USE OF SCALER ATTACHMENT TO RECTILINEAR SCANNER TO MEASURE ^{99m}Tc-PERTECHNETATE UPTAKE BY THE THYROID: CLINICAL STUDIES

Robert D. Leeper, Malcolm Powell, and Richard S. Benua

Memorial Sloan-Kettering Cancer Center, New York, New York

A simplified method for measuring the thyroidal uptake of ^{99m}Tc-pertechnetate was used to study 60 patients with normal and abnormal thyroid function. Output from the pulse-height analyzer of a single-headed rectilinear scanner was fed to a scaler and various areas of a thyroid scan could then be counted for background subtraction purposes. The ^{99m}Tc-pertechnetate uptake range in 47 euthyroid individuals was 0.4–3.5% which is similar to the range obtained by more complex gamma camera methods.

The described method utilizes relatively inexpensive and easily available equipment, allows for simultaneous optimum imaging conditions, eliminates tedious dot counting, and is as rapid as gamma camera methods.

Several reports (*1–4*) have shown that measurement of ^{99m}Tc pertechnetate (TcO_4^-) uptake by the thyroid is a useful index of thyroid function. Although TcO_4^- measures only trapping by the thyroid (*1*), its use has several advantages over ^{131}I uptake measurements. Pertechnetate delivers less radiation to the thyroid (*2*) and more activity can be used for thyroid uptake measurements and imaging. The 140-keV energy of ^{99m}Tc is also easier to absorb and collimate for imaging.

The principle problem involved in TcO_4^- thyroid uptake measurements has been to quantitate the neck background contribution to thyroid uptake. This problem has been approached in several ways: by dot counting (*1,4*), shielding (*1*), thigh activity measurements (*5*), or by use of scintillation cameras interfaced to computers which allow for background subtraction by data-processing methods (*2,3*).

We now report a simple method for measuring thyroid TcO_4^- uptake which eliminates the necessity for dot counting, allows for optimum scanning conditions, and which does not involve the use of more expensive gamma camera equipment with computer capability.

METHODS AND MATERIALS

The method is a modification of the dot-counting method of Williams, et al (*4*). Instead of hand counting dots, however, pulse output (clearly labeled on our instrument) from the pulse-height analyzer of a single-headed Picker Magnascanner with a 3-in. NaI crystal, color printer, and a Picker Model 2102 collimator is fed into a Canberra scaler during a scan. Total counts over various areas of the scan can then be obtained by stopping the scanner at selected points and noting total counts.

Activity injected into the patient was measured by scanning a Lucite block (Fig. 1) containing a plastic syringe with 5 ml of TcO_4^- (2 mCi) prior to injection and noting total counts accumulated on the scaler. The block is constructed so that the center of the syringe is at an average thyroid depth of 17 mm (*4*). Scanning speed was 300 cm/min. The syringe was rescanned after patient injection to measure residual activity.

Twenty minutes after injection the patients were scanned starting at a point below the lower edge of thyroid lobes. The starting point was usually just above the sternal notch level. Four complete lines were scanned (0.2-cm step increments), the scanner and scaler stopped, and counts recorded. The scan

Received Jan. 4, 1974; revision accepted July 2, 1974.

For reprints contact: Robert D. Leeper, Memorial Hospital for Cancer and Allied Diseases, 1275 York Ave., New York, N.Y. 10021.

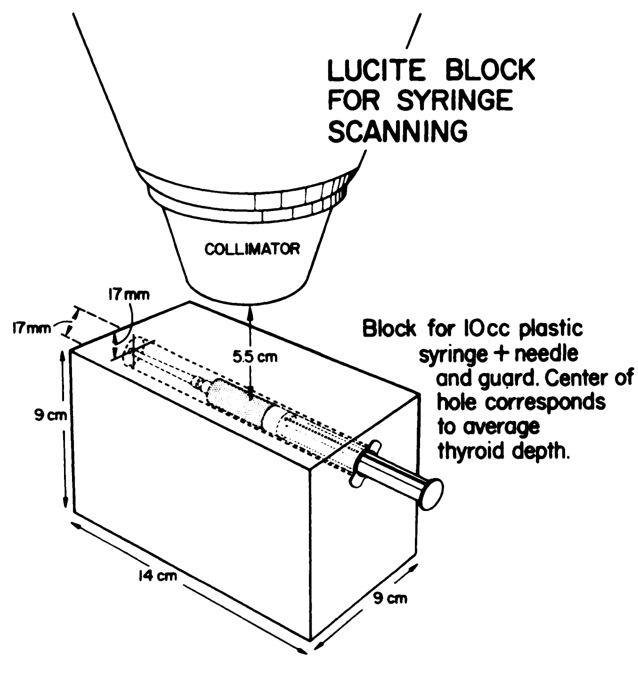

FIG. 1. Sketch showing Lucite block used for scanning the syringe before injection.

was restarted and continued until the entire thyroid was covered as determined by inspection of the tap scan. The scanner and scaler were again stopped, counts noted, four more lines cephalad to thyroid were scanned, and total counts recorded. Total time for the procedures was recorded. Speed, detector height, and dot factors were set in the usual way to obtain optimum scans. Tap scans of the 60-cycle test signal were made at the same speed settings used for both syringe and patient scans. Thus true speeds were obtained by measurement of tap spacing. The scan height was then measured. Decay factors were calculated from the syringe count time to the midpoint of the patient scan.

Scans of a 35-cc thyroid phantom were done to quantitate the effect of varying scanner head-to-phantom distances and of 0.5 and 2-cm equivalent tissue absorbers on the uptake.

Pertechnetate uptakes were measured in 60 consecutive patients. The thyroid function status of the patients was determined by simultaneous determination of the 24-hr ^{131}I thyroidal uptake and by measurement of T_3 resin uptakes [RT_3U], T_4I by column [$T_4(C)$], and Murphy-Pattee thyroxine [$T_4(D)$] in the serum. Calculation of the TcO_4^- thyroid uptake was quickly done on an Olivetti Programma calculator using the following formulas:

$$Bkg = C_a + C_b \times 0.625h$$

$$\%Tu = \frac{(C_t - Bkg) \times S}{(C_1 - C_2) \times 300} \times \frac{100}{df}$$

where Bkg = background; C_t = total counts recorded for scan; C_a = counts recorded for first four lines; C_b = counts last four lines = C_t − counts recorded before last four lines; 0.625h = constant × scan height (cm), constant derived from five lines per centimeter (0.2-cm steps), divided by total lines (in this case, eight) counted for background; %Tu = % thyroid uptake; S = scan speed (corrected) used in patient scan; C_1 = counts in syringe before injection; C_2 = counts in syringe after injection; 300 = scan speed (corrected) used in scanning syringe; and df = decay factor.

RESULTS

The mean ^{99m}Tc-pertechnetate uptake by the thyroid in 47 euthyroid patients was 1.3% and ranged from 0.4% to 3.5% (95% confidence limits). The values for the 60 patients studied which include 11 hyperthyroid and 2 hypothyroid patients are shown graphically in Fig. 2. The correlation coefficient between the TcO_4^- uptake and the 24-hr ^{131}I uptake was 0.70 in euthyroid patients.

The TcO_4^- uptake value was discordant with other indices of thyroid function in four instances;

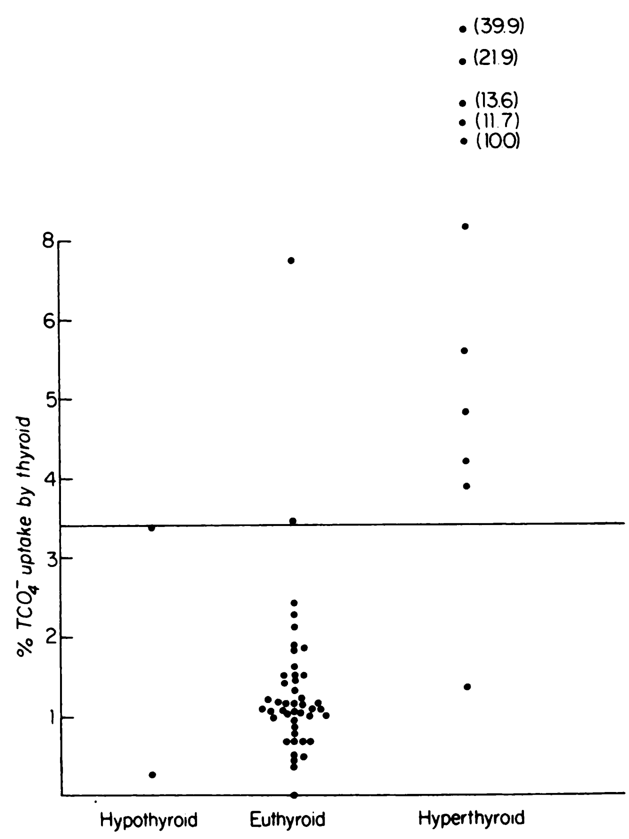

FIG. 2. Distribution of thyroid $^{99m}TcO_4^-$ uptake in various thyroid states.

TABLE 1. VARIATION OF TOTAL SCAN COUNT PHANTOM-TO-COLLIMATOR DISTANCE

Absorber thickness	Absorber-to-collimator distance (cm)	Percent of max integral count
0.5 cm	0	100.0
—	1	97.5
—	2	96.8
—	3	94.3
—	4	97.1
—	5	95.1
—	6	96.1
—	7	94.7
—	8	92.1
2 cm	0	83.7
—	1	82.1
—	2	80.6
—	4	81.9
—	6	79.6
—	8	80.0

Gross counts (100%) for first scan (0.5-cm absorber, 0 cm) are 7,993. Percentages corrected for decay. Time each scan—10 min. A 35-cc thyroid phantom containing 0.075 mCi $^{99m}TcO_4^-$ was scanned on Picker Magnascanner attached to scaler.

one high and one low uptake were found in patients with normal serum thyroid hormone levels. A third patient with probable Hashimoto's thyroiditis had a low serum thyroxine value and 24-hr ^{131}I uptake and normal TcO_4^- uptake. One hyperthyroid patient had a normal TcO_4^- uptake.

Table 1 shows the effect of various collimator-to-thyroid phantom distances on the counting rate obtained by scanning a 35-cc thyroid phantom. Variation of the distance to an overlying absorber from 0–8 cm caused few effects not explained by counting statistics. Increasing the absorber thickness by 1.5 cm caused an approximate 15% decrease in counting rate.

Average time for the total procedure and calculation was 45 min including the 20 min uptake time. The mean variation between actual speeds and the dial settings was ±2.4%. In actual practice it was found that if the neck was well extended, salivary gland uptake was rarely a problem.

DISCUSSION

The normal range of 0.4–3.5% for ^{99m}Tc-pertechnetate uptake by the thyroid found in these euthyroid patients compares favorably with the 0.24–3.4% range found by Maisey, et al (*2*) for a gamma camera system with pinhole collimator and computer capability and a range of 0.5–5.4% reported by Atkins (*1*). The range is lower than that reported for a thigh subtraction method (*5*). The correlation coefficient of 0.70 between TcO_4^- uptakes and ^{131}I uptakes is similar to that found by Hurley, et al (*3*). A higher correlation would be unlikely since ^{131}I uptake measures secretion and organification as well as trapping.

The use of the scaler attachment is an improvement over dot-counting methods (*1,4*) because dot factors and scan speed can be set to obtain optimum scans when the uptake is measured. Previous methods have not necessarily given optimum scans (*4*) because dots had to be separated for counting. The scaler selected for use in this system must give a linear response at the counting rates to be expected from the dose of TcO_4^- used.

The procedure is as rapid as more expensive computer-gamma camera techniques (*2*) and requires relatively inexpensive equipment. An additional advantage of this method over pinhole collimator techniques is that the inverse square law, which affects the counting rate when a pinhole collimator is moved away from the source, is not a major problem in this system (see Table 1). Gamma camera methods using parallel-hole collimators do not give optimum scans in our experience.

This method of measuring TcO_4^- uptake has the same problems as do all measurements of TcO_4^- uptake in that only the trapping mechanism is measured (*1*). However, measurement of the trapping rate, in conjunction with 24-hr ^{131}I measurements, gives additional information in the diagnosis of organification defects, which is not available with either measurement alone.

REFERENCES

1. Atkins H: Technetium 99^m pertechnetate uptake and scanning in the evaluation of thyroid function. *Semin Nucl Med* 1: 345–355, 1971

2. Maisey MN, Natarajan TK, Hurley PJ, et al: Validation of a rapid computerized method of measuring ^{99m}Tc pertechnetate uptake for routine assessment of thyroid structure and function. *J Clin Endocrinol Metab* 36: 317–322, 1973

3. Hurley PJ, Maisey MN, Natarajan TK, et al: A computerized system for rapid evaluation of thyroid function. *J Clin Endocrinol Metab* 34: 354–360, 1972

4. Williams ED, Glass HI, Goolden AWG, et al: Comparison of two methods of measuring ^{99m}Tc. *J Nucl Med* 13: 159–162, 1972

5. Hays MT, Wesselossky B: Simultaneous measurement of thyroidal trapping ($^{99m}TcO_4^-$) and binding ($^{131}I^-$): Clinical and experimental studies in man. *J Nucl Med* 14: 785–792, 1973