ESTIMATION OF THYROID UPTAKE OF ^{131}I FROM DIGITIZED SCINTISCAN MATRICES

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Digitizing and computer processing of scintiscan matrices provide accurate representation and high resolution of counting rates over small areas (*1–3*). Since radioactivity over the thyroid can be determined relatively accurately by external counting, it seemed reasonable to us that both the conventional total ^{131}I uptake (percentage of dose) and the distribution information could be determined simultaneously from the digitized scintiscan itself. This paper reports our results with this type of data presentation.

METHODS

Selection of subjects. Patients referred for ^{131}I thyroid-uptake determination and for scintiscanning were studied. The isotope was given orally in doses varying from 5 to 100 μCi. Scanning was performed within 5 min of the 24-hr uptake determination. Sixteen patients were studied a total of 19 times and a phantom was studied 14 times, using 19-hole and 31-hole collimators.

Scanning procedure. The details of the scintiscanning procedure have been described elsewhere (*4*). Briefly, the procedure involves recording the counts from a scintiscanner pulse-height analyzer along with x-y axis orientation signals on an 8-channel digitizing magnetic-tape recorder. These tapes are fed into a high-speed digital computer (IBM 7040) to reconstitute the data matrix, to analyze each datum point in accordance with the response characteristics of the collimator used (*2*), to store the data in a scan library and for other uses. Matrices are typed out by a high-speed printer (600 lines/min). Counting rates are depicted by various type symbols—usually 20 at a time—each one representing 5% of maximal radioactivity. The computer is programmed to print a key for the various counting rates, the actual number of gamma-ray counts per character, the total number of symbols of each counting increment printed on each scan, the total counting rate at each level separately and the total counting rate at any level plus all rates greater than this rate over the scan. All scan matrices were enlarged 1.75 times by the computer.

The lowest counting level which most closely corresponded to the outline of the thyroid gland (above background threshold) was chosen, and the total counting rate at that level and all those higher than it were compared with the radioactivity of the thyroid gland estimated by the thyroid uptake conventionally performed (*5*) in this institution. In this procedure the patient is given an oral dose of 5 μCi of ^{131}I and counted at 6 and 24 hr. A standard is also prepared and counted under the same geometric conditions. From these data total radioactivity (in microcuries) in the gland is determined. This value was correlated with counting rates obtained from the computer-processed thyroid-scan matrices.

Scans were performed with two collimating systems (Picker 2102 and 2107). Correlations between the two computer-processed scans and conventional thyroid uptakes were made separately.

Phantom scanning. A thyroid phantom (Picker NI-94198) was filled on two occasions with 48.0 and 48.6 μCi of ^{131}I. This was scanned at the focal point of both collimators at various times after filling. Total radioactivity contained in the phantom was calculated using appropriate decay factors.

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Counting rates from the digitized scan were correlated with the calculated radioactivity in the phantom. Since radioactivities in the patient and standard phantom were expressed in microcuries, percentage uptake of dose by the gland can be calculated easily.

Scans of the phantom were made at various speeds and at various line spacings to determine the effect of these factors on the computerized scans. The speed was calculated by the computer, and the line spacing was determined from the "dot" scan. Since the calculated counting rate was found to be essentially independent of line spacing and speed within the limits studied (0.1 and 0.5 cm and 30 and 120 cm/min, respectively), *in vivo* scanning was carried out between these limits, usually at 0.25 cm and 30 cm/min.

TABLE 1. COUNTING RATES AT VARIOUS LINE SPACINGS AND SPEEDS

Line spacing* (cm)	Counting rate (cpm)	Peak (counts/char)	Speeds† (cm/min)	Counting rate (cpm)	Peak (counts/char)
0.1	159,742	7.14	30	187,623	9.01
0.2	159,251	4.07	40	188,686	4.97
0.3	160,579	2.87	50	186,117	4.07
0.4	157,396	2.04	60	186,353	3.08
0.5	159,335	1.70	100	185,969	1.65
			120	188,975	1.32

* Scanned at 50 cm/min.
† Scanned at 0.25 cm spacing.

RESULTS

Counting rates obtained at various speeds and line spacings are given in Table 1. The correlation between conventionally performed thyroid uptakes and computer-processed digitized scans is shown in Fig. 1.

The formulas for least-squares fit for *in vivo* thyroid counting using the 19-hole collimator are

$$\hat{y} = 413.4 + 4163.4x$$

and

$$\hat{x} = -0.02285 + 0.0002367y$$

in which y = counts per minute in thousands and x = μCi ^{131}I in thyroids as shown in Fig. 1. For the phantom alone

$$\hat{y} = 1004.4 + 3884.6x.$$

There is no apparent departure from linearity. With the 31-hole collimator, the formulas for least-squares fit are

$$\hat{y} = 1870.41 + 517.18x$$

and

$$\hat{x} = 3.7486 + 0.001926y.$$

Estimates of radioactivity in phantoms and in patients from digitized scans were not sufficiently different to be of importance in the clinical situation.

DISCUSSION

The data indicate that digital-computer processing of scintiscan matrices is of value in summing counts over an organ such as the thyroid. With such a technique, both ^{131}I distribution and quantitative information can be obtained simultaneously at virtually no extra cost in time or expense. In our system it is easily effected by reading the total number of counts over the thyroid (above background) which are printed by the computer and comparing them with the counts obtained from a similar plot of a standard phantom scan.

In addition, it appears possible to quantitate activity over specific areas such as "hot" nodules or an entire lobe or to exclude a metastatic area that could produce falsely high uptake values.

Although it is not generally recognized as a suitable standard phantom for routine thyroid-uptake procedures, the Picker phantom proved to be a suitable standard in a moving-probe system when scanned at the focal point of the collimator. Perhaps a thinner standard phantom would work even better although according to Harris (*6*) "the quantitative value of counts from a scanner, moving or stationary, is reinforced by the fact that, as long as the scan completely covers the target, the total counts recorded are independent of source distance."

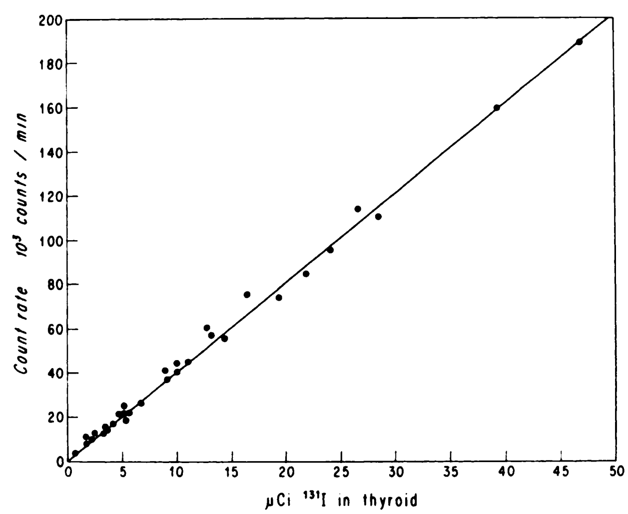

FIG. 1. Correlation between counting rate (cpm × 10^3) from digitized thyroid scintiscan matrix and amount of radioactivity present in thyroid gland or phantom (19-hole collimator used).

This general technique can be adapted to quantitate activity in other organs such as the kidney, liver, lung and spleen.

The general technique also permits precise determinations of counting-rate efficiency of various collimator systems. In the case of the collimators described here, the mean efficiency for ^{131}I in the thyroid gland was 70.0 cps/μCi for the 19-hole collimator and 7.9 cps/μCi for the 31-hole collimator. Within the limits studied, variations in speed and line spacing did not significantly alter the counting-rate calculation by the computer.

SUMMARY

The application of digital-computer processing of scintiscan matrices to the calculation of thyroid-uptake values is described. This technique lets one estimate ^{131}I thyroid uptake from the data produced by scintiscanning.

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