REFERENCES

1. Bénard F, Lefebvre B, Beuvon F, Langlois M-F, Bisson G. Rapid washout of technetium-99m-MIBI from a large parathyroid adenoma. *J Nucl Med* 1995;36:241–243.
2. Taillefer R, Boucher Y, Potvin C, Lambert R. Detection and localization of parathyroid adenomas in patients with hyperparathyroidism using a single radionuclide imaging procedure with technetium-99m-sestamibi (double-phase study). *J Nucl Med* 1992;33:1801–1807.
3. Chiu ML, Kronauge JF, Piwnica-Worms D. Effect of mitochondrial and plasma membrane potentials on accumulation of hexakis (2-methoxyisobutylisonitrile) technetium (I) in cultured mouse fibroblasts. *J Nucl Med* 1990; 31:1646–1653.
4. Crane P, Laliberté R, Hemingway S, Thoolen M, Orlandi C. Effect of mitochondrial viability and metabolism on technetium-99m-sestamibi myocardial retention. *Eur J Nucl Med* 1993;20:20–25.
5. Sandrock D, Merino MJ, Norton JA, Neumann RD. Ultrastructural histology correlates with results of thallium-201/technetium-99m parathyroid substraction scintigraphy. *J Nucl Med* 1993;34:24–29.

François Bénard
Guy Bisson
Bernard Lefebvre
University of Sherbrooke Central Hospital
Sherbrooke, Quebec, Canada

TO THE EDITOR: In a recent *JNM* Newsline article entitled "Scintimammography: Magic Bullet or False Promise" by Deborah Kotz (*J Nucl Med* 1995;36:15N–20N), Dr. Khalkhali from the UCLA School of Medicine in Los Angeles is quoted as saying that the radiation dose to the patient from this procedure " . . . was equal to the amount of radiation a person gets when he/she flies round-trip from New York to Los Angeles." I believe it important to point out that this statement is inaccurate. The total body absorbed dose from an injection of 740 MBq (20 mCi) of ^{99m}Tc-sestamibi used in scintimammography is approximately 3.3 mGy (330 mrad) (*1*). The effective dose rate from background radiation at an altitude of 10 km (33,000 ft.) is 5 μSv/hr (0.5 mrem/hr) (*2*). Since the body is uniformly irradiated, this dose is equivalent to an absorbed dose rate of 5 μGy/hr (0.5 mrad/hr). For a 5-hr commercial airline flight across the United States, the total absorbed dose is thus 25 μGy, or 50 μGy (5 mrad) round-trip. This is a factor of some 66 times lower than the sestimibi absorbed dose.

The situation, however, is actually worse than this. A proper comparison of radiation risk requires comparisons of effective dose (*3,4*) which take into account the differing tissue sensitivities to radiation, and not absorbed dose, which measures only energy deposition per unit mass of tissue and does not include biological factors. Using the appropriate tissue weighting factors (*3,4*) and the absorbed doses from ^{99m}Tc-sestamibi to individual organs (*1*), the administration of 20 mCi of sestimibi results in an effective dose of 570 mrem to women (410 mrem for men), as determined from data presented in Table 4 of the Cardiolite kit. Thus, the ratio of increased radiation risk for scintimammography versus a round trip airline flight coast to coast is closer to 114:1.

REFERENCES

1. Radiopharmaceutical Internal Dose Information Center, July, 1990, Oak Ridge Associated Universities, Oak Ridge, TN. In: Table 4 of Du Pont Pharma's (Du Pont Radiopharmaceutical Division, The Du Pont Merck Pharmaceutical Co., Billerica, MA) Cardiolite Tc-99m Sestamibi preparation kit, March 1994.
2. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1977. In: *Sources and effects of ionizing radiation report A/32/40*. Thirty Second Session, Supplement No. 40. New York: United Nations.
3. ICRP Publication 60. 1990 Recommendations of the International Commission on Radiological Protection. *Annals of the ICRP* 1990;21:85–86.
4. NCRP Report No. 116. Limitation to exposure from ionizing radiation. NCRP; 1993.

Richard H. Behrman
New England Medical Center
Tufts University School of Medicine
Boston, Massachusetts

REPLY: We wish to acknowledge the dosimetry comparison error pointed out by Dr. Behrman; the total body absorbed dose from 740 MBq (20 mCi) ^{99m}Tc-sestamibi is indeed about 3.3 mSv (330 mrem) and a cross-country round trip air flight is about 0.05 mSv (5 mrem). The effective dose cited in ICRP no. 62 (*1*) is 5.5 mSv (555 mrem) for exercising adults and 6.20 mSv (629 mrem) for resting adults, which is even higher than Dr. Behrman has calculated.

However, the fact that we have an absorbed dose factor of about 125 between the two sources does not mean that we have a risk factor difference of 125. It is entirely possible, and at this point probable, that chronic absorbed doses of radiation at these low levels engender no risk at all. Indeed, the radiopharmaceutical dose could more easily be regarded as hormetic than hazardous. There are no valid epidemiologic data documenting harm at these low absorbed doses.

The linear, no-threshold hypothesis may have been appropriately conservative in the early decades of our study of the biological effects of ionizing radiation, when a limited amount was known. When a lot of smart people spend much money and a hundred years looking for harm without finding any, it probably is not there. When they occasionally find examples for which low doses exert beneficial effects, after a few decades, it is certainly time to stop hypothesizing the "healthy worker effect," "biological subgroup differences," "confounding variables," or "insufficient sample size" and state the most sensible scientific conclusion: Low doses of ionizing radiation do not appear to have deleterious effects and appear, on occasion, to be beneficial.

The recent work published in *Science* on the DNA repair enzyme system(*2–7*) provides ample evidence for repair of damage from low levels of a variety of environmentally encountered hazardous agents, of which oxygen is perhaps the most hazardous of all. In addition, stimulation of such repair systems by one agent could protect against other hazardous agents and could quite simply account for hormetic effects.

It is time for us to get away from the tired old guard, the antinuclear terrorists, the environmental lawyers and uneducable regulators, and switch paradigms at long last. Try reading Rosalyn Yalow (*8*), Bernard Cohen (*9*) and Zbigniew Jaworowski (*10*). Delve into T.D. Luckey's 1991 textbook *Radiation Hormesis* with over 1000 references(*11*). We think it most probable that the emperor has no clothes.

Iraj Khalkhali
Carol S. Marcus
Harbor-UCLA Medical Center,
Torrance, California

REFERENCES

1. ICRP no. 62. Radiological protection in biomedical research. Oxford, UK: Pergammon Press; 1993.

2. Marx J. DNA repair comes into its own. *Science* 1994;266:728–730.
3. Koshland Jr DE. Molecule of the year: the DNA repair enzyme. *Science* 1994;266:1925.
4. Culotta E, Koshland Jr DE. DNA repair works its way to the top. *Science* 1994;266:1926–1929.
5. Sancar A. Mechanism of DNA excision repair. *Science* 1994;266:1954–1956.
6. Hanawalt PD. Transcription-coupled repair and human disease. *Science* 1994;266:1957–1958.
7. Modrich P. Mismatch repair, genetic stability and cancer. *Science* 1994;266:1959–1960.
8. Yalow RS. Concerns with low-level ionizing radiation. *Mayo Clin Proc* 1994;69:436–440.
9. Cohen BL. Test of the linear-no threshold theory of radiation carcinogenesis for inhaled radon decay products. *Health Phys* 1995;68:157–174.
10. Zaworowski Z. Hormesis: the beneficial effects of radiation. *21st Century Science and technology* 1994;7:22–27.
11. Luckey TD. *Radiation hormesis*. Boca Raton, FL: CRC Press; 1991.

Disseminated Bone Marrow Metastases from Primary Breast Cancer: Detection and Follow-up by Radioimmune Bone Marrow Scintigraphy

TO THE EDITOR: We read with interest the article of Rieker et al. (*1*) concerning the use of radioimmune bone marrow scintigraphy in patients with disseminated bone marrow metastasis. Indeed, radioimmune bone marrow scintigraphy is extremely useful to exclude bone marrow metastasis, especially in patients with an equivocal bone scan showing features of metabolic bone disease or of a "sub"-superscan as described by Podoloff and Kim (*2*). We want to make three comments based upon our experience of 92 radioimmune bone marrow scintigrams performed in 58 patients.

1. Radioimmune bone marrow scintigraphy as follow-up parameter should be used cautiously. In one patient who had hormonally treated adenocarcinoma of the prostate, the initial bone marrow scintigram demonstrated almost complete destruction of the hematopoietic marrow (Fig. 1), as described in the case report of Rieker et al., whereas bone scintigraphy was not suggestive of disseminated bone metastasis. During follow-up, however, the patient developed spinal cord compression originating from vertebral body of T6-7, which was confirmed on MRI. Although bone scintigraphy would have demonstrated the metastatic lesion, bone marrow scintigraphy would certainly have missed this metastatic extension in the completely destructed bone marrow. Each of these modalities (radioimmune bone marrow scintigraphy, bone scintigraphy and MRI) provide specific physiological or anatomical information unique to that method. These modalities are complementary and, depending on the clinical context, one should choose the most relevant imaging technique.

   Therefore, we do not agree with Rieker et al. that bone marrow immunoscintigraphy can replace bone scintigraphy and MRI in follow-up.
2. Rieker et al. suggest that the increased uptake in the liver and spleen seen in the follow-up study could be due to a HAMA reaction (*1*). Our previous experience as well as that of Joseph et al. (*3*) found that a HAMA reaction is encountered in 10% of patients having repeated injections of the monoclonal antibody BW 250/183. In these patients, radioimmune bone marrow scintigraphy can still evaluate tumors, except in the thoraco-lumbar spine (T8-L1), which is obscured by activity from the liver and spleen. In their article, however, Rieker et al. stated that HAMA in the serum was slightly elevated (*1*). In addition, tracer uptake in liver and spleen is limited and is comparable with uptake seen on the initial radioimmune bone marrow scintigram of the patient previously mentioned (Fig. 1). Rieker et al. should still consider extramedullary hematopoiesis as a possible explanation for increased liver and spleen accumulation.
3. Finally, the suggestion that bone marrow immunoscintigraphy may be used to monitor therapeutic response should certainly be validated in a larger patient group and be compared with less expensive and more readily available techniques.

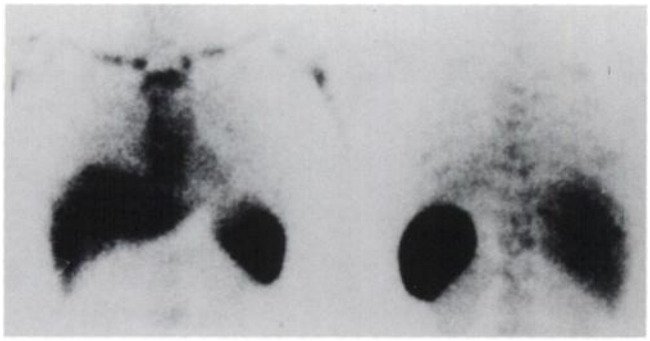

FIGURE 1. Initial bone marrow scintigram obtained 3 hr postinjection of ^{99m}Tc-labeled BW 250/183 demonstrates minimal tracer uptake in the axial skeleton, reflecting the destruction of the hematopoietic tissue, peripheral marrow expansion in the upper arms and increased liver and spleen uptake, probably due to extramedullary hematopoiesis, which does not obscure the thoraco-lumbar spine.

REFERENCES

1. Rieker O, Grünwald F, Layer G, et al. Disseminated bone marrow metastases from primary breast cancer: detection and follow-up by radioimmune bone marrow scintigraphy. *J Nucl Med* 1994;35:1485–1487.
2. Podoloff DA, Kim EE. "Sub"-superscan—manifestation of bone marrow metastases. *Clin Nucl Med* 1989;14:597–602.
3. Joseph K, Höffken H, Bosslet K, Schorlemmer HU. In vivo labeling of granulocytes with ^{99m}Tc anti-NCA monoclonal antibodies for imaging inflammation. *Eur J Nucl Med* 1988;14:367–373.

Jan Roland
Jean Servais
Pierre Scalliet
Johan Vandevivere
Middleheim General Hospital
Antwerp, Belgium

Boudewijn Brans
UZA
Antwerp, Belgium

REPLY: We appreciate the comments of Roland et al., who report another example of a false-negative bone scan and a true-positive radioimmune bone marrow scan due to disseminated bone marrow metastases. We agree with Roland et al. that radioimmune bone marrow scintigraphy should not generally replace bone scintigraphy in patients with suspected bone metastases. Our case (*1*) was taken from an unpublished prospective study that compared the accuracy of bone scintigraphy, radioimmune