SPECT Imaging of Pediatric Brain Tumor with Hexakis (Methoxyisobutylisonitrile) Technetium (I)

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Technetium-99m-Hexamibi [Hexakis (methoxyisobutylisonitrile) technetium (I)] was developed as a myocardial perfusion agent with biologic properties similar to those of thallium-201 (^{201}Tl). As ^{201}Tl has recently been observed to be of value for the diagnosis of brain tumors when used in conjunction with single-photon emission computed tomography (SPECT) imaging technology, the possibility that the biologic similarity of the two radiopharmaceuticals extended to their affinity for tumors was tested. A 5-yr-old female patient with a brain stem astrocytoma showed marked focal uptake of ^{99m}Tc-Hexamibi at the site of tumor recurrence as defined by biopsy and prior ^{201}Tl/SPECT study. Tumor-to-normal cortex radioactivity ratios for the ^{99m}Tc-Hexamibi/SPECT study were 132:1 and the spatial resolution of the ^{99m}Tc-Hexamibi images was high. This observation suggests that ^{99m}Tc-Hexamibi merits further study as a potential agent for SPECT imaging of human brain tumors.

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Thallium-201 (^{201}Tl), although developed for the evaluation of myocardial perfusion, has been found to be of value in the evaluation of tumor viability in adult and pediatric patients when used in conjunction with SPECT (*1,2*). The physical properties of technetium-99m (^{99m}Tc) (including gamma ray energy and radiation dose) are, however, superior to those of ^{201}Tl, and it would be preferable to have available a ^{99m}Tc radiopharmaceutical whose biologic properties paralleled those of ^{201}Tl. Several ^{99m}Tc radiopharmaceuticals have been developed as potential replacements for ^{201}Tl for the functional imaging of myocardial perfusion but none have been examined for possible uptake by tumors. One of the more promising classes of ^{99m}Tc myocardial perfusion agents is the hexakis (isonitrile) technetium (I) complexes (*3,4*), including hexakis (2-methoxyisobutylisonitrile) technetium (I) (^{99m}Tc-Hexamibi) (Cardiolite, DuPont, N. Billerica, MA). This study reports the uptake of ^{99m}Tc-Hexamibi by a pediatric brain tumor.

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CASE REPORT

The patient was a 5-yr-old girl who originally presented with right-sided clumsiness and hearing loss, and was treated by resection of a Grade 2 cerebellar astrocytoma followed by radiotherapy. Two years later she developed new neurologic deficits—increasing dysarthria, decrease in appetite, followed by a left peripheral facial palsy, and ataxia. Over the next 6–9 mo, a left gaze preference appeared. The computed tomography (CT) study showed increasing mass effect, but could not distinguish between recurrent tumor and radiation necrosis. At repeat posterior fossa craniectomy and C1 laminectomy, the right cerebellar hemisphere was very swollen, and the fourth ventricle was markedly displaced to the left. A frozen section of the cerebellum showed low-grade astrocytoma. Tumor was debulked in a plane extending through the cerebellar hemisphere up to the tentorium, and also at the brain stem level. Only subtotal removal could be achieved because of the diffuse intraaxial brainstem involvement. The patient was started on chemotherapy postoperatively. SPECT was performed 3 mo after the second resection. During this period, the patient showed increasing neurologic deficit. Magnetic resonance scans obtained 5 wk before, and 3 days after SPECT showed expansion of the brain stem and upper cord with increasing mass both within the cerebellar vermis and right hemisphere.

Informed consent was obtained prior to initiation of the study. The patient received 1.5 mCi of ^{201}Tl intravenously and data collection was started immediately postinjection. SPECT data were collected in 64 steps of 30 sec each through 360° using a rotating gamma camera (Siemens Orbiter 7500, Hoffman Estates, IL) equipped with a 30° slant-hole collimator. The patient then received 10 mCi of ^{99m}Tc-Hexamibi and a second data set was collected using the same conditions as for ^{201}Tl SPECT. The data were processed and image reconstruction performed with an ADAC 3300 system using a Butterworth filter and filtered backprojection (ADAC Laboratories, Milpitas, CA). Tumor-to-normal tissue ratios were calculated using the average count rate per pixel in a region of interest including the tumor divided by the average count rate per pixel for a region in the contralateral cerebral cortex.

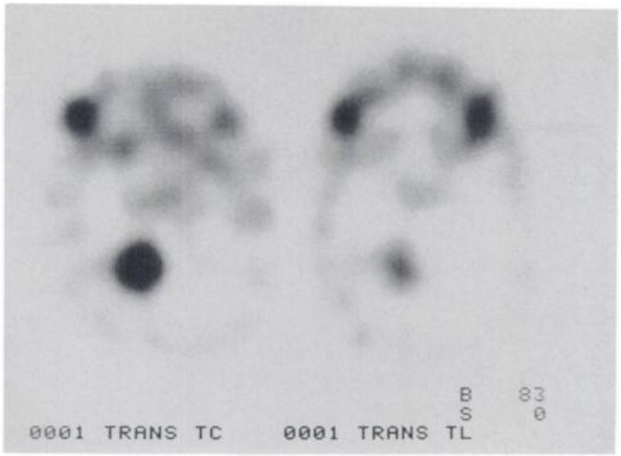

FIGURE 1
Technetium-99m-Hexamibi (left panel) and ^{201}Tl (right panel) SPECT images in the transaxial plane with image contrast adjusted for optimal contrast in the ^{201}Tl image.

Focal uptake of ^{99m}Tc-Hexamibi was noted involving the tumor site in the right anterior cerebellum (Fig. 1). There was minimal uptake of the tracer by normal brain. Technetium-99m-Hexamibi showed greater uptake at the tumor site than ^{201}Tl, and defined the margins of the lesion more clearly. Tumor-to-normal cortex ratios were 132:1 for ^{99m}Tc-Hexamibi and 80:1 for ^{201}Tl.

DISCUSSION

The area of focal uptake of ^{99m}Tc-Hexamibi corresponds to active growth of recurrent tumor as demonstrated by the ^{201}Tl study as well as recent biopsy and clinical evidence of active disease. Visual inspection indicates and quantitative analysis confirms that ^{99m}Tc-Hexamibi is taken up to a greater extent by the tumor than is ^{201}Tl. This difference is illustrated by the different gray scales required to optimize the ^{99m}Tc-Hexamibi and ^{201}Tl images (Fig. 1). The distribution of both tracers within the tumor is similar.

It is particularly interesting to note that the tumor-to-normal cortex ratios observed in the ^{99m}Tc-Hexamibi/SPECT study not only exceed those observed with ^{201}Tl by more than 50% but also exceed by almost twentyfold the values reported for PET studies of brain tumors using [^{11}C]L-methionine, the most tumor-avid, positron-emitting radiopharmaceutical that has been developed to date (*5*).

Studies are currently underway to determine if similar results are observed with tumors other than pediatric astrocytomas as well as to elucidate the mechanism of uptake of ^{99m}Tc-Hexamibi by the tumor. If a similar pattern of uptake is observed for other types of tumors, ^{99m}Tc-Hexamibi has the potential to offer significant clinical advantages over both ^{201}Tl SPECT and PET while incorporating the practical advantages inherent in a kit-based ^{99m}Tc radiopharmaceutical.

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