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Contrast Enhancement of the Irradiated Spinal Cord in Children

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Four children are reported in whom marked contrast enhancement of the spinal cord and roots was demonstrated by computed tomography months to years after relatively low dose therapeutic irradiation of paraspinal tumors, the radiation field including the cord. This phenomenon, previously unreported, probably represents subclinical radiation injury. None of the children had any neurologic abnormalities.

Recently, we observed marked contrast enhancement of the spinal cord and roots by computed tomography (CT) after intravenous contrast medium injection in four children who had received irradiation of paraspinal tumors.

Computed tomographic metrizamide myelography is an established method of examining the spinal canal and its contents [1]. Because of the high attenuation of the mixture of metrizamide and cerebrospinal fluid, the cord and roots as well as lesions within the dural sac are well visualized.

The radiographic density of cerebrospinal fluid may also be increased by intravenous injection of contrast medium. Chemically demonstrable iodine in the cerebrospinal fluid after intravenous injections of contrast medium has been reported [2–4], and in 1979 Coin et al. [5] described enhancement of the cerebrospinal fluid in the spinal subarachnoid space, detectable by CT. However, the enhancement was insufficient to offer any details of the intraspinal structures.

Contrast enhancement of the cord itself, albeit slight, has been reported by Isherwood et al. [6] and Resjo et al. [7] after intravenous contrast medium injection. Similarly, cord tumors may be opacified.

Nakagawa et al. [8] reported 19 cases of intraspinal tumors examined with CT after intravenous contrast medium injection. One of these, a highly vascular hemangioblastoma, enhanced enough to be directly visible. Handel et al. [9] reported a spinal cord astrocytoma, in which a nodular area of marked contrast medium enhancement was visualized by CT. To our knowledge, direct contrast enhancement of the spinal cord after irradiation has not been reported previously. We offer our experience.

Subjects and Methods

Our four patients all suffered from malignant disease in the abdomen or chest, and all had therapeutic radiation of the tumor volume, the radiation fields including the spinal canal. Details are provided in table 1. The dose to the cord was relatively low, about the same as the tumor dose, 1,200–2,400 rad (12–24 Gy). None of the patients had any neurologic disturbances nor any other clinical or radiologic signs of intraspinal involvement of tumor. The CT examinations were performed to evaluate the effects of radiation treatment; the findings in the spinal canal were quite incidental or retrospective. In cases such as these, we routinely inject intravenous contrast medium before CT to detect vascular lesions. The injections (Hypaque, H 60%, 3 ml/kg body weight) are administered 15–30 min

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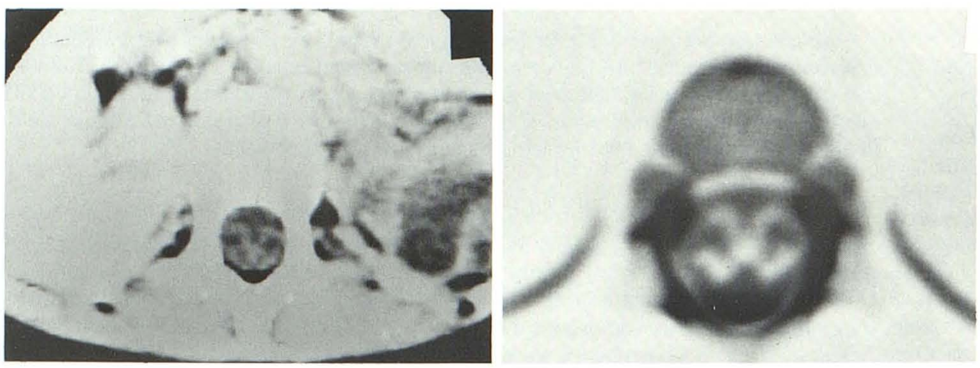
TABLE 1: **Clinical Summary of Patients with CT after Spinal Cord Irradiation**

Case No.	Gender	Age		Diagnosis	Radiation Treatment		Part of Cord Irradiated
		At Radiation	At CT Examination		Field	Tumor Dose (rad [Gy])	
1	F	16 months	6 years	Inoperable retroperitoneal neuroblastoma	Abdomen	2,400 (24)	Lower thoracic and lumbar
2	F	10 months	11 months	Neuroblastoma, right eye; spread to liver and bone marrow	Cranium Abdomen	1,200 (12) 1,200 (12)	... Lower thoracic and lumbar
3	M	4 years	4½ years	Wilms tumor	Abdomen	2,400 (24)	Lower thoracic and lumbar
4	M	12 years	13 years	Rhabdomyosarcoma of chest	Chest	1,500 (15)	Thoracic

Note.—Interval between irradiation and CT was 4½ years, 1 month, 3 months, and 1 year in cases 1–4, respectively.



A B

Fig. 1.—**A**, Case 1, 4½ years after irradiation. After contrast medium injection. Tip of conus and upper lumbar roots. **B**, Another patient. Normal anatomy of tip of conus with CT metrizamide myelography. Reversed density mode provides best visualization of conus and roots and facilitates comparison with **A**.

before the CT examination. All examinations except one were performed with a General Electric CT/T 8800. The first examination in case 4 was performed with an Ohio Nuclear Delta 50 scanner.

Case Reports

Case 1

A 6-year-old girl was treated for unresectable retroperitoneal neuroblastoma. A CT scan 4½ years after abdominal radiation with intravenous contrast medium injection revealed enhancement of the lower conus and the roots of the upper cauda equina (fig. 1). This observation was made retrospectively, and the attenuation value was not measured.

Case 2

An 11-month-old boy had metastatic neuroblastoma. A CT scan with intravenous contrast medium before radiation therapy did not show any remarkable enhancement of the intraspinal structures; the attenuation of the conus was 24 Hounsfield units (H). A repeat scan with intravenous injection of contrast medium 1 month after abdominal radiation revealed a pronounced enhancement of the conus; attenuation of the conus was 51 H (fig. 2).

Case 3

A 4½-year-old boy had Wilms tumor. CT examination before treatment with intravenous contrast injection revealed no pathologic intraspinal changes. The attenuation of the cord at the level T10 was 23 H (fig. 3A). Repeat CT with intravenous contrast injection 3 months after thoracic irradiation revealed a pronounced enhancement of the cord; the attenuation at the T10–T11 level was 94 H (fig. 3B).

Case 4

A 13-year-old boy had rhabdomyosarcoma of the chest. CT before treatment revealed a normal cord without significant contrast medium enhancement; the attenuation value was 36 H (fig. 4A). Repeat CT 1 year after thoracic irradiation revealed the thoracic cord adherent to the anterior wall of the spinal canal. Before injection of contrast medium, the attenuation of the cord was 33 H. After injection, there was pronounced enhancement; the attenuation was 63 H (figs. 4B and 4C). The first examination was performed with an Ohio Nuclear Delta 50 scanner and the second with a General Electric CT/T 8800.

Discussion

Without injection of any contrast medium, the CT appearance of the dural sac and its contents is a homogenous density within the spinal canal enclosed by the epidural fat.

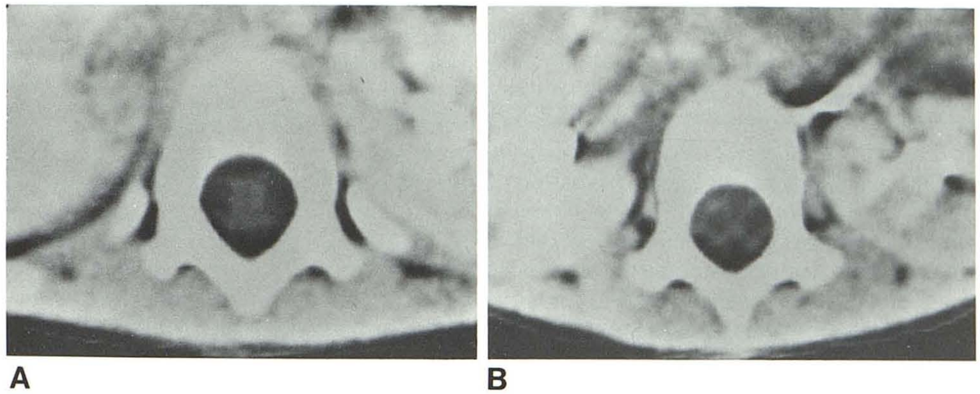


Fig. 2.—Case 2, 1 month after irradiation. **A**, Enhancement of conus and roots. **B**, Tip of conus and roots of upper cauda equina.

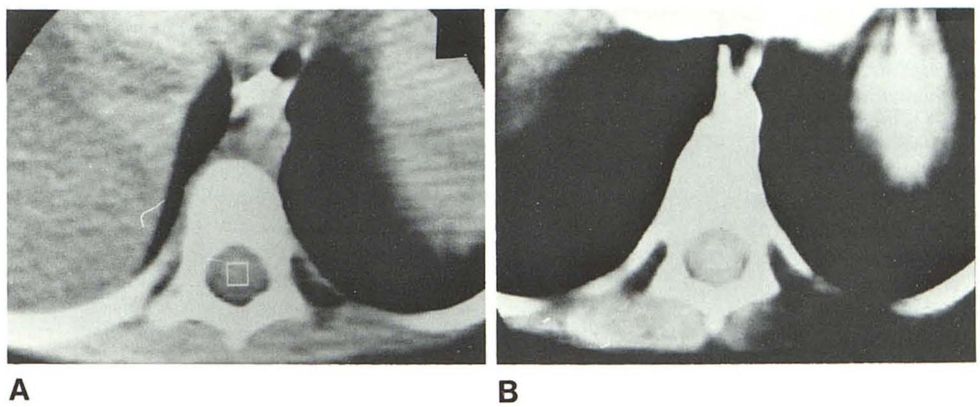


Fig. 3.—Case 3. **A**, Before radiation treatment. Attenuation of cord at level T9 after intravenous contrast medium injection is 23. **B**, At same level 3 months after irradiation. Attenuation after contrast medium is 94.

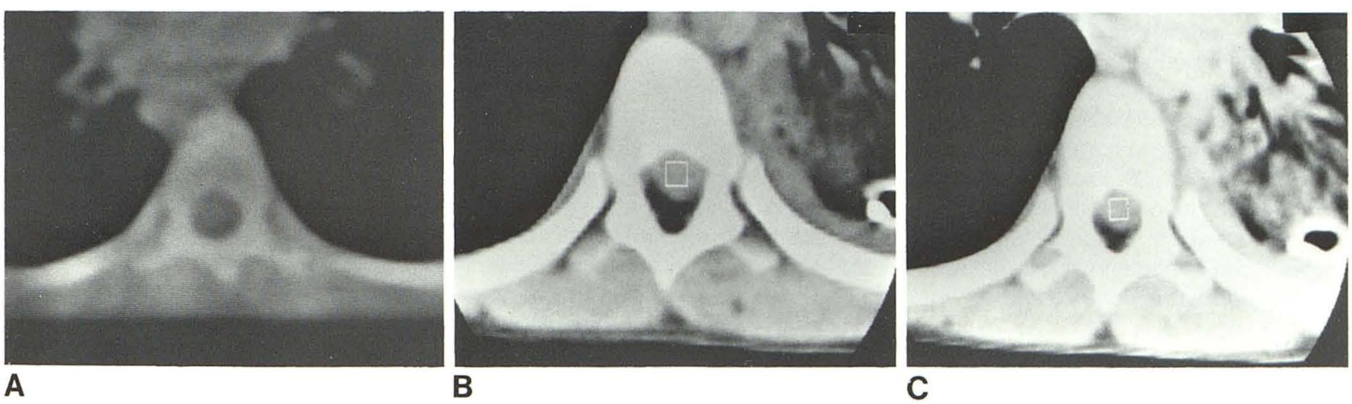


Fig. 4.—Case 4. **A**, Before radiation treatment. Cord centrally placed in canal; attenuation value after intravenous contrast medium injection is 36 H (Delta 50 scanner). After radiation treatment, before (**B**) and after (**C**) intravenous contrast medium injection. Cord adherent to anterior part of spinal canal. Attenuation value increases from 33 (**B**) to 63 (**C**).

However, the cervical cord at the C1–C2 level may be seen within the subarachnoid space [10]. The normal attenuation values of the child's spinal cord are 30–40 H before intravenous contrast medium injection; they increase about 10 units afterward [1]. We have also found that in children who have had repeated examinations at intervals of 2–12 months, the attenuation value of the nonirradiated cord has been the same within a 10 H range. Thus, the enhancement values reported in this paper, 27, 30, and 61 units, range beyond the usual enhancement and reflect real changes of the attenuation of the cord and roots. This alteration is not limited to these four children; we have seen it in others subsequently and believe it is a common phenomenon that has not been recognized previously.

The reason for the phenomenon is not clear. It might be due to radiation-induced hypervascularization or to radiation-induced damage of the blood–nervous tissue barrier. As the changes were observed as long as 4½ years after irradition, it is probably not a hypervascular reaction.

A report by Mikhail [11] in 1979 of a large series with radiation-induced brain damage showed that after large doses (about 7,000 rad [70 Gy]), brain necrosis showed contrast medium enhancement detectable with CT.

Our cases had no neurologic disturbances and thus no signs of radiation myelitis. However, it is probable that the enhancement of the cord and nerve roots represents subclinical damage induced by the radiation. Whether the phenomenon has any clinical significance or usefulness is yet to be determined.

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