Improved Detection of Metastatic Melanoma by T2*-Weighted Imaging


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BACKGROUND AND PURPOSE: The imaging features of metastatic melanomas are distinctive due to the presence of melanin and the propensity for hemorrhage. Both hemorrhage and melanin can produce T1-weighted hyperintensity and T2*-weighted signal intensity loss. We hypothesized that T2*-weighted images would improve detection of metastatic melanoma.

METHODS: The T2* and T1 characteristics of 120 newly detected metastatic brain lesions from 31 patients with malignant melanoma were compared with those of 120 brain metastases from 23 patients with lung cancer.

RESULTS: Melanoma metastases were 5 times more likely to demonstrate prominent T2*-related signal intensity loss (susceptibility effect) than were lung metastases (42% vs 8%; \(P < .01\)), and 4.5 times more likely to demonstrate T1 hyperintensity (55% vs 12%; \(P < .01\)). Patients with melanoma had lesions that were either hypointense on T2*-weighted images, hyperintense on T1 images, or both, in 71% (88/120), compared with 19% (23/120) of lung carcinoma metastases (\(P < .01\)). Melanoma lesions were 16 times more likely than lung cancer lesions to show combined T2* related signal intensity loss and T1 hyperintensity (\(P < .01\)). Remarkably, 8 melanoma lesions (7%) in 3 patients were detectable principally on the T2*-weighted sequences, whereas no lung cancer lesion was detected solely on susceptibility images. We found a direct correlation between melanin content and T1 hyperintensity but no correlation between T2* intensity and melanin.

CONCLUSION: T2*-weighted images improve lesion detection in patients with melanoma metastases, and in conjunction with T1-weighted sequences, can suggest melanoma as the etiology of an intracranial mass. This sequence should be employed for evaluation of possible brain metastasis in patients without a known primary malignancy and in studies for melanoma staging.

Materials and Methods

Patients. The medical records and neuroimaging studies of patients with known malignant melanoma who had newly detected brain metastases were reviewed. Inclusion criteria included the availability of preirradiation T1-weighted MR images with and without gadolinium enhancement and T2*-weighted images. We examined 120 lesions from 31 patients with melanoma. For a comparison group, the imaging findings of 120 lesions from 23 patients with brain metastases from lung carcinoma were reviewed. Very large lesions with extensive necrosis and markedly heterogeneous signal intensity changes were excluded. Approval for this study was obtained from the institutional review board.

Imaging. MR imaging was performed with a 1.5T unit. The MR imaging scans included T2*-weighted gradient-echo (susceptibility; repetition time, 750 milliseconds; effective echo time, 25 milliseconds; flip angle, 20°; number of excitations, 2); T1-weighted (repetition time, 400–625 millisecond; effective echo time, 14–17 milliseconds; number of excitations, 1); T1-weighted with gadolinium (repetition time, 400–625 milliseconds; effective echo time, 14–17 milliseconds; number of excitations 1), and fluid-attenuated inversion recovery (FLAIR; repetition time, 9000 milliseconds; effective echo time, 120 milliseconds; inversion time, 2200 milliseconds; number of excitations, 1) sequences. All sequences were performed with a section thickness of 5 mm with a 1-mm gap.

Data Analysis. Axial T1-weighted images before and following the administration of gadolinium, FLAIR images, and T2*-weighted images were retrospectively reviewed in a nonblinded fashion by 2 neuroradiologists. Lesions were scored as (1) not detectable, mildly conspicuous, or very conspicuous; (2) hypointense, isointense, or hyperintense; (3) contrast enhancing or not contrast enhancing; and (4) with or without vasogenic edema. Lesions that demonstrated heterogeneous signal intensity were judged to be predominately hyperin-
Lesions were identified on other sequences. In one patient, the presence of presumed melanoma demonstrated no edema on FLAIR images, and did not enhance. In one patient, the presence of presumed melanoma brain metastasis would not have been detected without the T2*-weighted sequence. In the other 2 patients, additional lesions were identified on other sequences.

Fifty-five percent (66/120) of melanoma metastases showed conspicuous T1 hyperintensity, compared with 12% (15/120) of lung cancer metastases (P < .01). Thus, T1 hyperintensity was 4.5 times more common in melanoma lesions than in lung carcinoma metastases.

There was variation of T2*-weighted effect and T1 hyperintensity within the lesions of individual patients (that is, lesions in an individual patient exhibited a wide variation in imaging findings). Melanoma metastases were either hypointense on T2*-weighted images, hyperintense on T1-weighted images, or both in 71% (85/120) of melanoma lesions, compared with 19% of lung lesions (P < .01). Combined T1-weighted hyperintensity and T2*-weighted signal intensity loss were present in 26% (31/120) of melanoma lesions but in only 2% of lung lesions (P < .01). Therefore, this combination was 16 times more likely in lesions from melanoma than in lesions from lung cancer.

Additional MR imaging characteristics of the metastatic lesions, including enhancement and presence of edema, are presented in Table 3. Contrast enhancement was less commonly detectable in patients with melanoma than with lung cancer (P = .02).

**Correlation of Melanin Content and Imaging Findings**

Tumors were graded histopathologically as amelanotic (3), slightly melanotic (10), or heavily melanotic (7). The brain metastases of patients whose biopsies showed heavy melanin were more likely to demonstrate T1 hyperintensity than were the metastases in patients with amelanotic or lightly melanotic tumors (P < .01). A similar correlation was not observed for susceptibility effect.

**Discussion**

Our data demonstrate that T2*-weighted signal intensity loss and T1 shortening are both 5 times more common in melanoma metastases than in lung cancer metastases. Three quarters of melanoma metastases had either susceptibility effect or intrinsic T1 hyperintensity, whereas only 25% had both findings, demonstrating that individual metastatic lesions had considerable variation in the findings on these sequences. The combination of T2*-weighted signal intensity loss and T1 hyperintensity in a lesion, however, was 16 times more common with melanoma metastases than with lung cancer metastases. It is important to note that 7% of melanoma lesions were detected principally on T2*-weighted sequences. Finally, we found a direct correlation between melanin content in tumor cells from biopsy tissue and T1 hyperintensity, whereas this finding was not seen with susceptibility effect.

Despite its relative rarity as a systemic neoplasm, melanoma is the third-most-common primary to produce brain metastasis and thus must be considered as the cause of newly
detected brain masses in patients with no known primary. Our findings demonstrate that T2*-weighted and T1 sequences can be used to increase the level of suspicion for melanoma as the source of brain metastases. Contrast-enhanced MR imaging, however, remains the gold standard for the diagnosis of brain metastasis, and biopsy of a brain or extracranial lesion is required to establish a specific histopathologic diagnosis.

The observation that occasional melanoma lesions are detected primarily or solely on T2*-weighted sequence was unexpected. Although other lesions, such as cavernous angioma, hypertensive hemorrhage, or hemorrhagic infarction, would be a possible cause of these isolated T2*-weighted findings, it is more likely that the changes were produced by small melanoma metastases. This finding underlines the value of the T2*-weighted sequence in patients with known melanoma who are undergoing CNS staging.

Two major explanations have been advanced to explain T1 relaxation in melanoma. Melanin itself may lead to T1 shortening. Melanoma metastases have a well-known propensity for hemorrhage, and methemoglobin can also produce T1 shortening. In addition to T1 shortening, melanin and blood products may also produce susceptibility effect on T2* images because of the presence of metal ions including iron, copper, manganese, and zinc.

To test the relationship between melanin content and find-
ings on T2*-weighted and T1 images, we estimated the melanin content of the tumor cells in biopsy material. We found an association between tumors with heavy melanin content and the presence of marked T1 hyperintensity in the brain metastases. This analysis used the biopsy tissue from another site as a surrogate for the melanin content of the brain lesions, and it is known that the melanin content of primary and metastatic lesions within an individual patient’s body can vary. We found, however, that all biopsies from separate sites in 3 patients had the same melanin content, which suggests that marked variation between lesions is not common.

No correlation was found between melanin content and susceptibility effect, which suggests that T1 shortening correlates more closely with melanin content than does the T2*-weighted signal intensity loss. This finding might suggest that other characteristics of the metastasis, such as the metal content of melanin or the presence of hemorrhage, are important in determining susceptibility effect. In vitro analysis will be required to clarify this issue.

In conclusion, T2*-weighted images may improve detection of metastatic melanoma in patients undergoing tumor staging, because some lesions are detectable principally or solely on these images. In addition, T2*-weighted images can be used to suggest melanoma as the etiology of lesions with the appearance of brain metastases.

References