data sets? What was the average effective half-life? For those patients who showed evidence of slow uptake, would the effective half-life and calculated absorbed dose be much lower if only the 48- and 72-hr points were joined by a straight line and an adjustment was made for the amount the 24-hr data point was below the extrapolated line? Would measurements during therapy produce values only 66% or less of their current values using their technique?

Our results indicate that absorbed doses lower than those calculated by Maxon et al. correlate with response. Refinements in their current protocol for predicting absorbed dose or measurements during therapy might eliminate the discrepancy. On the other hand, one could argue that a systematic error in our volume estimates caused the difference. It is also possible their current protocol produces a value for absorbed dose which works well enough as an index for handling thyroid cancer patients, or changes in their protocol might indeed lower any upward bias but, unfortunately, increase the variance of the calculated absorbed dose and thus be of questionable value. Our protocol was consistent in using the same pixels to estimate volume and uptake; this fact should have prevented propagation of error in the calculated dose. Overall, further research appears to be needed.

REFERENCES

1. Maxon III HR, Englaro EE, Thomas SR, et al. Radioiodine-131 therapy for well-differentiated thyroid cancer—a quantitative radiation dosimetric approach: outcome and validation in 85 patients. *J Nucl Med* 1992;33: 1132–1136.
2. Koral KF, Adler RS, Carey JE, Beierwaltes WH. Iodine-131 treatment of thyroid cancer: absorbed dose calculated from post-therapy scans. *J Nucl Med* 1986;27:1207–1211.
3. Adler RS, Koral KF, Carey JE, Kline RC, Beierwates WH. Two-orthogonal-view method for quantification of rad dose to neck lesions in thyroid cancer therapy patients. *Med Phys* 1982;9:497–505.

Kenneth F. Koral
Ronald S. Adler
University of Michigan Medical Center
Ann Arbor, Michigan

REPLY: The paper (*1*) to which Drs. Koral and Adler refer is a clinical report that prospectively evaluated outcome when patients with thyroid cancer were treated on the basis of radiation absorbed doses calculated from diagnostic radioiodine studies using methods that we have described previously (*2,3*). The point was to validate the clinical utility of treatment thresholds derived from our initial studies (*4*) in a second, separate group of patients. The article is not about methodologies of quantitative dosimetry but rather deals with the clinical utility of quantitative dosimetry, using our methods, as a basis for therapy decisions.

Koral and Adler refer to one subgroup of our study population that consisted of 23 patients who had a total of 78 nodal metastases: 16 of 23 had nodal metastases as well as residual thyroid tissue and/or other metastases and 7 of the 23 had nodal metastases only. When all 23 patients were considered as a group, 74% of the patients and 81% of their nodal metastases responded to initial radioiodine therapy with complete resolution of the nodal metastases as judged by physical examination and visual interpretation of subsequent images. When we looked at the small subgroup of seven patients who had only nodal metastases then, at an average radiation dose of 14,000 rad, 86% of patients were treated successfully. This study was designed to evaluate the efficacy of using thresholds of 30,000 rad to ablate thyroid remnants and of 8500 rad for nodal metastases, and therefore none of the patients in this study were treated with lower doses.

In 1983 (*4*) we had demonstrated that, when doses of 8000 rad or more could be delivered to metastatic foci, then significantly more lesions responded to treatment than at lower doses between 3500 and 8000 rad (98% versus 63%, $p < 0.001$). None of the metastases in our original series responded to doses of less than 3500 rad. Kimmig and Hermann (*5*) also reported that three of four patients with metastatic foci receiving greater than 10,000 rad responded to treatment, whereas 0/7 who received less than 4000 rad to their metastases did so. Flower and colleagues (*6*) subsequently noted that only two of eight patients with nodal metastases appeared to respond to radiation doses less than 3000–4000 rad. Thus, while it is clear that there are occasional patients who will respond to lower radiation doses, the percentages that do so are quite small and are unacceptable clinically.

The comments offered by Koral and Adler are concerned mainly with techniques of dosimetry and are largely based on their earlier report of immediate post-^{131}I therapy studies (*7*), using a different methodology, in nine nodal metastases in four patients who responded to ^{131}I therapy. In that paper, one of three lymph node metastases quantitated in one patient showed a radiation dose that was "≥2400 rad" (upper limit of calculation not specified), whereas all of the other eight nodal metastases in the four patients received essentially 3500 rad or more, and five of the eight received more than 8000 rad. Thus, their findings are not inconsistent with our earlier observations (*4*).

With respect to some of their other questions, a single exponential curve fit the data in our patients quite well, and only one of our patients with nodal metastases demonstrated a delayed peak uptake at 48 hr. The range of effective half-lives of ^{131}I in the patients in question was 26-160 hr, underscoring the need for individualized quantitative dosimetry in each patient. We did not perform quantitative calculations after the actual therapeutic administrations since that would have increased patient morbidity by prolonging the period of time that the patients were required to maintain both a hypothyroid state and a low iodine, protein- and calorie-deficient diet.

Clearly, there are uncertainties in any dosimetric method employed, and I wish to iterate that our results are based on the conjugate view techniques developed here at the University of Cincinnati. In that regard, I am grateful for an opportunity to correct a misstatement in our most recent paper (*1*) that occurred on the last line of the last paragraph in the section on diagnostic ^{131}I scans on page 1133. I inadvertently included a description from another paper that I was writing at the same time on quantitative blood dosimetry and stated that "The effective half-time of ^{131}I in lesions was based on an exponential fit of those same uptake data, assuming only physical decay beyond 72 hr." In our quantitative dosimetric approach to the ablation of thyroid remnants and to the treatment of metastases, the effective half-time is based on an exponential fit of the uptake data only, and we do *not* assume physical decay beyond 72 hr. The methods remain those described by us earlier.

In summary, the quantitative dosimetric approach that we have developed does permit rational clinical decisions with pre-

dictable, clinically acceptable results. The data are quite consistent with those reported in other, more limited studies. Clearly methodologic differences may exist between centers, and if people do not follow our protocol, then they may need to establish their own thresholds, both dosimetric and clinical, for acceptable responses. I appreciate the continued interest of Drs. Koral and Adler in our work.

REFERENCES

1. Maxon HR, Englaro EE, Thomas SR, et al. Radioiodine-131 therapy for well differentiated thyroid cancer—A quantitative radiation dosimetric approach: outcome and validation in 85 patients. *J Nucl Med* 1992;33: 1132.
2. Thomas SR, Maxon HR, Kereiakes JG. In vivo quantitation of lesion radioactivity using external counting methods. *Med Phys* 1976;3:253.
3. Thomas SR, Maxon HR, Kereiakes JG, Saenger EL. Quantitative external counting techniques enabling improved diagnostic and therapeutic decisions in patients with well-differentiated thyroid cancer. *Radiology* 1977;122:731.
4. Maxon HR, Thomas SR, Hertzberg VS, et al. Relation between effective radiation dose and outcome of radioiodine therapy for thyroid cancer. *New Engl J Med* 1983;309:937.
5. Kimmig B, Hermann HJ. Measurement of dose during radioiodine treatment of thyroid cancer. *Acta Endocrinol* 1983;252(suppl):72.
6. Flower MA, Schlesinger T, Hinton PJ, et al. Radiation dose assessment in radioiodine therapy. 2. Practical implementation using quantitative scanning and PET, with initial results on thyroid carcinoma. *Radiother Oncol* 1989;15:345.
7. Koral KF, Adler RS, Carey JE, Beierwaltes WH. Iodine-131 treatment of thyroid cancer: absorbed dose calculated from post-therapy scans. *J Nucl Med* 1986;27:1207.

Harry R. Maxon III
University of Cincinnati Medical Center
Cincinnati, Ohio