Discordant Technetium-99m-MIBI and Technetium-99m-HMPAO Uptake of Recurrent Occipital Meningioma on Brain SPECT Images

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Technetium-99m-HMPAO and ^{99m}Tc-MIBI brain SPECT, MRI, CT and cerebral angiogram were studied in a patient with recurrent occipital meningioma. MRI and CT of the head showed right cerebral hemispheric tumor masses involving parasagittal, temporal and parietoccipital areas. The angiograms showed an intense vascular tumor blush in recurrent mass lesions supplied by the following arteries: the meningeal branch of the right external carotid artery, the right middle cerebral artery, the right anterior cerebral artery and the right posterior cerebral artery. Although demonstrable ^{99m}Tc-MIBI lesions mass exactly corresponded to CT and MRI (T-1) findings, mass lesions exhibited a mismatch between ^{99m}Tc-MIBI (increased uptake) and ^{99m}Tc-HMPAO (absent uptake) brain SPECT images. Technetium-99m-MIBI images, rather than ^{99m}Tc-HMPAO brain SPECT, resulted in the correct pathological diagnosis of recurrent meningioma.

Key Words: technetium-99m-MIBI; technetium-99m-HMPAO; occipital meningioma; SPECT

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Meningiomas comprise 15% of adult intracranial tumors. Technetium-99m-HMPAO uptake in the meningioma has been controversial. HMPAO uptake as well as nonlocalization of HMPAO has been reported in the tumor (*1–3*). Thallium-201-chloride brain SPECT has been used to detect brain tumors and to assess tumor viability. Likewise, ^{99m}Tc-MIBI brain SPECT can detect brain tumors such as gliomas (*4*) and meningiomas (*1,2*). Although ^{201}Tl-chloride has been shown to be an effective radiopharmaceutical in the detection of various tumors, the advantages of ^{99m}Tc-MIBI over ^{201}Tl-chloride as a tumor imaging agent include: the ready availability of the MIBI kit; preferable gamma energy from ^{99m}Tc, which has a higher tumor uptake than ^{201}Tl (*5,6*); rapid blood clearance (*7*); and the use of a larger dose compared with ^{201}Tl-chloride. Therefore, ^{99m}Tc-MIBI should be the radiopharmaceutical of choice for tumor imaging. We report on a patient with recurrent occipital meningiomas who underwent ^{99m}Tc-HMPAO and ^{99m}Tc-MIBI brain SPECT rapid sequential cerebral flow studies in correlation with CT, MRI of the head and cerebral angiography. We found that meningiomas may have a triad of scintigraphic findings: increased angiographic flow with decreased retention of ^{99m}Tc-HMPAO and discordant increased retention of ^{99m}Tc-MIBI.

CASE REPORT

A 68-yr-old right-handed man was readmitted because of headaches, blurred vision and increasing difficulty walking for more than 6 mo. Two years earlier, he had undergone occipital craniotomy for meningioma resection from the right occipital lobe. Pathology of the resected tumor revealed aggressive meningioma with evidence of several tumor cell islands invading the cortical surface. He suffered from a left homonomous hemianopsia which had been present since the time of surgery. Examination of the calvarium revealed an occipital protuberance, 3–4 cm in size, on the right that was nontender and nonmobile. The patient's gait was slightly wide and broad-based. Due to tumor recurrence, he was referred for nuclear medicine studies.

With the patient in a sitting position, his head against the detector of a gamma camera, a posterior cerebral first-pass flow study with 2 sec/frame was obtained after intravenous injection of 25 mCi ^{99m}Tc-MIBI. The study showed two areas of increased radioactivity in the right cerebral hemisphere (Fig. 1A). One hour after the radiopharmaceutical injection, the patient was placed under a triple-head camera fitted with an ultra-high resolution collimator for acquisition of SPECT data from 120 projections over 360°, with 30 sec/projection. The acquisition time was 22 min. The SPECT images were reconstructed using a Butterworth filter, backprojection and attenuation correction. The SPECT images showed multiple irregular areas of increased uptake in the right occipital, temporal and parasagittal regions (Figs. 1B, C). Technetium-99m-MIBI uptake in the tumor masses was so intense and radioactivity in the skull and choroid plexus appeared to be faint (Fig. 1D). The ratios of the region of the interest (ROI) of the tumor (the highest uptake), the choroid plexus and skull were calculated: on the transaxial section, the tumor-to-skull ratio was 3.4 and 4.2 of the tumor/choroid plexus; on the coronal section, the tumor-to-skull ratio was 2.8 and 3.5 of tumor/choroid plexus. The choroid plexus-to-skull ratio on both the coronal and transaxial sections was 0.8.

Two weeks later, ^{99m}Tc-HMPAO brain studies were performed. Anterior cerebral first-pass flow imaging with 2 sec/frame after injection of 30 mCi ^{99m}Tc-HMPAO shows increased radioactivity in the peripheral right hemisphere, but the high activity gradually faded during the venous phase (Fig. 2A). The SPECT images obtained 1 hr postinjection showed an area of decreased uptake in the right occipital region (Figs. 2B, C). Concurrent contrast CT of the head showed enhanced masses in the right occipital with parasagittal involvement and an occipital skull defect, which occurred as a result of an earlier craniotomy. MRI T-1 weighted images with gadolinium showed areas of hypersignal intensity in the right cerebral hemisphere involving the right occipito-parietal, the right temporal and the parasagittal regions (Fig. 3).

Three months after these imaging studies, the patient was referred for palliative radiotherapy. However, it was then decided that the patient would benefit from debulking surgery followed by postoperative irradiation. As preparation for the surgery, a cerebral angiogram was obtained, which demonstrated vascular supply from the meningeal branches of the right external carotid artery which displayed extensive tumor blush to the right temporo-parietal, the right occipital and parasagittal regions of the brain. The internal

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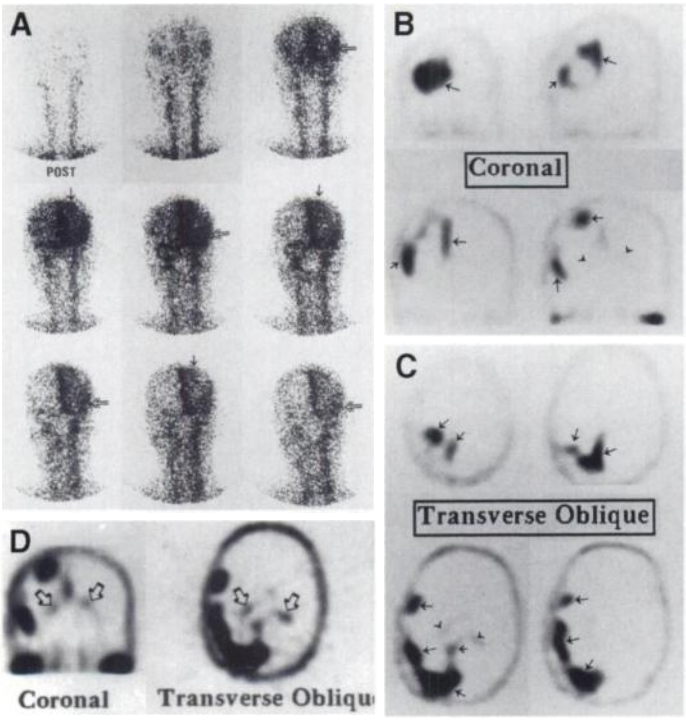

FIGURE 1. Technetium-99m-MIBI SPECT images. (A) Posterior cerebral rapid, sequential flow study shows increased activity in the right cerebral hemisphere in the parietal (arrow) and temporal areas (open arrow) throughout the arterial, capillary and venous phase. (B) Coronal brain images show areas of increased uptake (arrows) in the right occipital, temporal and posterior temporal regions. Intense uptake in the tumors is higher than both choroid plexuses (arrowheads) and peripheral activity of skull/scalp. (C) Transverse brain images show areas of intense uptake in the right occipital and right temporal lobes along the choroid plexus (arrow heads). Areas of intense uptake are higher than the choroid plexus (arrows). (D) Coronal and transaxial images show intensity of the choroid plexus (open arrows) and skull to be less than the tumor uptake.

carotid artery supply was from the right frontal and right temporoparietal lesions from the right middle and anterior cerebral arteries. The third component of blood supply was from the posterior cerebral artery supplying the occipital lesion, which also extends to the left side of the midline. The patient underwent debulking of the

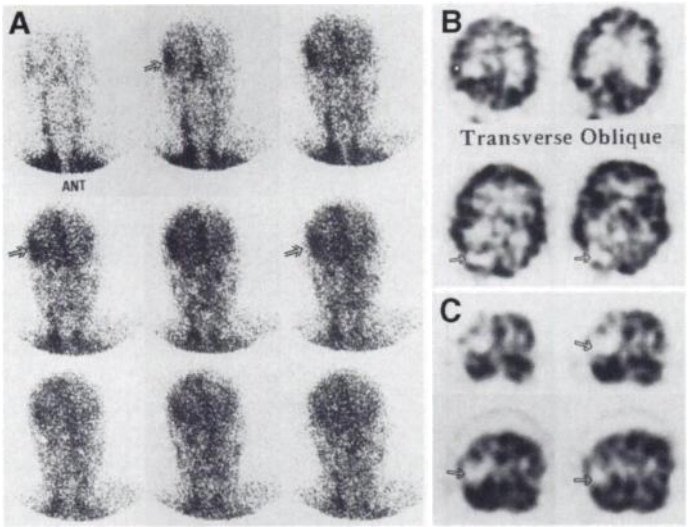

FIGURE 2. Technetium-99m-HMPAO SPECT images. (A) Anterior cerebral rapid, sequential flow study shows increased lateral radioactivity on the right hemisphere (open arrow). Area of radioactivity disappears in the last image. (B) Transverse and oblique images show a "cold" area in the right occipital lobe (open arrow). (C) Coronal images show a large "cold" area in the right occipital lobe.

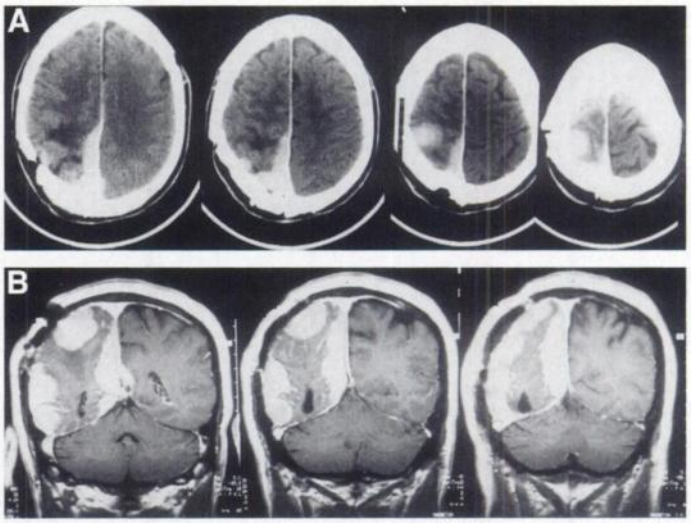

FIGURE 3. (A) Contrast (omnipaque) CT scans show enhanced masses in the right posparietal and right parasagittal region. Occipital skull defect is due to previous craniotomy. (B) Coronal section MR images of the right hemisphere involving the parasagittal, temporal and parietal regions. The skull defect in the parietal area was due to previous craniotomy.

right occipital tumor mass. Microscopically, the tumor was characterized by predominantly syncytial pattern, thus confirming recurrent meningioma. The patient died 6 wk after the debulking surgery.

DISCUSSION

Two separate radionuclide cerebral angiograms showed increased radioactivity in the cerebrum with recurrent meningiomas during the arterial phase. When ^{99m}Tc-MIBI was used as the imaging agent, areas of radioactivity in the involved cerebral hemisphere were increased during the arterial phase and persisted at higher levels throughout the venous phase. When ^{99m}Tc-HMPAO was used, increased radioactivity in the involved hemisphere during the arterial phase faded away on the venous phase. This discrepancy indicates that brain tumor masses did not accumulate and retain ^{99m}Tc-HMPAO even though vascularity of the meningiomas was increased, as evidenced by elevated flow during the arterial phase. Our patient's tumor masses had localized and trapped ^{99m}Tc-MIBI (*8*). The scintigraphic findings of increased uptake in ^{99m}Tc-MIBI brain SPECT and absent uptake in ^{99m}Tc-HMPAO brain SPECT resulted in a mismatch between the ^{99m}Tc-HMPAO and ^{99m}Tc-MIBI SPECT images.

Photopenic or decreased uptake of the recurrent meningioma on ^{99m}Tc-HMPAO brain SPECT may be explained by the contribution of the craniotomy-induced skull defect, a characteristic of the radiopharmaceutical and/or neovascular formation in the meningiomas. Technetium-99m-HMPAO, a lipophilic agent, crosses the intact blood-brain barrier and remains in normal neurons of the brain in proportion to tissue perfusion. Because recurrent tumor replaces normal brain tissue, ^{99m}Tc-HMPAO would not localize in the tumor areas.

Neovascular formation of the tumor accounts for the variable amounts of functioning arteriovenous shunting. An intense tumor vascular blush in our patient's cerebral angiographic findings reflected neovascular formation. Because of the arteriovenous shunting, HMPAO failed to localize in the meningiomas; this is similar to gliomas with poor uptake of HMPAO in tumor sites (*9*).

An additional or alternative explanation of the nonuptake of ^{99m}Tc-HMPAO is that the tumor cells of meningiomas may not

have the functional capacity to localize HMPAO. This hypothesis may relate to the glutathione contents in the tumors (*7*). High glutathione values were found in eight meningiomas with significant ^{99m}Tc-HMPAO uptake; low uptake in two patients with calcified meningiomas who had lower glutathione value was evident (*10*). Whether glutathione in our patient's meningiomas was lower than normal brain tissue and led to absent HMPAO uptake in the tumors is unknown. We do know that our patient's meningiomas were characterized by tumor blush and tumor stain on his angiograms.

Technetium-99m-MIBI, with properties similar to those of ^{201}Tl-chloride, has been used as a tumor imaging agent as well as a myocardial perfusion imaging agent. Although the exact mechanism of tumor uptake of ^{99m}Tc-MIBI is unknown, it has been suggested that MIBI could bind to cytosol in tumor cells. The cationic charge, MIBI's lipophilic property, plasma membrane potentials and cellular mitochondria content may play important roles in tumor uptake (*6,7*). Technetium-99m-MIBI uptake has been described in primary brain tumors (*8,11,12*) and in secondary brain tumors (*13*).

Normal MIBI uptake in the choroid plexus may complicate scan interpretation, especially if a lesion is in a deep-seated or paraventricular location (*11*). However, a tumor in the cerebellum (*13*) or in peripherally located areas would not interfere with scan interpretation, as was the case with our patient. In the future, normal choroid plexus uptake may be used as a comparison to determine the intensity of tumor uptake. Compared with the uptake in a metastatic lesion of the brain from the lung (*13*), the uptake in meningiomas appeared to be much higher in our patient. Cesani et al. (*8*) previously reported a case in which the intensity of meningioma uptake demonstrated significantly higher than normal choroid plexuses and peripheral activity of the scalp/skull. The locations of ^{99m}Tc-MIBI brain SPECT findings of our patient correlated well with the CT and MRI findings. Also, our patient's meningiomas concurred with previously reported characteristics for angiographic (*15,16*), CT (*15,16*) and MRI (*16–19*) findings.

CONCLUSION

The lack of HMPAO uptake in our patient's meningiomas might be explained by a skull defect due to previous craniotomy, replacement of normal brain tissue by tumor and/or functioning arteriovenous shunting due to tumor vascular blush, as demonstrated on cerebral angiograms. The discordant ^{99m}Tc-MIBI and ^{99m}Tc-HMPAO uptake in our patient's recurrent meningioma is of interest, and an extended serial study using these two tracers should be further pursued.

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