

prediction of the pharmacokinetics of the drug after the intra-arterial administration.

Cluster analysis of the intravenous ^{15}O -water data, the ^{18}F -FU influx data and the ^{18}F -FU trapping data revealed at least two different transport systems of FU. A nonperfusion-dependent transport system was noted in 6 of 24 lesions. The data support the hypothesis that PET double-tracer studies can be used to select lesions showing a nonperfusion-dependent transport system and exclude them from the intra-arterial chemotherapy.

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Bone Marrow Uptake of Thallium-201 Before and After Therapy in Multiple Myeloma

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We describe a patient with multiple myeloma who was found to have diffuse bone marrow uptake of ^{201}Tl . Magnetic resonance (MR) imaging of the lumbar spine demonstrated abnormal low signal intensity on T1-weighted images and abnormal high signal intensity on T2-weighted images. The bone marrow consisted of 68% plasma cells, and the serum immunoglobulin (Ig)G concentration was 7900 mg/dL. After receiving chemotherapy, the percentage of plasma cells and serum IgG concentration declined and there was a decrease in the bone marrow uptake of ^{201}Tl . However, the MR abnormalities in the lumbar spine showed no change after chemotherapy. This patient illustrates a limitation of the use of MR imaging for evaluation of disease state in patients with multiple myeloma, and

demonstrates the potential usefulness of ^{201}Tl imaging in these patients.

Key Words: thallium-201; multiple myeloma; diffuse bone marrow pattern; magnetic resonance imaging; chemotherapy

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One of the major goals of imaging in patients with multiple myeloma is to determine changes in disease state after treatment. Waxman et al. (1) have described the usefulness of ^{67}Ga imaging to identify a subgroup of multiple myeloma patients with rapidly progressive disease who may benefit from alternative therapy such as irradiation. Recently, the myocardial perfusion agents $^{99\text{m}}\text{Tc}$ -sestamibi and $^{99\text{m}}\text{Tc}$ -tetrofosmin have been under investigation for nuclear oncology (2–3). Magnetic resonance (MR) imaging of the spine has recently been shown

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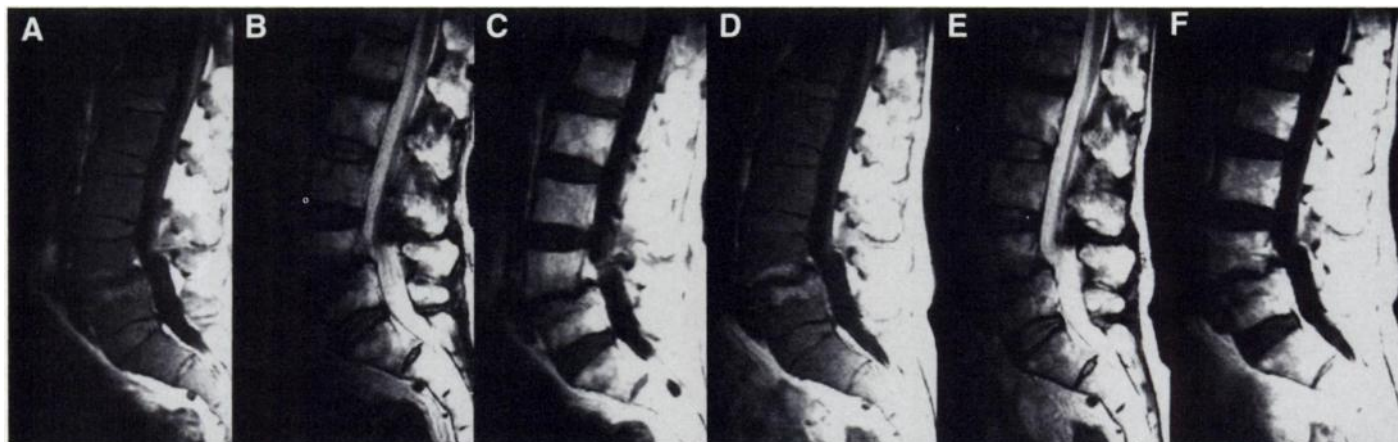


FIGURE 1. A 56-yr-old man with multiple myeloma. MR images of the lumbar spine (T1- and T2-weighted sagittal images, postgadolinium) Before (A,B,C) and after (D,E,F) treatment with chemotherapy. Note that the heterogeneous enhancement seen before treatment shows little change after treatment.

to be an independent predictor of disease progression in multiple myeloma patients (4–6). We describe a patient with multiple myeloma who had diffuse bone marrow uptake of ^{201}Tl , and abnormal signal intensity on MR imaging of the lumbar spine. After chemotherapy, the percentage of plasma cells in bone marrow decreased, and there was a marked decrease in the serum immunoglobulin (Ig)G concentration. The diffuse uptake on ^{201}Tl imaging largely resolved, but there was little change in the MR appearance of the lumbar spine. This patient illustrates the potential usefulness of ^{201}Tl for evaluation of multiple myeloma patients, which may reflect the clinical state better than MR imaging.

CASE REPORT

A 56-yr-old man with the signs of anemia was admitted to Kurume University Medical Center. On thin layer chromatography, the diagnosis of multiple myeloma (IgG; κ type) was confirmed. The percentage of plasma cells in the bone marrow was 68% (normal range, <3%) and the serum IgG concentration was 7900 mg/dL (normal range, 850–1800 mg/dL). This patient underwent two cycles of a chemotherapy protocol combining vincristine, melphalan, predonisone, ranimustine and interferon- α . After receiving chemotherapy, the patient's plasma cell percentage decreased to 2.8% and the serum IgG concentration decreased to 2680 mg/dL. No abnormalities were seen on a bone scan using $^{99\text{m}}\text{Tc}$ -MDP. A radiograph of the skull revealed no osteolytic lesions typical of myeloma. MR images of the lumbar spine were acquired on a machine with a superconducting magnet operating at 0.5 T (Magnex 50HP Shimadzu Co., Kyoto, Japan) using a spine coil. Imaging parameters were as follows: conventional spin-echo sequences (repetition time millisecond/echo time millisecond 400–600/15–20) for T1-weighted images, (2000–3000/90–120) for T2-weighted images and (2000–3000/20) for proton-density images; 5-mm section thickness without interslice gap; 256×256 acquisition matrix. Also, a short time inversion recovery (STIR) (TR/TE 1500/100/22) was applied to acquire images with fat suppression. Gradient echo sequences were not used. MR images of the lumbar spine showed low signal intensity on T1-weighted images, high signal intensity on T2-weighted images and heterogeneous enhancement on T1-weighted images after intravenous injection of gadolinium but there was no change on repeat imaging 1 wk after chemotherapy (Fig. 1). Subsequently, the patient was injected with ^{201}Tl (148 MBq) and underwent whole-body imaging 20 min after radiotracer injection. Whole-body images were acquired using a large field-of-view, dual detector camera equipped with a low-energy, high-resolution, parallel-hole collimator and interfaced to a computer system. Energy discrimination was

provided by a 15% window centered on the 68 keV photopeak of ^{201}Tl . Data acquisition lasted 12 min, during which approximately 800,000 counts were collected. Early ^{201}Tl images were used for evaluation as described by Tsubuku (7). Before chemotherapy, ^{201}Tl scintigraphy demonstrated diffuse bone marrow uptake of radiotracer that largely resolved after chemotherapy (Fig. 2). Thallium-201 scintigraphy was performed within 3 days after MR imaging.

Two observers, blinded to the patient's clinical status and to the results of other imaging studies, evaluated either the MR images or ^{201}Tl images for the presence of abnormal findings. Evaluation of the MR images or ^{201}Tl images was done by a consensus.

Informed consent for participation in this study was obtained from the patient as part of the protocol approved by the Institutional Clinical Subpanel on Human Studies at the Kurume University School of Medicine.

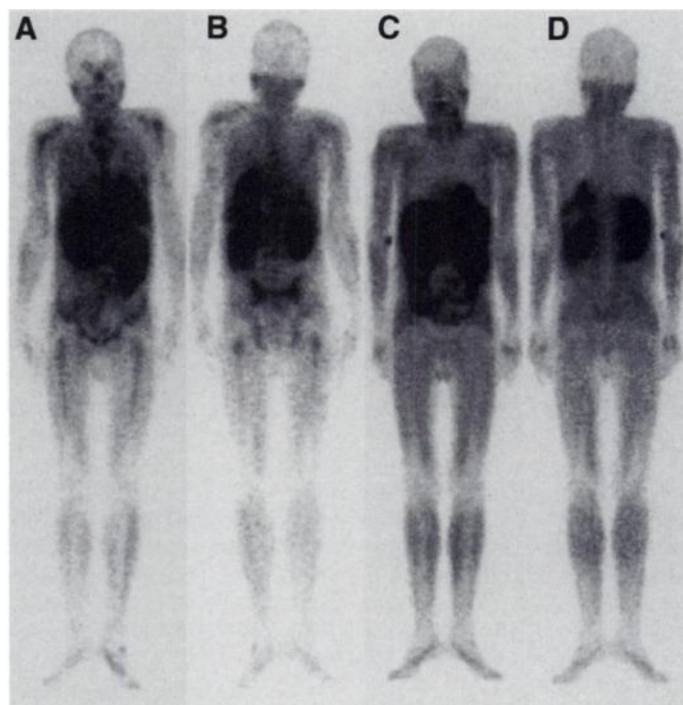


FIGURE 2. Thallium-201 whole-body imaging. Before (A,B) and after (C,D) treatment with chemotherapy. Note that there is a marked decrease in the diffuse bone marrow uptake of radiotracer after treatment, which correlates with the percentage of plasma cells in the patient's bone marrow, and with the serum IgG concentration. (A,C) Anterior whole-body image. (B,D) Posterior whole-body image.

DISCUSSION

This patient confirms the recent report concerning diffuse bone marrow uptake of ^{201}Tl in multiple myeloma patients and that the uptake reflects the viability of myeloma cells (7). Tsubuku (7) advocated the use of early ^{201}Tl images to evaluate the disease state in multiple myeloma patients.

MR imaging in multiple myeloma patients has recently been the subject of debate. Ludwig et al. (8) reported that MR imaging detected myelomatous involvement of vertebral bodies significantly more often than was suspected from plain radiography. Also, they concluded that MR imaging can indicate when early local and/or systemic treatment is needed to prevent the collapse of vertebral bodies or even paraplegia in multiple myeloma patients. Daffner et al. (9) reported that MR imaging reveals typical neoplastic bone lesions on T1-weighted images as areas of reduced signal intensity in comparison with that of adjacent normal bone marrow. van de Berg et al. (4) described that MR imaging of the bone marrow in patients with Stage I multiple myeloma is an independent factor in the prediction of disease progression. Rahmouni et al. (10) have shown that the MR appearance of spinal myeloma changes after treatment and contrast-enhanced images in particular may be useful to monitor the response to treatment. Further, they described that the main MR characteristic of a therapeutic response was a lack of enhancement of the lesion on MR images obtained after administration of contrast material. Mouloupoulos et al. (11) reported that conversion from a diffuse to a variegated or focal pattern, and a decrease in the amount of marrow abnormality with persistent enhancement, were observed in patients who showed a partial response, and that diffuse enhancement was associated with more advanced disease. Our patient's MR images showed little change after chemotherapy. The low signal intensity on T1-weighted images may represent an absence of fatty replacement or a generalized decrease in signal intensity, and there may be no correlation between findings on T1-weighted images and laboratory or bone marrow findings; however, findings on T2-weighted images correlated to the bone marrow findings before chemotherapy (12). Moreover, the appearance of the marrow is dependent not only on the extent of disease but also on the extent of fatty replacement (12). Our patient illustrates a potential pitfall in using MR imaging to evaluate multiple myeloma patients.

This patient also reminds us that ^{201}Tl remains a cost-effective and useful mainstay for nuclear oncology imaging, and may reflect the degree of cell proliferation.

Clinical assessment of the response to therapy remains a major problem in the follow-up of multiple myeloma patients. Thallium-201 imaging may be involved in evaluating both the extent of disease and the impact of therapy because early ^{201}Tl whole-body imaging has been shown to be correlated with the therapeutic effect. Tsubuku (7) reported that the early ^{201}Tl whole-body images are more useful than delayed images in multiple myeloma patients, and he demonstrated that ^{201}Tl could also be used to assess multiple myeloma relapse.

CONCLUSION

Thallium-201 whole-body imaging may be a useful addition to the noninvasive techniques available to assess the therapeutic effect of chemotherapy in patients with multiple myeloma.

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