings to suggest that given the accurate depiction of the central canal and the cystic parts of the tumor, a syrinx would be imaged equally well.

Spinal cord sonography has been limited. It has been performed successfully in postoperative patients where a previous laminectomy provided an acoustic window [1]. Such an imaging technique allows differentiation between cystic and solid lesions and between an enlarged and atrophic spinal cord [1]. The physical characteristics of the probe for this type of scanning are not stringent. Near-field problems do not interfere significantly since the area of interest is deep. This

type of skin-surface imaging can be performed using commercially available transducers. Such transducers, however, are not suited for intraoperative spinal cord imaging because the near-field artifacts preclude imaging the relatively small spinal cord on direct contact. The size of the surgical exposure also limits the physical dimensions of the probe. Currently a small standoff transducer that eliminates or markedly reduces the near-field artifact is most applicable for transdural, spinal cord imaging. The standoff probe is not plagued by near-field artifacts, because the fluid-filled gap introduced between the piezoelectric crystal and the transducer face separates the region of interest from the artifact region. The near-field problems with the mechanical crystal still exist but are removed from the image and confined to the transducer. The spurious echoes in the near field are caused by phase interference that in turn results from unequal paths traveled by the sound waves to an object near the transducer face. Therefore, the technical specifications of a transducer for spinal cord imaging are different from those usually used for intracranial neurosonography.

In evaluating the general requirements of intraoperative neurosonography, it is clear that more than one transducer is needed to encompass the full scope of the imaging demands. Different probes are required for deep intracranial lesions, as compared with the probe required for superficial lesions or for spinal cord imaging. A number of currently available probes can be used for intracranial lesions. Superficial lesions can still be a problem because of near-field artifact. For superficial cortical lesions and for spinal cord imaging a similar transducer design can be used, such as a mechanical sector design with an offset to reduce near-field problems. A phased linear-array probe could be considered since it also does not suffer near-field problems, and newer designs can provide a sector of image. Another major parameter is the frequency of the transducer. Intracranially the 3–7.5 MHz range seems appropriate with the higher frequencies, providing greater spatial resolution at the cost of depth of penetration. For spinal cord and superficial cortical lesions, 10 MHz (and higher) transducers provide excellent spatial resolution; because of lesion location the limited depth penetration is not a major constraint. For spinal cord imaging in particular, a high-frequency transducer that affords greater spatial resolution seems optimal.

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