should be localized in two planes by performing anterior and the relevant lateral views. In some cases, an oblique view may also be necessary. These precautions will ensure that the lesion is correctly sited within the gland. Second, it is absolutely necessary to adhere to strict criteria in the interpretation of lesions detected by ultrasonic scanning. A cystic lesion should be sonolucent with posterior echo enhancement. The authors correctly used ultrasound at varying levels of attenuation, and indeed this is necessary in confirming the presence of a cyst, since some solid lesions—and in particular malignant lesions—may have sparse echoes of reduced intensity (*3*).

We have used radionuclide scanning and gray-scale echography for the past 4 years as complementary procedures in the investigation of solitary thyroid nodules. During this time we have found this combination of procedures ideal in the preoperative assessment of such lesions, and of greater value than the combination of cesium and technetium scanning, in determining the necessity for surgery (*2*).

We thoroughly endorse the authors' approach to the assessment of thyroid nodules, but would warn that errors of interpretation may be made, unless the above precautions are taken.

ERNEST F. CROCKER
ANDREW F. McLAUGHLIN
GEORGE J. BAUTOVICH
Royal Prince Alfred Hospital
N. S. W., Australia
ROGER F. UREN
American Hospital of Paris
Paris, France

REFERENCES

1. SANDERS AD, SANDERS RC: The complementary use of B-scan ultrasound and radionuclide imaging techniques. *J Nucl Med* 18: 205–220, 1977

2. CROCKER EF, McLAUGHLIN AF, UREN RF, et al: Comparison of caesium scintiscanning with grey scale echography in the investigation of solitary, nonfunctioning thyroid nodules. In *Ultrasonics in Medicine*, Kazner E, ed, Amsterdam, Excerpta Medica, 1975, pp 207–212

3. CROCKER EF, McLAUGHLIN AF, KOSSOFF G, et al: The gray scale echographic appearance of thyroid malignancy. *J Clin Ultrasound* 2: 305–306, 1974

Reply

Review of the original sonogram shows that the lesion in the right lobe of the thyroid is partially echo-free and partially echo-filled; it was correctly reported at the time. The purpose of the figure in our article was to show how, by varying the power output, it is possible to differentiate between a cystic and a solid homogeneous mass within the thyroid. We regret that the labeling on the figure was misleading. Both the area anterior to the solid homogeneous mass and the labeled echo-free area are involved in the neoplastic process.

ROGER C. SANDERS, M.D.
Johns Hopkins University
Baltimore, Maryland

Method to Calculate Activity of a Source from Counting Rates in Single and Coincidence Photopeaks

In 1963 Harper et al. (*1*) published a special γ-spectrometric method to measure the activity of a source. The formula underlying their method reads (in our notation):

$$D = \frac{\eta_1 \times \eta_2}{[\eta_1 + \eta_2]^2} \cdot \frac{[N_1 + N_2 + 2N_{sum}]^2}{N_{sum}}, \qquad (1)$$

where D is the activity (dps) of a source emitting photons γ_1 and γ_2 with abundances η_1 and η_2 at energies E_1 and E_2; N_1 and N_2 are the counting rates in the observed photopeaks at E_1 and E_2 (e.g., produced by a Na(Tl) scintillation spectrometer); and N_{sum} is the counting rate in the coincidence peak at the apparent energy $E = E_1 + E_2$. The special merit of their method is that the true abundances are not required, but only their ratio η_1/η_2, which is less difficult to estimate. Moreover, a relatively large error in this ratio has only a small effect on the result, D, as can easily be verified. Equation (1) is not correct, however, and should be replaced by:

$$D = \frac{g}{G} \cdot \frac{\eta_{12}}{[\eta_1 + \eta_2]^2} \cdot \frac{[N_1 + N_2 + 2N_{sum}]^2}{N_{sum}}, \qquad (2)$$

where η_{12} is the abundance of correlated photons, γ_1 and γ_2, cascaded in pairs. The factor g takes into account the angular correlation between the photons γ_1 and γ_2 (*2*). If there is no angular correlation, g will simply be equal to G, the geometrical efficiency. The result, D, is then independent of the geometry! It will be clear that the advantages of the method no longer exist in its correct version.

The fundamental error—the use of $\eta_1 \times \eta_2$ instead of η_{12}—seems to be caused by confusion of two different types of "sumpeak:"

$$N_{sum} = D \cdot G \cdot g \cdot \eta_{12}, \qquad (a)$$

which is valid when photons γ_1 and γ_2 are emitted in cascade (*3*); and

$$N_{acc.\ sum} = D^2 \cdot G^2 \cdot \eta_1 \times \eta_2 \cdot 2\tau, \qquad (b)$$

which describes the counting rate in the sumpeak due to accidental coincidences ("accidentals") between uncorrelated photons γ_1 and γ_2 (*4*). τ is the resolving time of the detection system.

We have tacitly assumed for both cases the absence of attenuation between source and detector, and a 100% photoelectric detection efficiency for γ_1 and γ_2.

We find the incorrect equation (1) also applied in References *5–8*.

We note three restrictions for the validity of equation (2)—equally necessary if equation (1) had been correct.

1. No attenuation between source and detector.
2. 100% photoelectric absorption of γ_1 and γ_2 in the detector.
3. The incident rate of photons must be sufficiently low to make "accidentals" negligible.

The first and second imply no coincidences between a photon γ_1 and a Compton-scattered γ_2, and vice versa.

If the foregoing three restrictions are met, we have for the single peaks observed:

$$N_1 = D \cdot G \cdot (\eta_1 - g \cdot \eta_{12}), \qquad (3)$$

and

$$N_2 = D \cdot G \cdot (\eta_2 - g \cdot \eta_{12}), \quad (4)$$

these being the single-energy peaks corrected for counts lost in their sumpeak [Eqn (a)]. Equations (3), (4), and (a) then yield Eqn (2).

K. J. VAN DAMME
Institute for Radiopathology and Radiation Protection
Leiden, The Netherlands

REFERENCES

1. HARPER PV, SIEMENS WD, LATHROP KA, et al: Production and use of iodine-125. *J Nucl Med* 4: 277–281, 1963

2. VAN DAMME KJ: A disregarded geometrical effect on an elegant method to measure the activity of a radio-isotope emitting two γ-rays in cascade. *Int J Appl Radiat Isot* 28: 675, 1977

3. BRINKMAN GA, ATEN AHW JR, VEENBOER JTH: Absolute standardization with a NaI(Tl) crystal—I. *Int J Appl Radiat Isot* 14: 153–157, 1963

4. POLIC EF: Liquid scintillation counting equipment. In *Instrumentation in Nuclear Medicine*, vol 1, Hine GJ, ed. New York, Academic Press, 1967, p 236

5. ELDRIDGE JS, CROWTHER P: Absolute determination of I^{125}. *Nucleonics* 22: 56–59, 1964

6. BORDELL FL, SAYEG JA, WALD N: In vivo measured effective half-life of ^{125}I in human thyroids. *Phys Med Biol* 17, No. 3: 365–373, 1972

7. ACKERS JG: Routine thyroid monitoring in ^{125}I-production workers, Paper H6. Amsterdam, Third European Congress of the International Radiation Protection Association, May 1975

8. BRINKMAN GA, LINDNER L, VEENBOER JTH: Sumpeak calibration of ^{125}I. *Int J Appl Radiat Isot* 28: 271–275, 1977

Reply

The calculation of the activity of an I-125 source (*1*) from measurements of the pulse-height spectrum—in particular using the sum peak—was carried out using the classical coincidence-counting approach (*2*), since all observed photons are included in the photopeak and sum peak. The counting rates used were sufficiently low that random coincidences were negligible.

Let us consider $N_1 = A\epsilon_1$ (a), and $N_2 = A\epsilon_2$ (b), where A is activity, ϵ_1 and ϵ_2 are the probabilities of detecting an event following a disintegration, N_1 is the counting rate for one component of a coincident pair, and N_2 is the rate for the other. Let N_{12} be the coincidence rate. When the detection of two such coincident events is otherwise uncorrelated, the probability of detecting them in coincidence is the product of the individual detection probabilities. Thus, $N_{12} = A\epsilon_1\epsilon_2$ (c). Combining expressions (a), (b), and (c), $A = N_1N_2/N_{12}$ (d).

In the case of iodine-125, emission of the coincident photons is assumed to be isotropic without angular correlation, since the K-capture branch results completely from deexcitation of the atom, rather than directly from nuclear processes. Similarly, the events associated with the coincident decay from the 35-keV level ($T_{1/2} = 1.6$ ns), which follow the K capture, result in emissions that are 90.7% K fluorescent photons and 9.3% unconverted gammas. It appears impossible that any angular correlation could exist under such circumstances, and to the best of our knowledge, none has been reported.

In the spectrum of I-125 the single primary photopeak contains the K fluorescent photons resulting from K capture and those from internal conversion in the K shell following K and L capture, as well as the unconverted gamma photons. These are not resolvable with NaI(Tl). The sum-peak counting rate, N_{sum}, represents events in which two coincident photons are detected simultaneously, i.e., $N_{sum} \equiv N_{12}$. The total detection rate, N_T, is thus equal to the photopeak rate plus twice the sum-peak rate.

Let η_1 be the number of K x-rays emitted per disintegration, following K capture. This is the product of the K-capture fraction, 0.813 (*3*), and the fluorescence yield, 0.855 (*4*). Let η_2 be the number of photons emitted during the coincident γ decay. This is the product of the K-capture fraction, 0.813, the K-conversion fraction 0.80 (*5*), and the K fluorescence yield, 0.855 (*4*), plus the product of the K-capture fraction 0.813 and the unconverted gamma abundance 0.0666 (*6*). The total number of emitted K and γ photons per disintegration is $\eta_T = 1.4669$ (*5*). Thus,

$$N_1 = \frac{\eta_1}{\eta_T} N_T, \text{ and } N_2 = \frac{\eta_1}{\eta_T} N_T.$$

Substitution in Eqn (d) gives the activity at the point where the coincident branching occurs, i.e., the product of total activity and the K-capture fraction:

$$0.813\ A = \frac{\eta_1\eta_2}{\eta_T^2} \cdot \frac{N_T^2}{N_{sum}},$$

and

$$A = \frac{\left(\frac{N_2}{2.04}\right)^2}{N_{sum}},$$

as reported previously, with a slight correction introduced by the more recent abundance figures (*5*). Under the conditions of I-125 decay, the independent detection probability of the two coincident photons permits the statement, objected to by van Damme, that $\eta_{12} = \eta_1\eta_2$ (van Damme's notation). Measurements in a deep well crystal, where the geometry approaches 4π, would remove even this theoretical objection.

PAUL V. HARPER
KATHERINE A. LATHROP
Franklin McLean Memorial Research Institute
Chicago, Illinois

REFERENCES

1. HARPER PV, SIEMENS WD, LATHROP KA, et al: Production and use of Iodine-125. *J Nucl Med* 4: 277–289, 1963

2. CAMPION PJ: The standardization of radioisotopes by the beta-gamma coincidence using high efficiency detectors. *Int J Appl Radiat Isot* 4: 232, 1959

3. DER MATEOSEAN E: Scintillation spectrometer determination of L-capture to K-capture in Cd^{109} and I^{125}. *Phys Rev* 92: 938, 1953

4. NIJGH GJ, WAPSTRA AH, VAN LIESHOUT R: *Nuclear Spectroscopy Tables*, Amsterdam, North Holland Publishing Co, 1959, p 81

5. BOWE JC, AXEL P: Decay of Te^{125m}. *Phys Rev* 85: 858, 1952

6. DILLMAN LT, VON DER LAGE FC: *Radionuclide Decay Schemes and Nuclear Parameters for Use in Radiation-Dose Estimates, MIRD Pamphlet No 10*, New York, Society of Nuclear Medicine, 1975, p 71