POTENTIAL ERRORS IN THE RADIOASSAY OF ^{125}I

David Hunter, Arthur F. Dratz, Robert H. Rohrer, and James C. Coberly

Emory University School of Medicine, Atlanta, and Veterans Administration Hospital (Atlanta), Decatur, Georgia

The radioassay of very small ^{125}I samples in both conventional and side-hole well crystals has been investigated. Using a multichannel analyzer, the source was counted at various positions within these well crystals. The effect of using a single-channel pulse-height analyzer was simulated by summing the counts over a 24-keV range across the primary peak, over a 30-keV range across the sum-coincidence peak, and over a 56-keV range across both peaks. In all crystals the primary peak was independent of sample position within the well over a range of several centimeters. The contribution of the sum-coincidence peak varied significantly with sample position in the conventional well crystals. With the side-hole crystal the counts contributed by the sum-coincidence peak exhibited a 2-cm plateau.

The increased use of very small samples of ^{125}I in radiochemistry has created a need for re-evaluation of quantitative counting in the presence of coincidence-summing scintillations (*1–4*). Iodine-125 decays by electron capture into ^{125m}Te which then undergoes isomeric transition. Both processes create vacancies in the K-electron shell of tellurium leading to the emission of characteristic x-rays, mainly at 27.5 keV. Frequently pairs of photons are emitted in coincidence producing a sum peak at approximately 55 keV. The primary emissions and abundances from ^{125}I are listed on Table 1 (*5*). Typical ^{125}I spectra taken with an NaI(Tl) crystal illustrate the primary peak at 28 keV and a sum-coincidence peak at 55 keV (Fig. 1).

TABLE 1. PRIMARY EMISSIONS FROM ^{125}I*

Type	Mean energy (keV)	Mean number/ disintegration
$K_{\alpha 1}$ x-rays	27.5	0.738
$K_{\alpha 2}$ xrays	27.2	0.378
$K_{\beta 1}$ x-rays	31.0	0.199
$K_{\beta 2}$ x-rays	31.8	0.0413
Gamma-1	35.5	0.0678
	(sum peak = $2 \times 27.5 = 55$ keV)	

* Ref. 5.

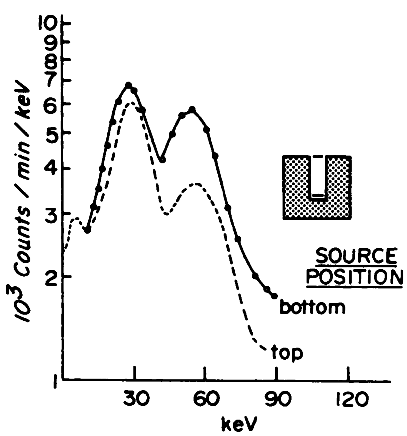

FIG. 1. Typical ^{125}I spectra obtained with source at different positions within 3 × 3-in. NaI(Tl) conventional well crystal.

MATERIALS AND METHODS

A 2-mm thick by 11-mm diam source of ^{125}I (0.1 μCi absorbed on resin sponge) was counted at numerous selected positions within the wells of the crystals listed in Table 2. The spectra were stored in sections of a multichannel analyzer memory at 1 keV per channel. Using the data-processing capabilities of the multichannel analyzer, the data were integrated over selected energy ranges (18–42 keV, 44–74 keV, and 18–74 keV) to evaluate the effects

Received Sept. 23, 1974; revision accepted April 10, 1975.

For reprints contact: David Hunter, Nuclear Medicine Dept., Bowman Gray School of Medicine, Winston-Salem, N.C. 27103.

TABLE 2. NaI(Tl) CRYSTALS

Crystal type	Crystal size (mm)	Well depth (mm)	Thickness Al well insert (mm)	Thickness of reflector material (mm)
CW*	43.75 × 50	37.5	≅0.25	Sprayed on
CW†	43.75 × 50	37.5	≅0.80	Al_2O_3
CW*	75.00 × 75	50.0	≅0.80	1.57
SH‡	75.00 × 75	75.0	≅0.48	MgO

* Conventional well crystal (Harshaw Integral Line).
† Conventional well crystal (Harshaw Standard Line).
‡ Side-hole crystal (Packard Instrument Co.).

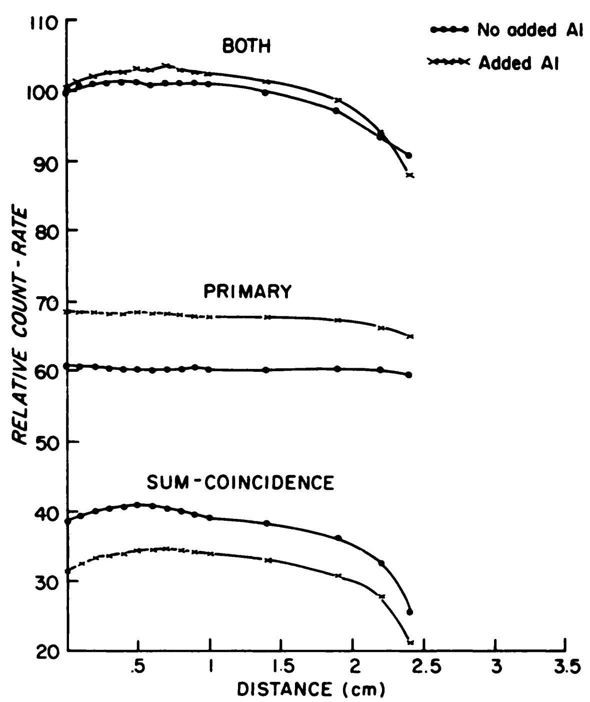

FIG. 2. Effect of source position upon relative counting rate of ^{125}I in 3 × 3-in. NaI(Tl) crystals. X values represent source distance above (+) and below (—) geometric center of each crystal measured along longitudinal axis of each well.

of various window arrangements. In all cases the integrated counts were greater than 3 × 10^5.

RESULTS

When a source was moved from the bottom to the top of a well in a 3 × 3-in. NaI(Tl) conventional crystal, there was a 43% loss in sensitivity at the primary peak and a 91% loss in sensitivity at the sum-coincidence peak (Fig. 1). Similar results were obtained with a 3 × 3-in. side-hole crystal. When the data from the various source positions were integrated over selected energy ranges (primary peak alone, sum-coincidence peak alone, and both peaks), the results shown in Fig. 2 were obtained. The counting rate values were normalized to a value of 100% for both-peaks data at the bottom of the conventional well and at the center of the side-hole crystal.

In the first 3 cm from the bottom of the conventional 3 × 3-in. well crystal, the counts contributed by the primary peak (18–42 keV) were relatively constant, with a mean value of 65.4% and a range of 64.1–66.4%. Over the same 3 cm, the counts contributed by the 44–74-keV sum-coincidence peak decreased from 33.6 to 23.6% and, when both peaks were included in the window, the counting rate decreased about 12%.

With the 3 × 3-in. side-hole crystal the counts contributed by the primary peak were relatively constant over a 4-cm range (2 cm above and below the center of the crystal). The mean percent value of the 4-cm plateau was 67.6% (range, 66.3–68%). At greater distances the counting rate decreased more rapidly than that observed with the conventional well crystal. Due to the curvature of the side-hole crystal at the end of the well, less crystal is available for absorption and more rapid decrease in counting rate could be expected. The counts contributed by the sum-coincidence peak exhibited a 2-cm plateau (1 cm above and below the center of the crystal) with a range of 30.9–31.9%. When both peaks were included in the window, a 2-cm plateau was observed with a range of 98.4–100.2%.

Somewhat different results were obtained with the 1.75 × 2-in. NaI(Tl) well crystals (Table 2). In both of these crystals there was a small increase in the contribution of the sum-coincidence peak when the source was moved over a 3-ml distance from the bottom of the well (Fig. 3). We suspect that slightly greater wall absorption occurs when the source is at the very bottom of the well. To check this supposition we inserted an aluminum splash guard having 0.25-mm thick walls and a 1-mm thick bottom. With this splash guard, an increase in the contribution of the sum-coincidence peak over the first 3 mm could be demonstrated in all crystals. The greatest change, approximately 31–36%, was observed in the small integral-line crystal. As shown in Fig. 3, the added absorption produced by the splash guard decreased the total contribution of the sum-coincidence peak by 7% and increased the contribution of the primary peak by 8%. When absorber material is present between the source and the crystal, the probability of detecting two photons in coincidence is reduced. Thus, absorbing material would tend to decrease the counts in the sum-coincidence peak and increase the counts in the primary peak.

The data in Fig. 3 are typical of those obtained with 1.75 × 2-in. NaI(Tl) crystals. The counts

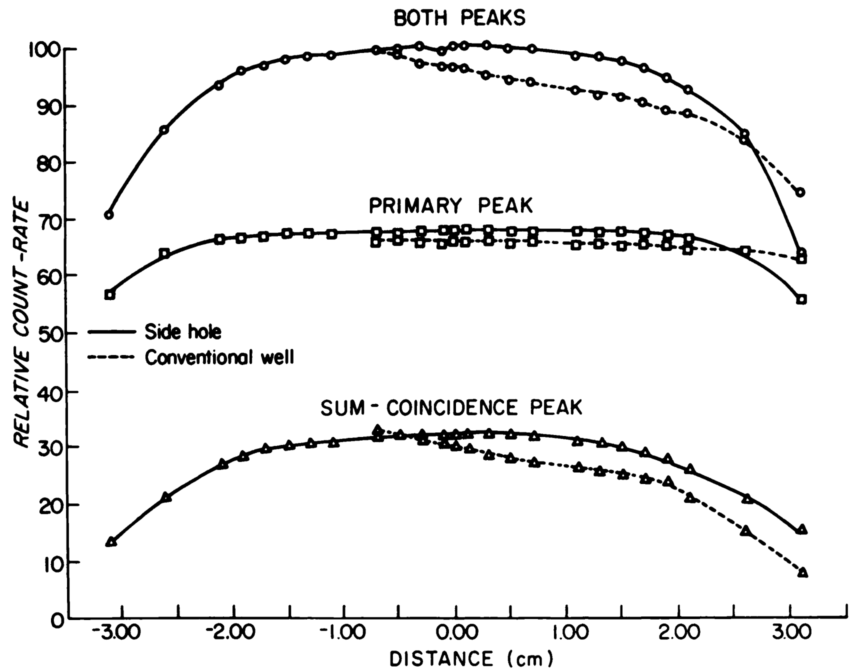

FIG. 3. Effect of source geometry upon relative counting rate of ^{125}I in 1.75 × 2-in. NaI(Tl) conventional well crystal with and without addition of aluminum splash guard. Counting rate values were normalized to value of 100% at bottom of well for both-peaks data without addition of splash guard. X values represent source distance above bottom of well.

contributed by the primary peak are relatively constant over a 2-cm range from the bottom of the well. The sum-coincidence peak, on the other hand, is continuously changing with distance, first increasing and then decreasing.

DISCUSSION

These data indicate that when a conventional well crystal is used to count very small ^{125}I samples, errors can be minimized by eliminating counts from the sum peak. The geometry independence of the 3 × 3-in. side-hole crystal has been documented for all three energy bands (the primary peak alone, the sum peak alone, and both peaks). In some clinical procedures the counting rate is very low. In such cases the summing phenomena of ^{125}I can be turned to advantage by using the side-hole crystal and bracketing both peaks. This will allow the user to attain a low fractional standard deviation with a minimum of counting time.

The automatic well counter may be needed to handle large numbers of small ^{125}I samples, but because the geometry may be critical, the instrument must place the sample accurately within the detector. When good duplication of the geometry between sample and standard is achieved, the errors are insignificant. Good pulse-height analyzer calibration is essential in counting ^{125}I. The energy dial should not cover too great a range since the energy of ^{125}I is very low. Therefore, a maximum full-scale calibration range of 250 keV is recommended. We consider it essential that both peaks be identified in order to place the desired window intelligently.

ACKNOWLEDGMENT

The authors express appreciation to Robert Harbort, Uppergate Computer Center, Emory University, Atlanta, Ga., for his assistance in providing the program for our plots.

REFERENCES

1. Eldridge JS, Crowther P: Absolute determination of ^{125}I in clinical applications. *Nucleonics* 22: No. 6, 56–59, 1964

2. Ring JG: Unpublished data, 1973

3. Ross DA, Rohrer RH, Harris CC: Quantitative counting in the presence of coincidence-summing scintillations. *J Nucl Med* 8: 502–514, 1967

4. Hunter D, Dratz AF, Rohrer RH, et al: Potential errors due to geometry in the radioassay of ^{125}I. *South Med J* 66: 1339, 1973

5. Dillman LT: Radionuclide decay schemes and nuclear parameters for use in radiation-dose estimation. MIRD Pamphlet No 4, *J Nucl Med* 10: Suppl No 2, 25, 1969